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The Association between Obesity and Urban Food Environments

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ABSTRACT *Several studies have examined associations between the food retail environment and obesity, though virtually no work has been done in the urban South, where obesity rates are among the highest in the country. This study assessed associations between access to food retail outlets and obesity in New Orleans. Data on individual characteristics and body weight were collected by telephone interviews from a random sample of adults (N=3,925) living in New Orleans in 2004–2005. The neighborhood of each individual was geo-mapped by creating a 2-km buffer around the center point of the census tract in which they lived. Food retailer counts were created by summing the total number of each food store type and fast food establishment within this 2-km neighborhood. Hierarchical linear models assessed associations between access to food retailers and obesity status. After adjusting for individual characteristics, each additional supermarket in a respondent's neighborhood was associated with a reduced odds for obesity (OR 0.93, 95% CI 0.88–0.99). Fast food restaurant (OR 1.01, 95% CI 1.00–1.02) and convenience store (OR 1.01, 95% CI 1.00–1.02) access were each predictive of greater obesity odds. An individual's access to food stores and fast food restaurants may play a part in determining weight status. Future studies with longitudinal and experimental designs are needed to test whether modifications in the food environment may assist in the prevention of obesity.*

KEYWORDS *Obesity, Food environment, Food stores, Fast food, Urban*

INTRODUCTION

The high obesity prevalence in the United States is of great concern.[1] Individuals who are overweight or obese are at greater risk for cardiovascular disease, stroke, diabetes, and hypertension.[2] Due to the prominent role that excess body weight plays as a risk factor for a number of chronic health conditions, an estimated 280,000 deaths per year in the United States may be attributable to obesity.[3]

In response to the continuing obesity epidemic, researchers have begun to assess the role of the neighborhood environment and its potential impact on obesity and health.[4–6] Some of the recent literature has focused on associations between neighborhood food access and body weight. Lopez found that metropolitan area residents in Massachusetts with a supermarket in their zip code were 11% less likely

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to be obese.[7] Morland et al. found that the existence of supermarkets in an individual's census tract decreased the likelihood of being obese while the presence of a convenience store had the opposite effect.[8] A similar finding was reported in a study of adolescents where increased access to chain supermarkets was inversely related to body mass index (BMI) and overweight status, while the converse was true for convenience store access.[9] Although similar results were reported in the above-mentioned studies, the findings in the literature are not always consistent. The link between convenience store access and obesity has not been observed in some studies,[10,11] nor has greater supermarket access always been found to decrease obesity risk.[11] Mixed findings appear to be most common when assessing associations between fast food access and body weight outcomes. About half of the current published literature has shown some positive association,[10,12–15] while the remaining studies have not demonstrated a relationship between greater fast food access and obesity.[11,16–19]

Considering that only a limited number of studies have examined food access and body weight, with findings that are not always consistent, further research in this field is warranted. Work in urban southern cities is especially needed, since little research has been performed in these areas, yet they have some of highest rates of obesity in the United States. Our study examined neighborhood access to food stores and fast food restaurants and obesity odds in New Orleans. The city of New Orleans has a high prevalence of obesity;[20] prior research has reported this area as having significant socioeconomic and racial disparities in food access, and many city residents face transportation challenges due to the lack of a household car.[21,22] Because of these conditions, this city was an especially appropriate setting for the examination of the food access–obesity question.

In this study, we hypothesized that greater supermarket access would be associated with a lower odds for obesity while greater convenience store and fast food access would be associated with higher obesity odds. Such associations were predicted since supermarkets are known to have a greater availability of healthy foods at lower prices, while convenience stores and fast food establishments are known to offer mostly inexpensive, energy-dense foods.[23,24]

METHODS

Study Sample

Data on our sample of respondents came from New Orleans Behavioral Risk Factor Surveillance System (BRFSS). This survey was the 2004–2005 local version of the national telephone survey coordinated by the US Centers of Disease Control and Prevention. A random-digit-dial method was used to gather information on individuals living in the city. Within each household, an adult, aged 18 years or older, was randomly selected to be interviewed. Demographic data, household income information, and census tract of residence were collected. Participants were asked to report their height and weight and levels of physical activity. Respondents who were pregnant (n=42), had missing BMI information (n=245), had implausible BMI values of greater than 60 kg/m^2 (n=4), or were missing data on gender, race, age, education, or physical activity (n=370) were eliminated from the analytic sample. In addition, respondents who lived in four census tracts (n=30) on the outer margins of the city that were considerably different (vastly greater land area, lower population density, and higher SES residents) from other tracts in the study area were not included. Inclusion of the tracts did not alter the results. The final analytic sample included 3,925 subjects. Of the 181 census tracts in New Orleans, our final sample of respondents lived in 167 of these tracts. Details regarding the BRFSS survey protocol, as well as the New Orleans version of it, have been published previously.[25,26] Since this study was based on data from publicly available sources in which subjects could not be identified, it was considered exempt from human subjects review by the Tulane University Institutional Review Board.

Food Retailer Database

Locations of food stores and fast food restaurants open during the years 2004–2005 were provided by the Louisiana Office of Public Health (OPH) food retailer database. This database included all outlets that sell food, and recorded information on each retailer's address, whether the retailer was a full-time or part-time grocery, and the retailer's total annual sales. OPH designated retailers as full-time groceries if greater than 60% of their sales were from food items, while all other stores that did not fit this criterion were designated as part-time. Using the full-time/part-time designation and the annual sales information, we classified retailers as one of five store types. Among stores with a full-time grocery designation, those stores with less than 1 million dollars in annual sales were classified as small food stores, those with sales between 1 million and 5 million dollars were coded as medium food stores, and those with sales that exceeded 5 million dollars were categorized as supermarkets. The supermarket category included supercenters like Wal-Mart. Stores with a part-time grocery designation were coded as either convenience stores or general merchandise stores based on key descriptive words in the store name. The convenience store category included chain convenience stores, drug stores, and gas stations that sold food. General merchandise stores included discount chain "dollar" stores and local discount retailers. Retailers that sold only incidental amounts of food, such as bookstores, video rental stores, and department stores, were not classified as food stores, nor were they included in the analysis. Fast food restaurants were defined as national, regional, and local chain fast food establishments, following previous research in New Orleans.[21] This work categorized restaurants as fast food establishments if they exhibited characteristics such as limited wait staff, payment before receiving food, takeout service, and quick food service.

Neighborhood Food Environment

This study used a 2-km buffer around the center point, or centroid, of each respondent's census tract to define the extension of a neighborhood food environment. The 2-km distance was assessed in all directions from the centroid along the network of streets using ArcGIS 9.2 (ESRI, Redlands, CA), which was also used to geo-code food stores and fast food restaurants to street addresses. This study calculated network distances to food stores because it is a more relevant measure of distance for food access than a straight-line calculation; whatever form of transportation people use, they must access stores along a network of streets. Count variables representing food store/fast food geographic access were constructed by summing the number of each food retailer type within the 2-km neighborhood. Prior literature has mainly used zip code or census tract boundaries as proxies for the food environment. Lopez used zip code areas to represent food environments in metropolitan Massachusetts, with these areas averaging 27 km^2 in size.[7] The census tracts in the Atherosclerosis Risk in Communities (ARIC) study used in food access research by Morland et al. reported average tract sizes from 8 to 20 km^2.[27] The urban census tracts in New Orleans are much smaller, with tracts averaging only 2.6 km^2 in size. Due to the much smaller size of New Orleans tracts, it is likely that the shopping areas for many residents extend beyond tract boundaries. As in previous work in New Orleans, we used the 2-km boundary to account for multiple forms of transport—walking, biking, public transportation, owned or borrowed car—that are commonplace here.

Body Weight Outcome

BMI was calculated using self-reported heights and weights. Individuals with a BMI of 30 kg/m^2 or greater were classified as obese, while those with a BMI less than 30 kg/m^2 were categorized as non-obese.

Independent Variables

Control variables included gender, race/ethnicity, poverty index ratio, age, educational attainment, frequency of moderate physical activity, frequency of vigorous activity, and television viewing. The race/ethnicity variable included four categories: White, African American, Latino, and other races/ethnicities. Poverty index ratio was calculated based upon how a household's annual income compared with the US Census Bureau's poverty threshold for a given household size.[28,29] This ratio was divided into three categories: less than 1.00 (below poverty line), 1.00–1.85, and greater than 1.85. As is common in studies using survey data, a number of participants in the sample did not provide information on their annual household income (15.4% of final sample). Rather than eliminate these respondents and potentially create a biased or non-representative sample of the study population, these participants were kept in the sample by assigning them a poverty index ratio based on their race/ethnicity and education level using a probability-based "hot-deck" imputation technique. Age was divided into three categories: 18–30 years, 31–50 years, and greater than 50 years old. Educational attainment was grouped into four categories: less than high school, high school graduate, some college, and college graduate or higher. Data on physical activity was entered as two separate continuous indicators for the number of days during a week that a respondent engaged in moderate activity and vigorous activity, respectively. Respondents were additionally asked to estimate the number of hours they spent watching television the day prior. Data on television viewing was converted into a dichotomous variable where participants with greater than 2 hours of viewing in a day were classified as high television users.

Statistical Analysis

Hierarchical linear modeling (HLM), with the *xtlogit* procedure in Stata/SE 9.0 (StataCorp, College Station, TX) was used for our multivariable analyses, due to the food retailer access measures entering into the models as cluster level group factors. This form of multilevel analysis is capable of simultaneously assessing the influence of group-level and individual-level predictors on individual-level dependent variables. Continuous variables were centered around their cluster means. A preliminary series of models were created where each separate regression equation included only one food retailer type access measure, e.g., a model with the supermarket count variable, but no other food retailer types. A set of follow-up models were tested that accounted for the presence of other food outlets, since urban residents typically live in neighborhoods featuring several types of stores, and models that include just a single food store type would not accurately represent the environment in which most people shop. The first of these reported models included both supermarket and convenience store counts, while the second model included both supermarket and fast food count variables. Other researchers examining food store access and obesity have used a similar methodology of including more than one food retailer type in the same model.[8–10]

RESULTS

The majority of the participants in our sample were female (Table 1). Nearly 60% of the sample was African American and 40% of the respondents lived at or below 185% of the poverty line. The large majority of the sample was 30 years old or older, and nearly 40% of the respondents were college-educated. The overall obesity prevalence of the sample was 26.5%. Those who exhibited higher obesity rates included females, African Americans, and older respondents. Individuals with less education and those from poorer households had higher rates as well.

Descriptive statistics on the food retail environment are provided in Table 2. The mean number of supermarkets within 2 km of respondents' census tract centroids was 1.49. Twenty-six percent of the respondents did not have any supermarkets that fell within this buffer (not shown). Households tended to have a much greater number of small food stores and convenience stores in their neighborhoods than supermarkets. The average number of fast food restaurants was also much higher than the number of supermarkets.

TABLE 1 Descriptive characteristics of study sample and obesity prevalence

Variable	*N*	%	Percent obese	(95% CI)
Total	3,925	100.0	26.5	(25.2, 27.9)
Gender				
Female	2,590	66.0	29.2	(27.5, 31.0)
Male	1,335	34.0	21.3	(19.1, 23.5)
Race/ethnicity				
White	1,394	35.5	14.1	(12.2, 15.9)
African American	2,274	57.9	35.1	(33.1, 37.1)
Latino	116	3.0	17.2	(10.3, 24.1)
Other	141	3.6	19.9	(13.2, 26.5)
Poverty index ratio				
Below 1.00	733	18.7	34.7	(31.2, 38.1)
1.00–1.85	852	21.7	32.5	(29.4, 35.7)
>1.85	2,340	59.6	21.8	(20.2, 23.5)
Age				
18–30	628	16.0	17.0	(14.1, 20.0)
31–50	1,437	36.6	26.4	(24.1, 28.7)
>50	1,860	47.4	29.9	(27.8, 32.0)
Educational attainment				
Less than high school	450	11.5	37.1	(32.6, 41.6)
High school graduate	1,028	26.2	31.6	(28.8, 34.5)
Attend some college	958	24.4	27.2	(24.4, 30.1)
College graduate or higher	1,489	37.9	19.4	(17.4, 21.4)

CI confidence interval

TABLE 2 Mean number of each food retailer type within respondents' neighborhoods

Food retailer type[a]	Mean	SD	Minimum	Median	Maximum
Supermarkets	1.49	1.29	0.00	1.0	5.00
Medium food stores	1.72	2.20	0.00	1.0	10.00
Small food stores	25.18	25.66	0.00	16.0	107.00
Convenience stores	11.28	6.89	0.00	10.0	35.00
General merchandise stores	0.86	0.89	0.00	1.0	3.00
Fast food restaurants	9.70	8.04	0.00	8.0	41.00

SD standard deviation

[a]A respondent's neighborhood extends from the center point of the census tract in which he or she lives for 2 km in all directions along the network of streets

Table 3 depicts the relationships between each of the food retailer count variables and obesity odds. Each cell in the table represents a separate regression model with a single food store or restaurant type as a predictor of obesity. In the unadjusted obesity models, respondents with a greater number of supermarkets in their neighborhood had lower odds for obesity (OR 0.91, 95% CI 0.84–0.99) while greater general merchandise access was associated with higher obesity odds. After adjusting for individual characteristics, odds ratios were all in the same direction as in the unadjusted models, though none were significantly different than one at a 95% confidence level.

Due to a high degree of collinearity between the small food store, convenience store, and fast food restaurant count variables, we did not include all of these access predictors in the same model. Supermarket access was not highly correlated with any of the other food store types or fast food restaurant access. Thus, we developed models that predicted obesity odds that included supermarket access along with one other food retailer count measure. Small food store access, medium food store access, and general merchandise access, each in separate models with supermarket access, did not show a significant association with obesity (results not shown). Models with access to both supermarkets and another food outlet type (either convenience stores or fast food restaurants) are shown in Table 4. In each model,

TABLE 3 Associations between food retailer counts and obesity

	Unadjusted models		Adjusted models[b]	
Food retailer type[a]	OR	(95% CI)	OR	(95% CI)
Supermarkets	0.912	(0.840, 0.991)*	0.951	(0.897, 1.008)
Medium food stores	1.003	(0.960, 1.049)	1.011	(0.976, 1.046)
Small food stores	1.004	(1.000, 1.007)	1.001	(0.998, 1.004)
Convenience stores	1.010	(0.996, 1.025)	1.010	(0.999, 1.021)
General merchandise stores	1.171	(1.048, 1.309)**	1.014	(0.928, 1.108)
Fast food restaurants	1.007	(0.995, 1.020)	1.009	(1.000, 1.019)

OR odds ratio, *CI* confidence interval

Each cell represents a separate HLM regression model describing the relationship between obesity and the number of outlets of a specific retailer type

[a]Number within 2-km neighborhood

[b]Each adjusted model included gender, race/ethnicity, poverty index ratio, age, education, physical activity, and television viewing as covariates

*$p<0.05$, **$p<0.01$

TABLE 4 Multivariable models predicting obesity odds

	Model 1[b]		Model 2[c]	
	OR	(95% CI)	OR	(95% CI)
Group-level predictor				
Access to food retailers[a]				
Supermarkets	0.936	(0.882, 0.994)*	0.932	(0.877, 0.990)*
Convenience stores	1.013	(1.001, 1.024)*	–	–
Fast food restaurants	–	–	1.012	(1.003, 1.022)*
Individual-level predictors				
Gender				
Female (reference)				
Male	0.836	(0.707, 0.987)*	0.836	(0.707, 0.987)*
Race/ethnicity				
White (reference)				
Black	2.859	(2.351, 3.476)**	2.850	(2.344, 3.465)**
Latino	1.233	(0.735, 2.069)	1.233	(0.735, 2.070)
Other	1.505	(0.957, 2.367)	1.502	(0.955, 2.362)
Poverty index ratio				
Below 1.00 (reference)				
1.00–1.85	0.975	(0.783, 1.214)	0.980	(0.787, 1.220)
>1.85	0.774	(0.626, 0.957)*	0.779	(0.630, 0.963)*
Age, years				
18–30 (reference)				
31–50	1.859	(1.448, 2.387)**	1.861	(1.449, 2.390)**
>50	2.020	(1.578, 2.585)**	2.019	(1.578, 2.584)**
Educational attainment				
Less than high school (reference)				
High school graduate	1.022	(0.800, 1.305)	1.012	(0.793, 1.292)
Attend some college	1.086	(0.835, 1.411)	1.078	(0.830, 1.401)
College graduate or higher	0.991	(0.753, 1.305)	0.981	(0.746, 1.291)
Number of days moderate physical activity	0.969	(0.940, 0.999)*	0.969	(0.940, 0.999)*
Number of days vigorous physical activity	0.854	(0.811, 0.899)**	0.853	(0.811, 0.898)**
Television viewing				
≤2 h/day (reference)				
>2 h/day	1.369	(1.175, 1.594)**	1.367	(1.173, 1.592)**

OR odds ratio, *CI* confidence interval

[a]Number within 2-km neighborhood

[b]Model 1 includes both supermarket and convenience store counts along with individual-level covariates.

[c]Model 2 includes both supermarket and fast food restaurant counts along with individual-level covariates.

*$p<0.05$, **$p<0.01$

supermarkets were significantly associated with lower obesity odds (OR 0.93, 95% CI 0.88–0.99). In the first model, convenience store access significantly increased the likelihood of obesity (OR 1.01, 95% CI 1.00–1.02), while in the second model, fast food access was a significant positive predictor (OR 1.01, 95% CI 1.00–1.02). In both models, being male and engaging in greater amounts of moderate or vigorous physical activity lowered odds for obesity. Respondents who were African American, older, and watched greater than 2 hours of television a day had higher odds for obesity.

DISCUSSION

This study found supermarket access inversely associated with obesity. The converse was found for fast food restaurants and convenience stores: greater access was associated with a greater likelihood of being obese.

Our findings linking food retailer access with obesity are consistent with results published from earlier studies. Powell et al. found that greater availability of chain supermarkets decreased the likelihood of overweight in adolescents while greater access to convenience stores was associated with greater odds.[9] Morland et al. demonstrated a similar inverse relationship for supermarket access and a positive association between fast food access and obesity prevalence.[10]

A number of studies have found correlations between the food environment and dietary intake.[30–34] One study in particular, using an experimental design, found that individuals who previously consumed few fruits and vegetables significantly increased their consumption after a new supermarket was built in their neighborhood.[35] These studies underscore the possibility that the association between supermarket access and obesity found in our analysis, as well as in earlier studies, may be predominately mediated by dietary consumption. Individuals with greater access to supermarkets may consume a greater variety of healthy foods thus promoting healthier body weight. Though food store and diet associations have been found, research thus far has produced inconsistent findings when examining fast food access and diet.[12,17,36,37]

The connection between availability, diet, and weight status is complex. In a prior study that took place in a small geographic subsection of New Orleans, greater small food store and fresh vegetable availability was associated with higher vegetable intake.[30] However, in this study, which included the entire city, small food store access was not associated with weight status. The earlier study suggesting a possible dietary benefit of greater small food store access did not account for energy-dense snack foods which are abundantly stocked in such stores. The null small food store—obesity findings in this study may be due to weight status being influenced by the availability and consumption of various types of foods.

This study demonstrated associations between the food retail environment and obesity, though this analysis has some limitations. First, the research design for this study was cross-sectional. Thus, relationships found between our food access predictors and weight status cannot be considered causal. Second, BMI was calculated using self-reported heights and weights. Although prior research has suggested that men overreported their height and women underreported their weight, it is not clear whether any form of self-report bias was systematically related to our food access predictors.[38] Another possible limitation is bias introduced from not including respondents who were missing BMI data or who were missing data on individual independent variables, though we found that missing BMI information was not associated with the food store access variables nor did obesity prevalence vary significantly between respondents included in the analysis and those with missing data on individual control variables. Lastly, it is possible that differences in obesity odds may be attributable to other neighborhood characteristics or other unobserved effects. Neighborhood level effects, such as high crime rates and poor neighborhood walkability, could affect the physical activity levels of respondents and in turn body weight. However, models reported here do control for both moderate and vigorous physical activity. In addition, we tested models that included a census tract level social deprivation index (results not shown), which could partially account for socioeconomic related neighborhood characteristics. This index was modeled after a deprivation index used by food access researchers in Canada.[39] Our index incorporated 2000 census data on the percentage of household living in poverty, percent unemployment, and percent without a high school education. Inclusion of this social deprivation index did not change our original models. All prior significant associations between our predictors and obesity remained, with no change to the strengths of the associations, nor was the index significantly related to obesity odds after accounting for all other predictors.

In agreement with several studies conducted in other parts of the country, this research found that respondents with greater supermarket access were less likely to be obese, while greater fast food and convenience store access was predictive of higher obesity odds. While our findings are consistent with other studies, measures of the food environment have varied widely,[40] with different criteria used for defining food store access, making it difficult to compare effect sizes between studies. Nevertheless, the emerging research in this field suggests a relationship between the retail food environment and obesity. Further research is needed, especially studies with longitudinal and experimental designs,[41,42] to determine whether modifications in the food environment may aid in curbing the current obesity epidemic.

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