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Obesity prevalence and the local food environment

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Abstract

Disparities in access to healthy foods have been identified particularly in the United States. Fewer studies have measured the effects these disparities have on diet-related health outcomes. This study measured the association between the presence of food establishments and obesity among 1295 adults living in the southern region of the United States. The prevalence of obesity was lower in areas that had supermarkets and higher in area with small grocery stores or fast food restaurants. Our findings are consistent with other studies showing that types of food stores and restaurants influence food choices and, subsequently, diet-related health outcomes.

Keywords

Obesity; Food environment; Adult; Health disparities; Environmental justice; Policy

Introduction

Over the past decade, researchers have investigated the associations between food environments, diet, and health outcomes. Studies have demonstrated that access to food stores and restaurant types differ by neighborhood characteristics, such as socioeconomic and race/ethnic composition (Sooman and Macintyre, 1993; Wechsler et al., 1995; Fisher and Strogatz, 1999; Morland et al., 2002a; Zenk et al., 2005a; Horowitz et al., 2004; Austin et al., 2005; Block et al., 2004; Lewis et al., 2005; Cummins et al., 2005; Moore and Diez Roux, 2006; Galvez et al., 2007; Morland and Filomena, 2007). In addition, investigators have measured associations between the types of food stores (ex. supermarkets, small grocery stores) and restaurants (ex. full service, fast food) available in areas and the dietary intake of residents. For instance, Laraia et al. (2004) found pregnant women living in areas with fewer supermarkets had poorer diets. Similar results have been found in other populations (Morland et al., 2002b; Zenk et al., 2005b). The association between neighborhood availability of healthy affordable foods and dietary intake has been further supported by school-based interventions where exchanges for healthier foods were

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associated with better diets among children (French and Stables, 2003; Gortmaker et al., 1999).

Fewer studies have demonstrated the association between the local food environment and diet-related health outcomes. Inagami et al. (2006) evaluated the relationship between body mass index (BMI), neighborhood disadvantage, and distance to grocery stores. They found that BMI was higher when individuals shopped for groceries in more disadvantaged neighborhoods, but the effect was not influenced by the location of worship, medical care, entertainment, or work. These findings suggest a unique relationship between neighborhood socioeconomic status of grocery store and BMI. Morland et al. (2006) studied the association between the location of supermarkets and other food stores and the prevalence of obesity among men and women living in Mississippi, Maryland, North Carolina, and Minnesota. Authors found that adults living in areas with supermarkets had a lower prevalence of obesity compared to adults who lived in census tracts with no supermarkets. Alter and Eny (2005) found the density of fast food restaurants to be associated with cardiovascular events in Canada. In the United States, Maddock (2004) used state-level data to demonstrate a correlation between the density of fast food restaurants and state-level obesity prevalence. Finally, among a younger population, Sturm and Datar (2005) measured the association between changes in food prices, per capita number of restaurants and food stores with changes in BMI among children K-3rd grade. The authors found that fruit and vegetable prices were inversely associated with BMI.

All of these studies have made important contributions to the public health literature by beginning to provide empirical evidence of (a) disparities in access to healthy foods, (b) the impact of environmental factors on individuals' behaviors, and (c) the impact on subsequent diet-related health conditions. Because few published studies have linked the disparities in the types of food stores and restaurants with health outcomes, this study aimed to measure the association between neighborhood availability of food stores and cardiovascular health among adults living in the southern region of the United States. Because of these findings from other investigators (Inagami et al., 2006; Morland et al., 2006; Alter and Eny, 2005; Maddock, 2004; Sturm and Datar, 2005), we hypothesized that a higher prevalence of supermarket and a lower prevalence of small grocery stores and fast food restaurants would be associated with a lower prevalence of obesity among adult residents. Moreover, we hypothesized that those individuals living closer to supermarkets, as well as those living further from small grocery stores and fast food restaurants, would have lower BMIs.

Methods

Source population

From January to July 2003, a cross-sectional study was carried out in which a random digit dialed phone survey of the non-institutionalized adult population in two distinct geographic locations (Forsyth County, NC, and the city of Jackson MS) was conducted. A disproportionate sampling strategy was adopted for the Forsyth County, NC sample frame in order to ensure representation for areas outside of the Winston-Salem metropolitan area (but within the county). A further description of the study can be found elsewhere (Evenson and McGinn, 2005; McGinn et al., 2007).

Sample population

A sampling company (Genesys Marketing Systems Group) provided a listing of residential household phone numbers, while Clearwater Research, Inc. (Boise, Idaho), conducted the telephone surveys. They used Behavioral Risk Factor Surveillance System (BRFSS) telephone survey protocols of up to 15 call attempts for each sampled phone number distributed across weekday, weeknight, and weekend hours (Centers for Disease Control and Prevention, 1998). Respondents were randomly chosen in two stages: (1) the first stage at the household level, and (2) at the individual level. Surveys were only conducted in English. The average length of the telephone interview was 27min. A retest survey was conducted on 6% of the sample to ensure reliability of the data collected.

Despite using BRFSS protocols (Centers for Disease Control and Prevention, 1998) of up to 15 call attempts for each sampled phone number distributed across weekday, weeknight, and weekends, the Council of American Survey Research Organizations (CASRO) response rate was not as high as expected: overall 20.2%, rural Forsyth County 24.0%, Winston-Salem 24.5%, and Jackson 16.9%. The CASRO response rate reflects both the degree of cooperation and the efficiency of the telephone sampling.

Self-reported socio-demographics and health

All respondents were asked questions regarding age, gender, race/ethnicity, education, and employment. Employment was grouped into two categories: employed or not employed (out of work, homemaker, student, retired, or unable to work). Height and weight were self-reported and used to calculate BMI. Obesity was defined at $\geq 30\text{kg/m}^2$.

Measurement of the local food environment

Census tracts based on the 2000 US Census defined borders were used as proxies for neighborhoods in Jackson City, Mississippi, and Forsyth County, North Carolina. One hundred and two tracts were used in the analysis. Housing, transportation, and socio-demographic characteristics of tracts were obtained from the 2000 Census of Population and Housing Summary Files 3A. Block group data were summed for each census tract within places.

Business addresses of places where people could obtain food were collected from the local Departments of Environmental Health and state Departments of Agriculture in 2006. The 1997 North America Industry Classification System codes and definitions were modified to describe the types of food stores and food service places located in each census tract. Five categories for food stores and five categories for food service places were used. Food stores included: chain supermarkets, independently owned grocery stores, convenience stores, convenience stores attached to gas stations and specialty food stores. Food service places included: full service restaurants, franchised fast food restaurants, limited service places, limited service places that primarily sell one type of food, and bars/taverns.

All coding of food stores and food service places was done by a single trained individual and food retail and service establishment types were determined based on the name of the facility. Those places where the name was not recognizable were determined by using either

Superpages.com ($N = 17$) or Google Maps ($N = 6$). A total of 141 businesses could not be classified and were coded as ‘unknown.’

Geocoding residential and business addresses

All of the 3662 addresses of retail food stores and food service establishments located in Jackson City, Mississippi (and the Jackson metro area), and Forsyth County, North Carolina in 2006 were obtained from the Mississippi Department of Health and/or Agriculture and Commerce and the North Carolina Department of Environmental Health. After excluding Jackson metro area addresses located outside of the study areas ($N = 1300$), as well as eliminating the 846 excluded types (hospitals, schools, etc.), a total of 1516 eligible business addresses remained for the analysis. Of the remaining 1516 business addresses, 1462 (96%) were geocoded automatically to 2000 US defined census tracts using ArcGIS software v. 9.2 (ESRI, Redlands, CA, 2006). Census tracts for 45 addresses were determined by placing the addresses manually on an ArcGIS census tract map after determining their location from either Mapquest or Google Maps. A total of nine addresses could not be geocoded (0.6%). All ($n = 1295$) residential addresses were automatically geocoded to 2000 US defined census tracts using ArcGIS software 9.2 and distances. In addition, network distances were calculated between residential addresses and the nearest supermarket and franchised fast food restaurant using network analyst extension from ArcGIS software 9.1.

Statistical analysis

Using SAS, the number of each of the 11 types of food stores/service places was calculated for each census tract. Eleven indicator variables were then created for each type of business where census tracts containing more than the median of each type of food stores/service places were coded with 1 versus 0. The median was used as the cut point to account for the greater range of values for some types of stores/restaurants. Chain supermarkets, independently owned grocery stores, convenience stores with gas stations, specialty food stores, specialty restaurants, bars/taverns, and unknown types were coded 1 when *at least one* of that type of business was present. Convenience stores and franchised fast food were coded 1 when *more than one* of that type of business was present. Finally, full service restaurants were coded 1 when *more than 3* full service restaurants were present.

Descriptive analyses were conducted describing the study population. Subsequently, mixed models with a random intercept for each tract were used to estimate the associations between obesity and 11 types of food stores and food service places. Obesity was the dependent variable. For the first mixed model, all of the indicator variables for types of food stores and food service places located in participants' residential census tract were included. The second mixed model added the following individual-level variables: black (1) versus white (0), age (continuous), married (1) versus not married (0), and gender: female (1) versus male (0). Model 1 was unadjusted, whereas model 2 adjusted for individual-level factors as described in the mixed models. Models were restricted to black and white participants. Finally, to investigate the association between distances traveled to closest supermarket or franchised fast food restaurant and risk for obesity, log linear models were used. Prevalence ratios (PR) and 95% confidence intervals (CI) were calculated using SAS version 9.1 (SAS Institute Inc., Cary, NC, 2004).

Results

The mean age for participants was 48 years and the majority of participants were women (64.7%) and white (61.5%) (Table 1). Almost half of the participants were married (49.4%) and approximately two-thirds were currently employed (63.0%). Over two-thirds had an education beyond high school (67.8%). The mean BMI was 27.8 kg/m² with over a quarter of the population being obese (26.6%). The average distance to the nearest supermarket was farther than the nearest franchised fast food restaurant (1.77 vs. 1.39 miles). The average number of most types of food stores and food service places in each tract was less than one, with the exception of franchised fast food, full and limited service restaurants, and convenience stores.

The prevalence of obesity was lowered by 0.73 in areas that had at least one supermarket (Table 2). Areas with at least one limited service restaurant (PR = 0.66, 95% CI 0.50, 0.87) or at least one specialty food store (PR = 0.58, 95% CI 0.45, 0.74) were also associated with a lower prevalence of obesity. A higher prevalence of obesity was observed in areas with at least one independently owned grocery store (PR = 1.45, 95% CI 1.17, 1.79), at least one convenience store with a gas station (PR = 1.31, 95% CI 1.07, 1.60), or more than one franchised fast food restaurant (PR = 1.36, 95% CI 1.05, 1.77). Adjustments for individual-level effects attenuated the prevalence ratios only slightly.

Each mile closer to a supermarket was associated with a 6% higher prevalence of obesity (PR = 1.06, 95% CI 0.94, 1.20) and each mile closer to a fast food restaurant was associated with a lower prevalence of obesity (PR = 0.80, 95% CI 0.69, 0.92) (Table 3). As with the previous models, adjustment for individual-level factors attenuated the models only slightly.

Discussion

Investigators have been interested in the factors associated with dietary choices for many years. Furthermore, the structural influences of neighborhood availability of healthy foods have been considered a factor for the past 20 years (Turrell, 1996; US House of Representatives Select Committee on Hunger, 1987, 1992). Our study is placed in a small body of research, where investigators are beginning to measure the associations between the structural effects of built environments and risk for diet-related disease outcomes. Our findings, which are supported by other researchers (19–23), suggest that the prevalence of obesity is associated with the location of supermarkets, small grocery stores and fast food restaurants.

However, our distance results between home and supermarket or home and fast food restaurant were not in the direction hypothesized. One explanation may be that distance may be measuring a different construct than measured by the prevalence of stores within census tracts. Although measuring the prevalence of store types may be characterizing the availability of food stores, distance may be a measure of the utilization of neighborhoods to obtain food. Utilization may be a more complicated construct that encompasses components such as transportation, mobility, and other factors that were not captured in this study.

This study has several limiting factors. First, we included only two geographical areas to investigate these associations, which may not be generalizable to urban or very rural areas. Moreover, although we used randomization techniques for sampling, response rates were low and we cannot rule out that selection bias may have occurred as the survey respondents tended to be highly educated. Also, because we relied on residential home phones to conduct the interviews, it is possible that our sample is different from individuals who only have cell phones or cannot be reached because they have no ground telephone line. Another concern is that the food environment data were collected 3 years after the individual-level data were collected. There are no published data describing how fast food environments change, but it is possible that the frequency of types of food stores and restaurants described here does not accurately reflect the local food environment in 2003. Other limitations include the fact that height and weight were self-reported and, although we are confident about the reliability of participants report, it is possible that the reported BMI is not accurate. However, the reliability of responses was high (Evenson and McGinn, 2005) and it is unlikely that any bias that may have occurred differed by local food environment. Furthermore, our analysis is based on the density of stores within a census tract and assumes that all residents within the census tract (regardless of where they are located) have a similar exposure. It is possible, and in fact likely, that some of the people living in the residential census tract where exposure was assigned do not actually shop in that area. However, this misclassification of exposure is not likely to be associated with the adiposity of residents and therefore unlikely to have biased our estimates of effect. Finally, because of our cross-sectional design, we are limited in our ability to draw causal inference from our findings.

Nevertheless, our research contributes to a growing body of science, which aims to determine the relative influence of neighborhood food environments on population health. Very few studies have been published measuring the associations between local food environments and health outcomes. Our findings are consistent with the several other investigators who have collected similar data, thereby supporting the assertion that the physical availability of specific types of food stores and restaurants has an influence on food choices and subsequent diet-related health outcomes.

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Table 1Characteristics of study participants ($n = 1295$)

Demographic characteristics	
Mean age $\pm$ SD (years)	48 $\pm$ 17
Gender n (%)	
Men	457 (35.3)
Women	838 (64.7)
Race/ethnicity n (%)	
White	796 (61.5)
African American	499 (38.5)
Married n (%)	639 (49.4)
Currently employed n (%)	814 (63.0)
Current level of education n (%)	
Less than high school	112 (8.7)
High school grad/GED	304 (23.5)
Some tech school/college	329 (25.5)
College graduated	547 (42.3)
Cardiovascular health	
Obesity n (%)	344 (26.6)
Mean body mass index $\pm$ SD	27.8 $\pm$ 6.04
Mean distance to selected establishments (miles) $\pm$ SD	
Network distance to nearest supermarket	1.77 $\pm$ 1.10
Network distance to nearest franchised fast food	1.39 $\pm$ 1.03
Mean number of each type of food store/service place $\pm$ SD	
Chain supermarkets	0.52 $\pm$ 0.71
Independently owned grocery stores	0.89 $\pm$ 1.16
Convenience stores	1.20 $\pm$ 1.21
Convenience stores with gas stations	0.79 $\pm$ 1.07
Specialty food stores	0.26 $\pm$ 0.66
Full service restaurant	4.82 $\pm$ 5.04
Franchised fast food restaurant	1.71 $\pm$ 1.94
Limited service restaurant	2.73 $\pm$ 2.70
Limited service restaurant with specialty	0.62 $\pm$ 1.31
Bars and taverns	0.12 $\pm$ 0.39
Unknown type	0.37 $\pm$ 0.63

SD = standard deviation; n = number; % = percent.

Table 2Associations between location of food stores and food service place and obesity ($n = 1295$)

Type of food store or food service place	Model 1		Model 2	
	PR	95% CI	PR	95% CI
Food stores				
Chain supermarkets	0.73	(0.60, 0.90)	0.78	(0.63, 0.95)
Grocery stores	1.45	(1.17, 1.79)	1.31	(1.05, 1.62)
Convenience stores	0.95	(0.78, 1.17)	0.91	(0.75, 1.12)
Convenience stores with gas stations	1.31	(1.07, 1.60)	1.19	(0.97, 1.46)
Specialty food stores	1.22	(0.92, 1.61)	1.15	(0.87, 1.52)
Food service				
Full service restaurant	1.16	(0.94, 1.42)	1.15	(0.94, 1.42)
Franchised fast food	1.36	(1.05, 1.77)	1.30	(1.00, 1.69)
Limited service restaurant	0.66	(0.50, 0.87)	0.73	(0.56, 0.95)
Specialty food restaurant	0.58	(0.45, 0.74)	0.66	(0.51, 0.84)
Bar and taverns	1.20	(0.87, 1.64)	1.10	(0.81, 1.51)
Unknown	1.09	(0.89, 1.34)	1.06	(0.87, 1.30)

Table 3Associations between distance to nearest fast food restaurant or supermarket and obesity ($n = 1295$)

	<u>Mode 1</u>		<u>Mode 2</u>	
	PR	95% CI	PR	95% CI
Distance				
Network distance to nearest supermarket	1.06	(0.94, 1.20)	1.03	(0.91, 1.17)
Network distance to nearest fast food	0.80	(0.69, 0.92)	0.88	(0.75, 1.02)

Model 1 is unadjusted; Model 2 is adjusted for age, race, gender, and marital status. PR = prevalence ratio; CI = confidence interval.