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# Inequality in obesigenic environments: Fast food density in New York City

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ABSTRACT

The high prevalence of obesity in African American populations may be due to the food environment in residential communities, and the density of fast food restaurants is an important aspect of the restaurant landscape in US cities. This study investigated racial and socioeconomic correlates of fast food density in New York City. We found that predominantly Black areas had higher densities of fast food than predominantly White areas; high-income Black areas had similar exposure as low-income Black areas; and national chains were most dense in commercial areas. The results highlight the importance of policy level interventions to address disparities in food environments as a key goal in obesity prevention efforts.



## Introduction

Public discourse and public health research on obesity have intensified in the wake of marked increases in US obesity rates, increases that have been particularly acute among the disadvantaged (Drewnowski and Specter, 2004). For African Americans, obesity is endemic—the National Health and Nutrition Examination Survey (NHANES) gave prevalence rates at 45% in 2003–2004 (Ogden et al., 2006). Given that many African Americans are obese, and that in most US cities, African Americans reside in segregated neighborhoods, it is not surprising that research has documented an association between residential segregation and obesity. However, this association is not purely compositional in nature. Although Blacks are 1.7 times as likely as Whites to be obese, they are 3.1 times as likely to reside in relatively obese communities, and individuals living in neighborhoods with high proportions of obese residents are more likely to be obese themselves, net of individual-level factors (Boardman et al., 2005). A positive association also exists between BMI and metropolitan area level segregation after adjusting for compositional differences in socioeconomic and other factors. Compared to a person living at the lowest level of segregation (isolation index = 0.25), the odds of being overweight increased by 77% for residents living in areas with the highest level of segregation (isolation index = 0.83) (Chang, 2006).

These studies point towards the role of social processes as mediators of associations between segregation and overweight/obesity, including institutional forces other than the concentration of poverty. A likely mediator is the food environment in Black neighborhoods. Environments that promote high energy intake and sedentary behavior have been described as obesogenic (Swinburn et al., 1999) (also termed obesigenic). Research on the food environment in Black neighborhoods has focused on access to resources that mitigate against obesity—supermarkets and high-quality produce. These studies show that access is often inadequate for African Americans (Horowitz et al., 2004; Inagami et al., 2006; Lewis et al., 2005; Morland et al., 2002; Schulz et al., 2005; Zenk et al., 2005). Less research has been conducted on disparities in the availability of fast food, despite its implication in overweight and obesity. Fast food is high in calories, fat, and cholesterol (French et al., 2000), has an extremely high energy-density profile (Prentice and Jebb, 2003), and is often served in large portion sizes (Brownell and Battle Horgen, 2003; Nestle, 2002). Some research has begun to investigate obesity-related correlates of fast food density and consumption, documenting associations with weight gain, insulin resistance, overweight/obesity, and acute coronary syndromes (Alter and Eny, 2005; Bowman and Vinyard, 2004; Jeffrey et al., 2006; Pereira et al., 2005).

Fast food consumption has been found to be a strong contributor of dietary fat among African American women (Daroszewski, 2004), and between 1985–1986 and 2000–2001, Blacks frequented fast food restaurants (FFR) significantly more often than Whites (Pereira et al., 2005). These consumption levels may stem from greater availability of fast food in neighborhoods

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rather than from greater intrinsic demand. As in international settings (Cummins et al., 2005; Macdonald et al., 2007; Reidpath et al., 2002), US research on disparities in fast food density has focused on area income. This research has tended to document the inverse relationships between income and fast food exposure that have been observed internationally (Burdette and Whitaker, 2004; Morland et al., 2002; Zenk and Powell, 2008). However, other studies have reported that middle- and high-income neighborhoods have greater numbers and proximity to fast food (Austin et al., 2005; Wang et al., 2007).

Anecdotal evidence of low diversity of dining options in African American neighborhoods has been borne out by empirical research (Lewis et al., 2005), but less research has investigated fast food prevalence as a function of neighborhood racial demographics. It has been argued that residential segregation works to increase the density of fast food in Black neighborhoods by creating localized geographic market areas, fostering economic, business, and land use characteristics that promote fast food, concentrating available labor pools, and weakening community political strength that would be deployed to oppose fast food siting (Kwate, 2008). Some research does show fast food to be more prevalent in Black neighborhoods. In New Orleans census tracts with at least 2000 people per square mile, fast food density (the number of restaurants per square mile in geographically described shopping areas) was predicted only by percent Black. On average, predominantly Black neighborhoods contained 2.4 FFR per square mile, while White neighborhoods contained 1.5 (Block et al., 2004). In contrast, Zenk and Powell (2008) found that nationwide, Black neighborhoods had 30% less restaurants than White neighborhoods, and in the 20 largest cities, Black neighborhoods had 44% less. Morland et al. (2002) and Powell et al. (2007a) found fast food to be more prevalent in racially mixed and predominantly White, rather than Black neighborhoods.

The mixed findings indicate the need for additional investigations of racial disparities in fast food density. There is also little available data on the distribution of fast food *within* predominantly Black neighborhoods that vary in income level. Fast food is inexpensive, takes less waiting time, and has a restricted menu, and thus should appeal to individuals with low income, those in a hurry, and people with simple and consistent food preferences (Brown, 1990). For that reason, it is often argued that the high densities of fast food in Black neighborhoods simply reflect the marketing of an inexpensive product in low-income areas. In this case, predominantly Black neighborhoods with higher incomes should have lower densities of fast food than those with low incomes. However, if fast food density is driven primarily by neighborhood racial demographics, income should show less relative effect on the restaurant environment.

It also bears studying how density patterns map onto (multi) national chains compared to locally operated independent outlets. National supermarket chains are fewer in Black neighborhoods (Powell et al., 2007b; Sloane et al., 2003); the same may be true for national fast food outlets. One reason this might be so is because franchises of national chains require significant accumulated assets and expenditures for start-up. For example, though relatively few new franchisees obtain new stores, opening a new McDonald's store requires an initial fee of $45,000, plus equipment and pre-operating costs ranging from $685,750 to $1,504,000 depending on such factors as the size of the restaurant, the area of the country, and the landscaping needed ("New Restaurants", 2007). After an initial outlay of 40% of the cost, the remainder may be financed through traditional means. Most franchisees purchase an existing restaurant, which requires a minimum 25% cash down payment, with the rest financed over a maximum of 7 years ("Existing Restaurants", 2007). In either case, all store owners must possess a minimum of $250,000 in personal, non-borrowed assets in order to open a restaurant ("Purchasing Your Restaurant", 2007). Given that franchisees in Black neighborhoods have often been African American or affiliated with African American institutions (Love, 1995; Roberts, 1987; Schlosser, 2001), but Blacks have significantly less wealth than Whites (Conley, 1999; Shapiro, 2005), the financial requirements for franchising may act as a barrier to their operation.

Thus, we sought to investigate inequalities in the density of fast food in New York City (NYC), the most populous, and a highly segregated US city. Our aims were fourfold. First, we investigated whether fast food density was positively associated with the percentage of Black residents in the city's census block groups, and whether an interaction with area income was evident. Second, we investigated whether predominantly Black block groups showed variability in fast food density by income. Third, we examined whether predominantly Black and White areas with similar income levels had similar densities of fast food. Fourth, we investigated whether predictors of restaurant density differed for national chains compared to local outlets. We hypothesized that fast food density would be positively associated with the proportion of Black residents; that there would be no relationship between area income and fast food density in predominantly Black areas; that Black areas would have higher fast food density than comparable White areas; and that the relationship between percentage Black and fast food density would be strongest for local outlets.

## Method

### *Geography*

We examined fast food density in the 5730 census block groups comprising NYC's five boroughs: Manhattan, Brooklyn, Queens, The Bronx, and Staten Island. In 2000, NYC had 8,008,278 residents, of whom 24.5% were Black, 27% Latino, 35% White, and 9.8% Asian, and the median household income was $38,909 (New York City Department of City Planning, 2005). Although NYC is diverse in its racial/ethnic composition, it remains highly segregated, as shown in Fig. 1. NYC's Black residents generally reside in large, clustered, racially concentrated neighborhoods in the Bronx (particularly the Northeast section), Central Harlem, Central Brooklyn, and Southeast Queens.

### *Data sources*

#### *Fast food restaurants*

FFRs were defined as national chains and local establishments that: (1) do not provide table service; (2) serve patrons at a cash register or drive-thru window; (3) require payment before eating (National Restaurant Association, 2005); and (4) whose primary menu items were hamburgers, hot dogs, and fried chicken. Restaurant addresses were obtained from The NYC Department of Health and Mental Hygiene's on-line directory of restaurant inspections (New York City Department of Health and Mental Hygiene, 2005). The Department conducts inspections of all food service establishments in the city, and the most recent results are posted by name, borough, and zip code. We searched the directory for the following national chains: McDonald's, Burger King, Kentucky Fried Chicken, Wendy's, White Castle, and Popeye's. We then searched for common local chains[1] (e.g., Crown Fried Chicken, Kennedy Fried Chicken). Finally, restaurants that were

[1] Although we use the word "chains", we do not mean to imply operations that are recognized franchising companies. These restaurants are outlets that have several locations in the city, but are likely sole proprietorships or partnerships.

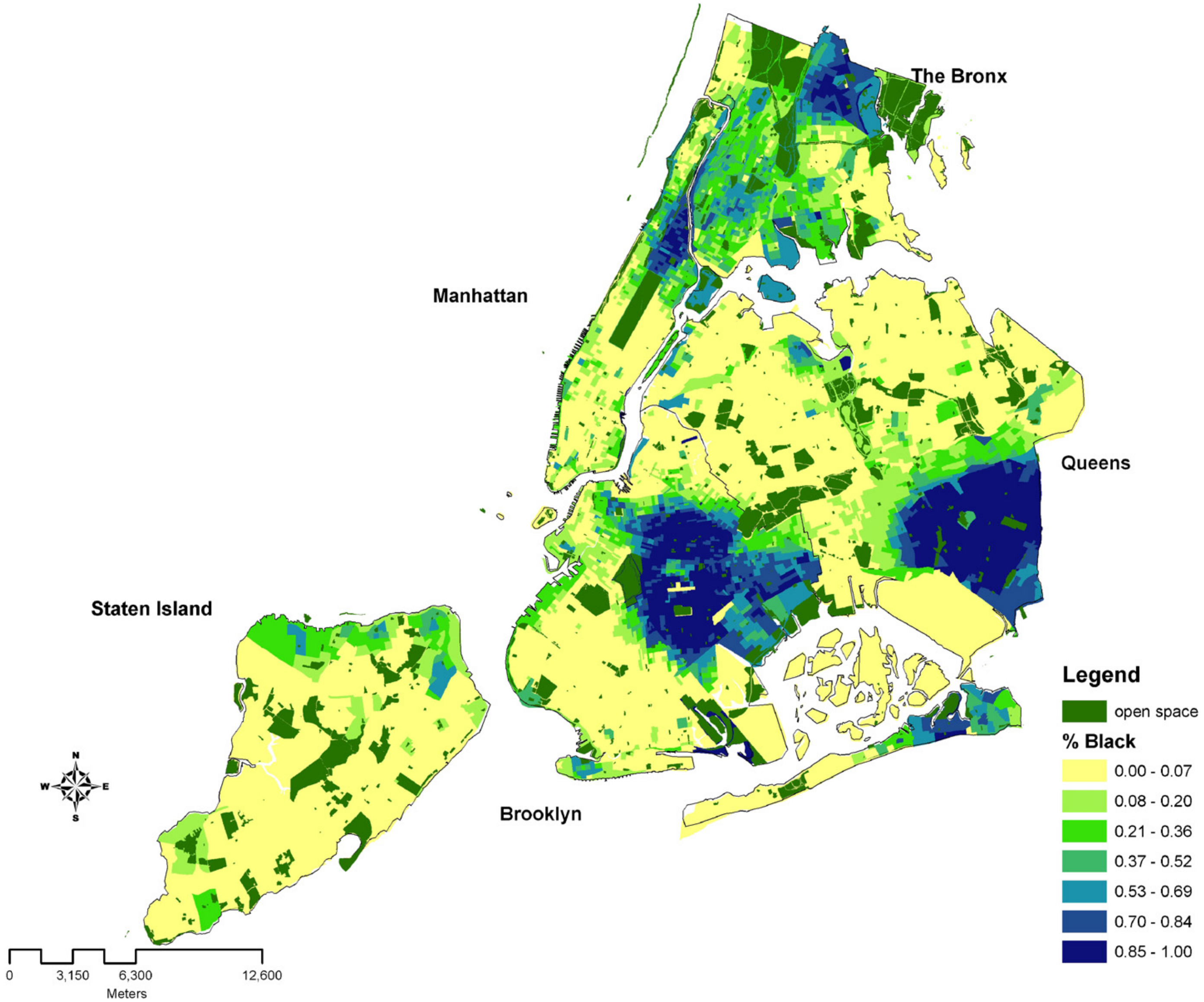


**Fig. 1.** Percent Black in NYC's block groups (Census 2000).

neither national nor local chains were included if their names contained any of our target menu items (e.g., "Frankfurter House" or "Joe's Fried Chicken"). Chinese take-out is often viewed by community residents as fast food (Pierre, 1993), and research in Los Angeles found that for African American women, Chinese and Mexican take-out contributed a substantial portion of dietary fat (Daroszewski, 2004). Given the ubiquity of Chinese take-out in NYC, and the frequency with which these restaurants sell fast food items such as fried chicken wings and French fries, we could have considered these outlets as fast food as well. We did not, because although they may serve less nutritious foods, they still tend to have a greater variety of options that are healthier than fast food (e.g., rice with steamed vegetables). Additionally, because we obtained restaurant locations from online databases, we were not able to parse out which Chinese restaurants were "fast food-like", and which were formal sit-down restaurants with a greater variety of options.

*City infrastructure and demographics*

Data on zoning was obtained from NYC tax lot base map files. Data on consumer expenditures were based on a derivation of the US Bureau of Labor Statistic's Consumer Expenditure Survey (supplied by a commercial GIS firm). We used data on average household expenditures for food away from home (lunch and dinner) for the year 2006. Area income and racial composition were derived from the 2000 US Census Summary Files 1 (SF-1) and 3 (SF-3) and also supplied by the GIS firm. A comparison of 2000 census data and estimates for the year 2006 revealed very high inter-correlations. Thus, we used 2000 data in order to allow comparison to other studies. Also, as previous research has defined "predominantly Black" areas as $>70\%$ and $>80\%$ Black (Morland et al., 2002; Zenk and Powell, 2008), we defined predominantly Black block groups as those with a percentage Black $>70\%$. The commercial GIS firm completed geocoding of fast food data, assignation of zoning class to block groups, construction of fast food density (described below), and importation of census data.

*Defining the outcome variable*

One commonly used assessment of the density of neighborhood features (e.g., alcohol ads) is the number of points per 1000 residents at a particular geographic level (e.g., block group).

However, simply adding the total number of sites in a given block group fails to take into account block group size and does not account for the fact that facilities affect residents in adjacent block groups (Downey, 2003). Thus, we employed a more inclusive method of quantifying exposure, which has previously been applied to mapping hazardous manufacturing facilities. After initial mapping, block groups were overlain with a custom grid demarcating smaller cells measuring $60 \times 60\,m^2$ (approximately 1/2 of a NYC block). Next, we calculated the number of restaurants within a 300 m radius from the center of each cell in the grid and this count value was assigned to each cell. The sum of values for all cells in the block group were divided by the number of cells, yielding the average exposure for the block group (Downey, 2003). In our analyses of national vs. local outlets, average exposure for national chains was computed by taking the sum of average exposure values for Burger King, McDonald's, Wendy's, White Castle, Kentucky Fried Chicken, and Popeye's. Average exposure for local outlets was computed by taking the sum of average exposure values for local chains and local individual outlets.

### *Analytic plan*

Our primary dependent variable was average exposure to FFR, as described above. We were interested in modeling FFR of each block as a function of block group characteristics (covariates). The primary covariate of interest was percent Black (BLK) and the remaining variables were: median age (AGE); population density, operationalized as persons per square mile (POP); percent White (WHT); median household income (MHI); average expenditures on lunch away from home (LUNCH); average expenditures on dinner away from home (DINNER); and zoning (ZONE). We modeled FFR by means of generalized additive models.

Generalized additive models can be described as non-parametric versions of generalized linear models (McCullagh and Nelder, 1989). In generalized linear models, a function of the mean of the dependent variable is expressed as a linear function of covariates, allowing for the possibility of non-Gaussian errors (e.g., Poisson or binomial). In generalized additive models, the relation between the dependent variable and the covariates is neither linear nor parametric, and thus allows for more flexibility. Fitting a generalized additive model involves estimating the non-parametric function linking each covariate to the dependent variable. Unlike generalized linear models, the dependence between response variables and covariates in generalized additive models are interpreted in terms of non-parametric functions rather than regression coefficients.

Specifically, define $\lambda_k$ to be the expected value of FFR for the $k$th block group. With $(x_k, y_k)$ representing the location of the block group and $\mathrm{COV1}_k, \ldots, \mathrm{COV}r_k$ representing the covariates, we fit the model

$$\log \lambda_k = s_{xy}(x_k, y_k) + s_1(\mathrm{COV1}_k) + s_2(\mathrm{COV2}_k) + \cdots + s_r(\mathrm{COV}r_k) \tag{1}$$

using Poisson errors. We chose to model the errors as Poisson because FFR is essentially a measure of the number of restaurants. In Eq. (1) above, the $s_i$'s are non-parametric smooth functions of individual covariates. Given data, these functions can be estimated, for example, using the *gam* function (Hastie and Tibshirani, 1990).

We selected the covariates that rendered the model (1) the best fit for the data by adding covariates in turn and testing at each step whether the new covariate was statistically significant. Specifically, let model 0 be the current model and model 1 be the model with a new covariate added, and let their deviances be D0 and D1, respectively. Then D0–D1 has an asymptotic $\chi^2$ distribution. A large value of D0–D1 indicates that the new covariate is significant. For more details, see Hastie and Tibshirani (1990). Note that two-way interactions can be modeled by including functions of two covariates $s_{ij}$ into Eq. (1).

Spatial information was included in the model in two ways. Firstly, the inclusion of the location of the block group as a covariate allows for modeling of any spatial trend that might be present in the data. Since we are modeling this non-parametrically, fairly complex spatial trends can be captured with very little prior assumptions about the actual structure. Secondly, some spatial correlation is captured through the covariates, which are themselves spatially correlated. It is possible that some residual spatial correlation that was not included in the covariates exists, and this would result in correlated errors. However, we expect the effect on our results to be small. Furthermore, positive spatial correlation will tend to even out variations in FFR and reduce significance of estimates. Thus if residual spatial correlation is present, the estimates of the regression coefficients would be less efficient, making the estimates from model (1) more significant than we observed (Chatterjee et al., 2000). We are currently working on using an alternate method, using point process theory to model the actual locations of restaurants. Differences in results between these two models will better enable us to quantify the effect of correlated errors.

## Results

### *Descriptive results*

There were 802 fast food outlets across the five boroughs. As shown in Fig. 2, many block groups were not exposed to fast food, and exposure was highest in the areas of the city where the proportion of Black residents was high,[2] as well as in central business and commercial districts, transportation hubs and tourist areas (e.g., Wall Street, Port Authority, Times Square). Because these commercial areas have relatively few residents but many FFRs, we excluded them from our regression analyses. To do so, we excluded these areas based on zoning. NYC tax lots are zoned residential, commercial or manufacturing, with overlays among them to varying degrees. In order to quantify zoning at the block group level, we assigned each block group the zoning code of the tax lot closest to the block group centroid. Using NYC zoning codes, we excluded block groups that were zoned as central commercial districts (offices and retail that serve the entire metropolitan region), high-bulk commercial districts (e.g., corporate headquarters, large hotels, entertainment facilities), parks, amusement parks, and heavy manufacturing industry. Five thousand five hundred and twelve block groups remained in the analyses, and were categorized into four zoning groups. The first three corresponded to the NYC Department of City Planning residential classifications of lower density (R-1 to R-5B), medium density (R6HF to R7x), and higher density (R8HF to R10x) (NYC Department of City Planning, 2006). We also included a fourth category that comprised manufacturing and the remaining commercial zones.

### *Aim 1: Relationship between percent Black and fast food density*

To study the relationship between proportion of Black residents and density of FFRs, model (1) was fitted and the model

$$\log \lambda_k = s_{xy}(x_k, y_k) + s_1(\mathrm{BLK}_k) + s_2(\mathrm{MHI}_k) + s_3(\mathrm{POP}_k) \tag{2}$$

[2] Latinos also comprise much of the population in the Bronx.

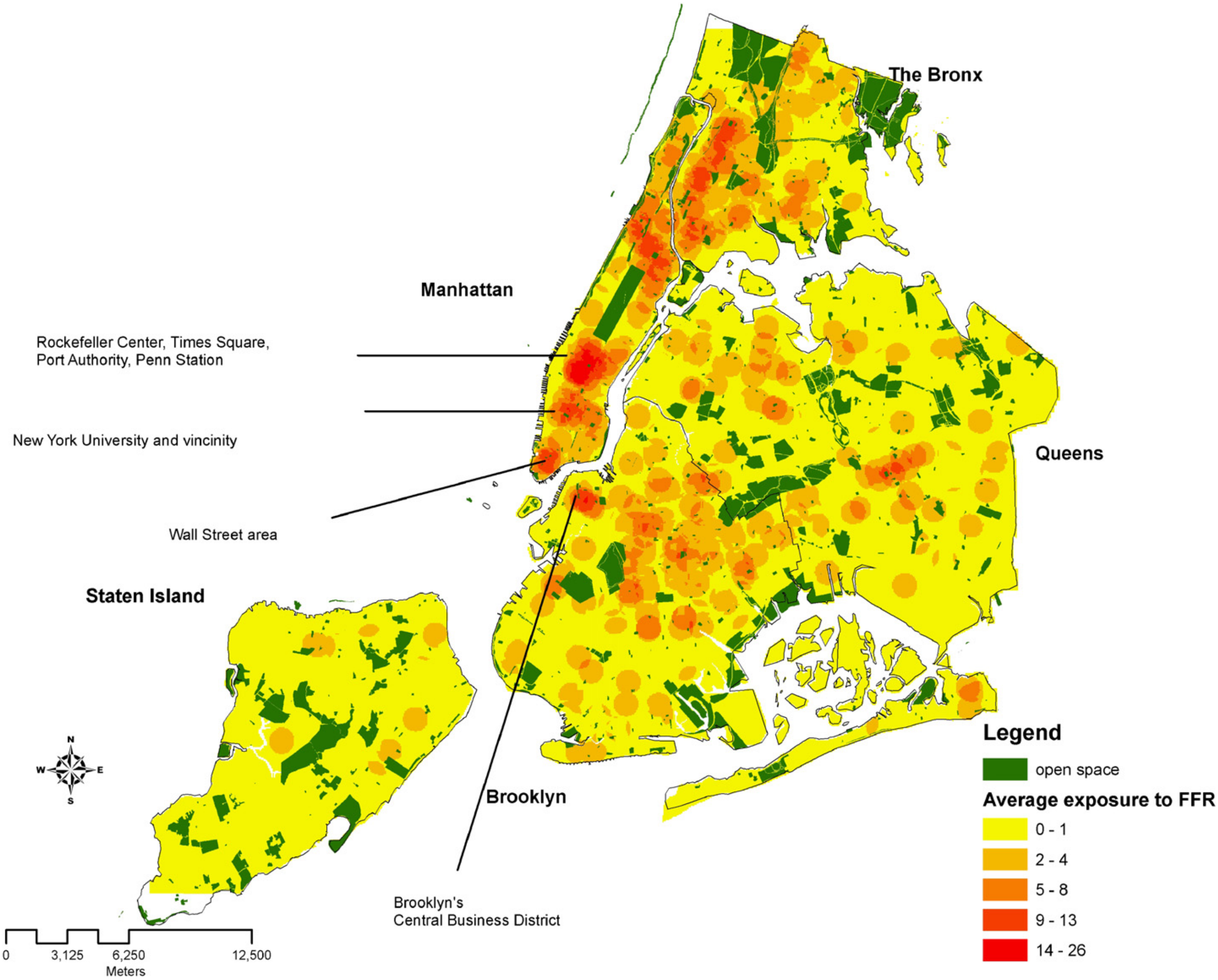


**Fig. 2.** Average exposure to fast food across NYC's five boroughs. Exposure is highest in non-residential areas (e.g., central business, shopping, transit, and tourist districts) and in residential areas with high proportions of Black residents (refer to demographics shown in Fig. 1).

produced the best fit, with the other covariates (median age, % White, and food expenditures) not statistically significant. This model accounted for 59.23% of the deviance in fast food density.

Fig. 3, panels a–d, shows the estimated effects of the covariates. The smooth curves for the covariate effects replace the more familiar regression coefficients in linear regression. The *y*-axis of each graph is the fitted non-parametric function value, which corresponds to the partial effect of that covariate on fast food density, and dashed lines show approximate 95% confidence limits for the estimate. Panel (a) shows that the peak in the two-dimensional surface for location occurred in Manhattan, mirroring the density patterns shown in Fig. 2. Panels (b) and (c) show the non-significant effects of median household income (although there was a mild protective effect for block groups with a median household income of \$0–\$40,000), and population density, respectively.

Panel (d) shows the effects of percent Black. The expected exposure of FFRs increased with the proportion of Black residents in the block group. The strong positive effect of percent Black stood in marked contrast to the other covariates. Next, we investigated possible interactions between percent Black and area income. This can be done by comparing model (2) with

$$\log \lambda_k = s_{xy}(x_k, y_k) + s_1(\mathrm{BLK}_k) + s_2(\mathrm{MHI}_k) + s_3(\mathrm{POP}_k) + s_4(\mathrm{BLK}_k, \mathrm{MHI}) \quad (3)$$

to test whether the additional interaction term $s_4(\mathrm{BLK}_k, \mathrm{MHI})$ is significant. Here $s_4(\mathrm{BLK}_k, \mathrm{MHI})$ is a two-dimensional smoothing surface for BLK and MHI which can describe a very general cross effect between these two variables.

Model (3) accounted for 72% of the deviance in fast food density. Nevertheless, a model comparison between model (3) and model (2) using deviance test shows that the additional interaction term of percent Black and median household income does not significantly improve model (2), ($p = 0.155$).

### *Aim 2: Median household income and fast food density in predominantly Black areas*

To investigate whether fast food density was similar among predominantly Black block groups of varied area incomes, we

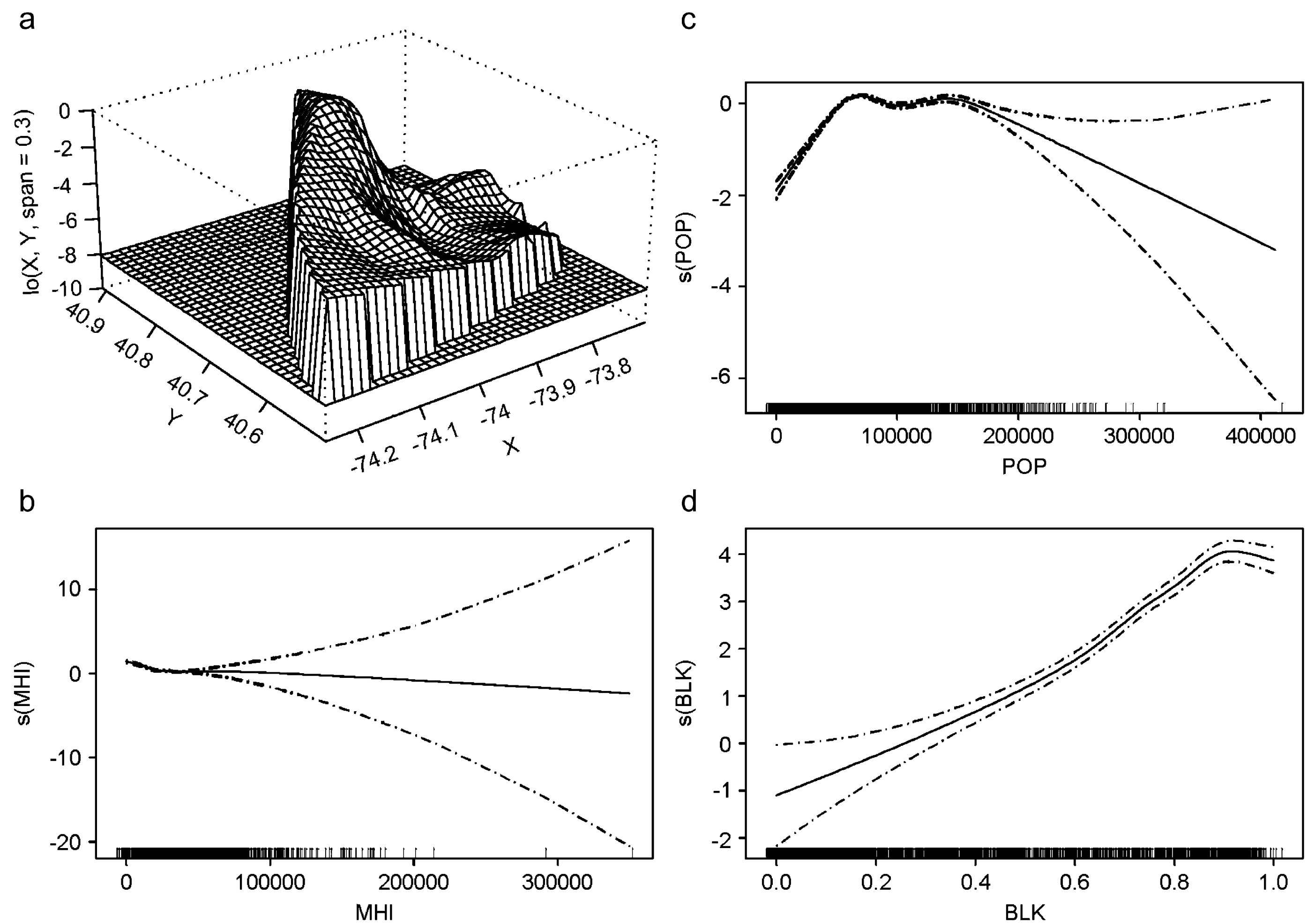


**Fig. 3.** Results for Aim 1. Panel a (top left): estimated spatial effects $\hat{s}_{xy}$ for FFR by location. This agrees with the real spatial effect shown in Fig. 2. Panel b (bottom left): median household income and FFR. Income appeared to have a mild protective effect against exposure for the block groups with an MHI of \$0–\$40,000. The confidence interval becomes very large for very high incomes since there are very few observations for these block groups. Panel c (top right): population density and FFR. Panel d (bottom right): FFR and percent Black. The expected exposure of fast food restaurants increased with the proportion of Black residents in the block group.

restricted the analysis to block groups that were $>70\%$ Black, and fit a modified version of model (2), in which we omitted percent Black as a predictor. In addition, because the predominantly Black block groups with the highest median incomes (primarily Southeast Queens) are more suburban in nature, we added population density to control for this possible confound.

The final model was:

$$\log \lambda_k = s_{xy}(x_k, y_k) + s_1(\mathrm{MHI}_k) + s_2(\mathrm{POP}_k) \tag{4}$$

This model accounted for 59.51% of the deviance in fast food density. All variables were statistically significant. As shown in Fig. 4, the significant effect for income was a slight inverse relationship between median household income and fast food density at the lowest end of the income spectrum (approximately \$0–\$20,000). Otherwise there was no effect of median household income on fast food density in predominantly Black block groups. As before, the wide confidence intervals at very high income levels are due to very few observations. Population density was positively correlated with fast food density, as expected.

*Aim 3: Fast food density in Black and White areas with similar median household incomes*

To investigate whether block groups that were predominantly White had the same exposure to fast food as predominantly Black block groups matched on median household income, we compared analyses in which we stratified all block groups into low ($<$\$25,000), medium (\$25,000–\$50,000), or high ($>$\$50,000) median household income, and considered the effects of percentage Black or percentage White within each. We fit model (2) with these three categories, giving

$$\log \lambda_k = s_{xy}(x_k, y_k) + s_1(\mathrm{BLK}_{1,k}) + s_1(\mathrm{BLK}_{2,k}) + s_1(\mathrm{BLK}_{3,k}) + s_2(\mathrm{MHI}_k) + s_3(\mathrm{POP}_k) \tag{5}$$

and

$$\log \lambda_k = s_{xy}(x_k, y_k) + s_1(\mathrm{WHT}_{1,k}) + s_1(\mathrm{WHT}_{2,k}) + s_1(\mathrm{WHT}_{3,k}) + s_2(\mathrm{MHI}_k) + s_3(\mathrm{POP}_k) \tag{6}$$

As shown in Figs. 5 and 6, at low- and medium-income groups, percent Black was always positively related to fast food density, and percent White was always negatively related. For both groups, there was no association between race and fast food density at high-income levels. Further, using the function predict.gam() in SPlus (version 7.0—Windows), we may predict the value of fast food density for a hypothetical situation. For example, a block group that is 80% White, with coordinates (−73.95, 40.85), a median household income of \$20,000 and a population density of 50,000 persons per square mile yields a predicted fast food density of 0.055. On the other hand, if the percentage Black is 0.8, the predicted fast food density is 0.627. The same picture emerges in high-income areas. With the same location and population, but

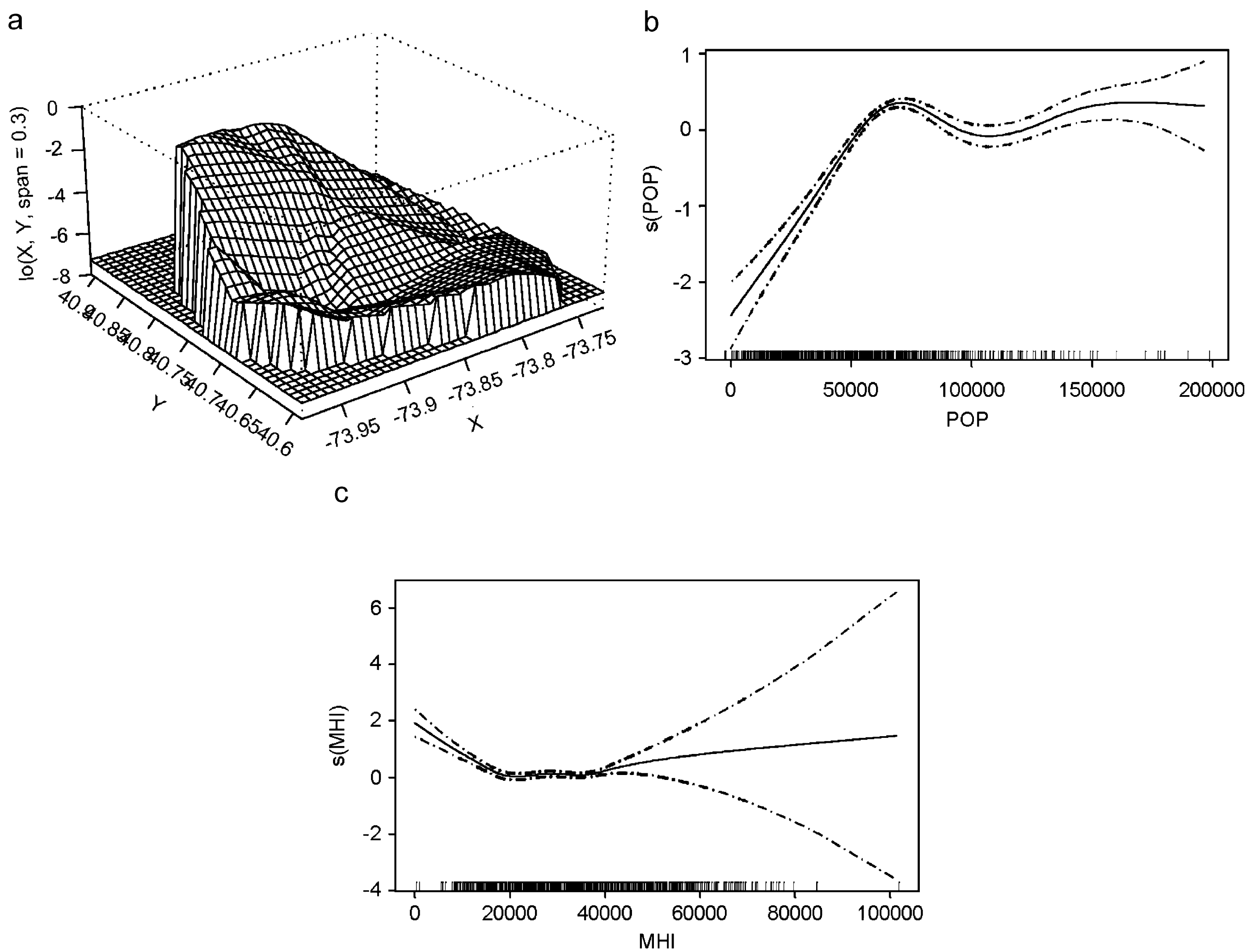


**Fig. 4.** FFR as a function of MHI in predominantly Black (>70%) block groups. Panel a (top left): estimated spatial effects $\hat{s}_{xy}$ for FFR by location. Panel b (top right): population density and FFR. Panel c (bottom): median household income and FFR. There is a slight protective effect at low, in comparison to extremely low-income areas, but area income is otherwise unrelated to fast food density.

with an area income of $80,000, the predicted fast food density will be 0.048 and 0.503 for block groups that are 80% White, and 80% Black, respectively. Both examples illustrate that percent Black and White have large and opposite effects on fast food density.

*Aim 4: National chains and local outlets*

To compare the national chains and local outlets, we fit model (1) two times, with the expected value of fast food density $\lambda_k$ replaced with $\lambda_k^{\mathrm{L}}$ and $\lambda_k^{\mathrm{N}}$, the expected values for local and national outlets, respectively. For local outlets, the best fit model is

$$\log \lambda_k^{\mathrm{L}} = s_{xy}(x_k, y_k) + s_1(\mathrm{BLK}_k) + s_2(\mathrm{MHI}_k) + s_3(\mathrm{POP}_k) \quad (7)$$

which is similar to that for the overall analysis (model (2)). This is to be expected because local FFRs constituted the majority of all FFRs. The effects were all significant and with $p$-values near 0. This model accounted for 77.58% of the deviance in local fast food density.

For national outlets, the best fitting model is

$$\log \lambda_k^{\mathrm{N}} = s_{xy}(x_k, y_k) + s_1(\mathrm{BLK}_k) + \mathrm{ZONE}_k \quad (8)$$

Again, all effects were significant with $p$-values near 0. This model accounted for 4.10% of the deviance in national chain fast food density. The small proportion of deviance accounted for by the model is due to the relatively small number of national restaurants in the dataset. In contrast to model (3), median household income and population density were unrelated to fast food density, but zoning was significant, such that national chains were least dense in low-density residential and most dense in commercial/manufacturing. Fig. 7 shows the estimated effects.

## Discussion

We found that percent Black in NYC's block groups was positively associated with fast food density, and this association was stronger than any other covariate, including median household income. We also found that with the exception of high-income block groups, in which no association was found between racial demographics and fast food density, the prevalence of fast food was always negatively related to percent White, and positively related to percent Black. Additionally, to our knowledge, this is the first study to report on the association between area income and fast food density within predominantly Black areas. Our results do not lend support to the idea that fast food is prevalent in Black neighborhoods simply because these areas are often low in income—more affluent predominantly Black areas

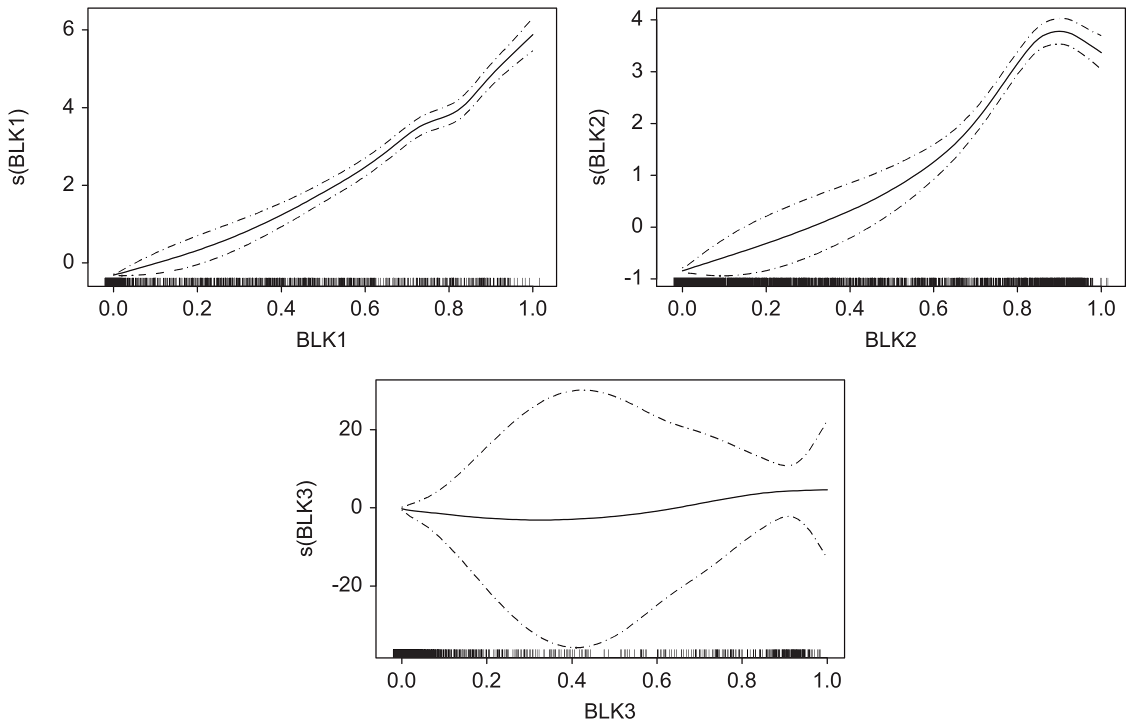


**Fig. 5.** FFR and percent Black, stratified at three income groups: BLK1 (<\$20,000), BLK2 (between \$20,000 and \$50,000), BLK3 (>\$50,000). For the low- and medium-income groups, exposure to fast food restaurants increased with increasing percentage of Black residents. For high-income groups, exposure to fast food restaurants did not increase with the proportion of Black residents.

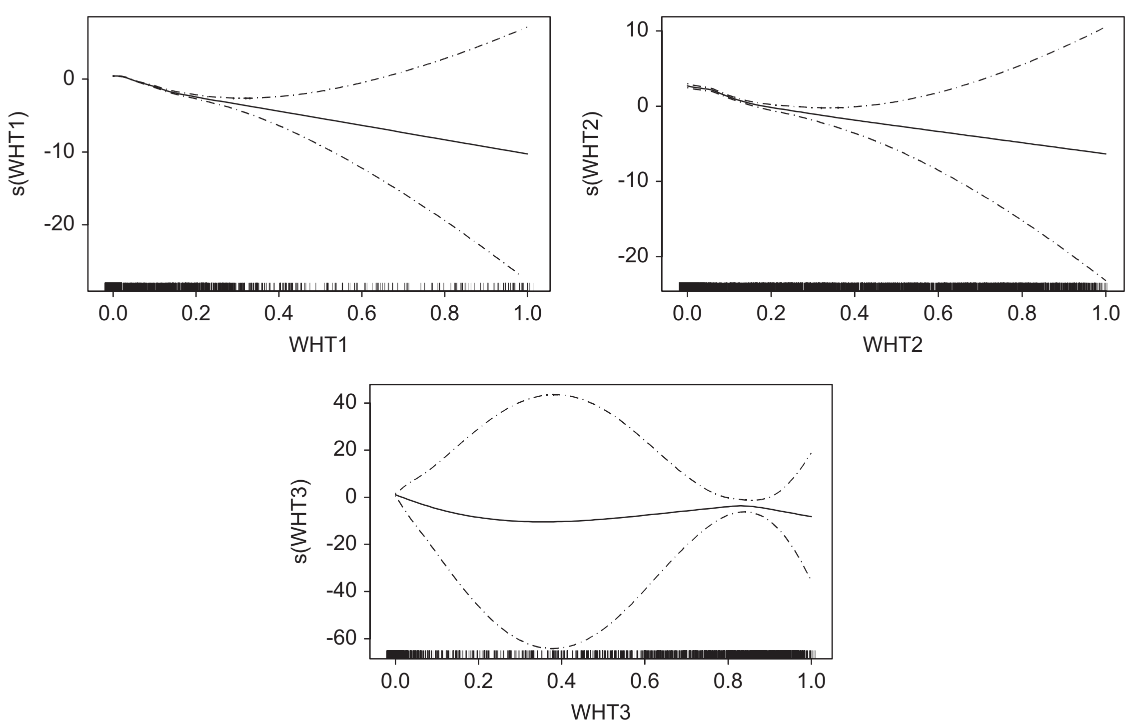


**Fig. 6.** FFR and percent White, stratified at three income groups: WHT1 (<\$20,000), WHT2 (between \$20,000 and \$50,000), WHT3 (>\$50,000). For low- and medium-income block groups, fast food exposure decreases with proportion of White residents, with no association between the two in high-income block groups.

had similar exposure to fast food as those of other income levels after controlling for relevant confounders. Taken together, these results starkly outline the role of racial segregation in shaping fast food exposure for Blacks and Whites in US cities.

We also found that national chains were least dense in low-density residential areas and most dense in commercial/manufacturing zones. Given that these areas are frequented by key target groups such as tourists, workers on lunch breaks, and

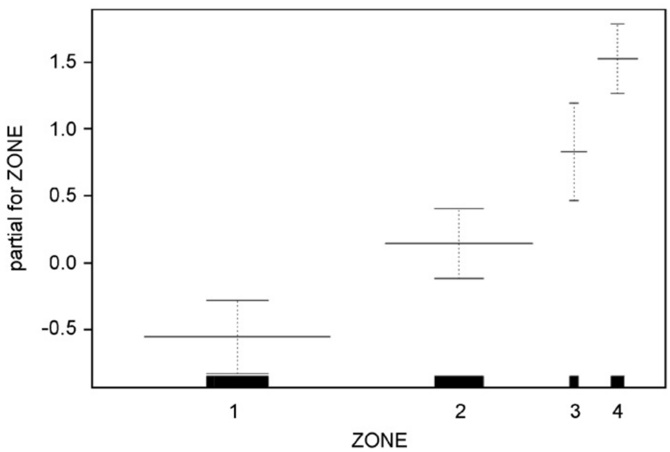


**Fig. 7.** National FFR by zoning categories. National chains are least dense in low-density residential and most dense in commercial/manufacturing: (1) lower density residential, (2) medium density residential, (3) higher density residential, (4) manufacturing/commercial.

shoppers, it is clear why national chains would be located in commercial districts. On the other hand, smaller, independent outlets would not be likely to operate in high-rent, business districts. Instead, "rickety fast-food joints" (Kleinenberg, 2002, p. 92) are often staples of the restaurant landscape in urban communities of color.

Our findings on percent Black as a predictor of fast food density are discrepant from some studies, with the exception of Block et al. (2004). Other research has found fast food to be more prevalent in racially mixed or predominantly White neighborhoods. The discrepant findings may be due in part to variation in fast food definitions across studies. For example, Block et al. (2004) examined only well-known national chains with two or more sites in the study area, and one local chain with five outlets. Food types included hamburgers, fried chicken, pizza and submarine sandwiches. Morland et al. (2002) used NAICS codes to extract business data on franchised fast food shops, pizza parlors and pizza delivery shops. Finally, Zenk and Powell (2008) and Powell et al. (2007a) obtained restaurant information from Dun & Bradstreet (D&B) for FFRs and stands. This category included fast food chains and independent outlets, but also a range of other restaurants, including delicatessens, sandwich and submarine shops, chili stands, grills, and carryout restaurants (not including pizza). Many of these restaurant types (e.g., pizza parlors, sandwich shops) are more likely to be located in predominantly White neighborhoods. For example, in NYC the sandwich chain Subway is most dense in predominantly White residential areas and commercial districts (map available upon request). Thus, the inclusion of such restaurants may skew associations between racial demographics and fast food prevalence. Business databases such as D&B may also contain more data for major chains than for the "rickety joints" often found in Black neighborhoods. For example, we searched D&B's "Million Dollar Database" and found McDonald's to be readily identified, but one local chain, Crown Fried Chicken, was not listed. Thus, in some studies, Black neighborhoods may appear to have fewer fast food outlets than is actually the case.

Some study limitations should be noted. First, because we obtained restaurant data from an online database of prior inspections, we are unable to determine whether all outlets continue to be in operation. There may also have been restaurants in operation that had not yet been inspected, and these would therefore not appear in our tallies. Second, in order to capture local outlets, we included restaurants that had specific menu items in the restaurant name. This may have resulted in under-inclusion if the target restaurants used names without reference to the menu (e.g., "Jane's Place"). It may also have resulted in over-inclusion, as sit-down restaurants such as grills, coffeshops, and fast-casuals may have included menu items in the store name (e.g., "Deluxe Burger"). However, because communities of color have fewer of these restaurants, over-inclusion would over-estimate exposure in predominantly White areas, rendering our findings an underestimate of the observed relationships. Third, our measure of exposure is based purely on geographic location. Store fascias may be an important determinant of the relationship between density and area demographics (Macdonald et al., 2007), and also shape consumer access. Thus, if many of the locations in a given block group are primarily drive-thrus that serve few pedestrians, the effective exposure level for neighborhood residents may be lower. Relatedly, a block group's average exposure may include proximal restaurants that are not practically accessible (e.g., on the other side of train tracks or topographical barriers). However, in NYC, we do not anticipate this to be a significant limitation given the nature of the built environment and the characteristics of most fast food outlets.

We used a radius of 300 m when computing the fast food exposure measure. We chose this because it was a reasonable walking distance. We did not explore the effects of changing this distance, although we suspect that changing the distance to 200 or 400 m would make little difference to our findings. Finally, as mentioned before, we did not include correlated errors in our model. Unmodeled correlated errors would reduce the significance of estimates. Since our analysis already shows a clear relationship between percent Black and fast food exposure, introducing correlated errors in our models should not make significant changes to our findings. The non-significant relationship between fast food density and median income at the very high incomes, is due to the small number of block groups at these very high incomes. Introducing correlation in the errors might reduce the size of these confidence bands but probably not enough to make any observed relationship statistically significant.

Thus, despite some study limitations, our findings have important implications for public health. We showed that predominantly Black areas were dense in restaurant outlets serving menu items that increase the risk of overweight and obesity, and obesity rates in NYC's predominantly Black neighborhoods range from 21% to 34% (NYC and Department of Mental Health and Hygiene, 2003). The potential impact of restaurant dining on health is not trivial. In 2001, approximately 42% of total food expenditures were spent on food away from home (Bowman and Vinyard, 2004) and this figure continues to rise. The numbers of FFRs have also increased dramatically in recent years (Powell et al., 2007b).

Municipalities are beginning to consider legislative means through which to shape the restaurant landscape. In some cities, zoning codes have centered around concerns about planning and architectural character. For example, Warner, New Hampshire regulates the distance within which fast food outlets may locate from each other (Mair et al., 2005). While the codes are not meant to remediate obesity rates, they may have such an impact nonetheless. Other cities have actively addressed the role of fast food in population health. In NYC, a recent ruling requires chain restaurants to post information on calorie content for menu items ("No More Dining", 2008). In Los Angeles, a moratorium on additional FFRs has been proposed for South L.A., a predominantly Black and Latino area with a high saturation of fast food and a high prevalence rate of obesity (Abdollah, 2007). Other interventions might include the use of conditional use permits to encourage restaurants to improve the nutritional quality of menu items, and to displace outlets that do not improve (Ashe et al., 2003). Our data highlight the need for attention to these, and other policy interventions as potential strategies to remediate disparities in food environments.

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