Title: Community Food Store Types Availability is Associated with Fruit and Vegetable Consumption in North Carolina

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Abstract
Despite the nutritional guidelines promoting consumption of fruits and vegetables, the level of fruits and vegetable consumption is drastically below the recommended levels nationally, as well as at the state levels. Among factors that may influence consumption of fruits and vegetables, it is held that factors within the food environment such as the availability of retail types that are conducive for easy access to fruits and vegetables within communities may be presenting barriers to purchase. We employ multilevel modeling approaches to investigate the determinants of fruit and vegetable intake in North Carolina, accounting for food environment factors. Results of the study indicate that availability of supermarkets and full service restaurants is associated positively with fruits and vegetable consumption while fast food outlets are associated negatively. Other smaller store types were not statistically significant. Individual factors including age, being female, employed, income and education all were positively associated with fruits and vegetable consumption. The significant positive association of area level food environmental factors with the consumption of fruits and vegetables indicates a complementary role for intervention directed at improving the availability of supermarket type stores so as to impact healthy food purchases and consumption.

Introduction

Various health conditions are influenced by dietary intake including cancer, diabetes and obesity. North Carolina is the tenth most obese state in the country (Trust for America's, 2010). The state's adult obesity rate is 29.4 percent, and, in North Carolina women are more obese than men at 29.7 percent. Furthermore, North Carolina ranks 11th in the nation, for childhood obesity with 18.6 percent of NC children obese. The link between energy imbalance- defined as the difference in caloric intake and energy expenditure is established as the cause of the obesity epidemic that is sweeping the United States. The beneficial health effects of the consumption of less energy dense foods particularly fruits and vegetables is well established, but consumption of these healthful foods is low in the US among adults, youth and children population. For example, at the state level in North Carolina, only 22% of adult and 15% of youth (9^{th} -12^{th} grade) claim eating fruits and vegetables at least five times per day. This despite the nutritional guidelines promoting consumption of fruits and vegetables, the level of fruits and vegetable consumption is drastically below the recommended levels nationally, as well as at the state levels.

Consumption of fruits and vegetables may be influenced by several factors, relating to individual, social and demographic factors and environmental factors. Individual factors relating to nutrition knowledge and health considerations are noted to influence dietary intake (Baranowski et al. 1999). Recent ecological approaches to public health suggest that the neighborhood food environment exerts considerable influence on individual dietary habits (French, and Stables,2003). Dubowitz et al. (2008) found a positive association between neighborhood socioeconomic status with fruit and vegetable intake among whites, black, and Mexican Americans in the US. In addition to socioeconomic context, the deprivation amplification theory suggests that factors within the food environment such as the availability, or lack thereof of retail store types that are conducive for easy access to fruits and

vegetables within communities may be presenting barriers and or opportunities for purchase and intake. Differences in number and types of retail stores available to consumers within the community, as well as the actual availability of healthful food within the different types of stores (Bodor J, Rose D, Farley T, Swalm C, and Scott S.,2008) will influence what foods are consumed. Furthermore, prices may be different in different communities and may have differential impact on affordability of food, thus influencing behavior of consumers towards food. (Centers for Disease Control and Prevention, 2009). Thus, differential access to health promoting resources, serve as either impediment or enhancement to healthy eating, especially in rural areas (Casey et al., 2008). The neighborhood food environment in recent times has been recognized more and more as playing important role in health behaviors and health outcomes.

The food environment in North Carolina has in recent years, undergone rapid changes that have implications for access to food. The economic downturn in the late 1990s, in part due to the rapid erosion in the textile manufacturing base of the state economy, as well as the loss of the tobacco industry, among other factors, have led to restructurings that have affected rural counties adversely in terms of lost jobs and incomes, thereby impairing their food security status. In addition to financial constraints faced by consumers, the geographical access to food stores has deteriorated given the outright store closings, as well as consolidations that have taken place. In particular, large food store chains have withdrawn from entire regions of the state, as well as from parts of local communities. In 2000 there were 2,106 supermarkets and other grocery stores; by 2006 this had declined to 1884 stores statewide, on the other hand smaller retail stores and limited eating places have experienced drastic increases in their numbers. The current economic downturn is likely to continue the downward slide in numbers of food supermarket outlets.

We employ multilevel modeling approaches to investigate the determinants of fruit and vegetable intake in North Carolina, accounting for food environment factor.

Data and Methods

Data for this study were obtained from two sources; 2006 U. S. Census Bureau, County Business Patterns (CBP), and Behavioral Risk Factor Surveillance Survey (BRFSS). Information on the number of food stores outlets classified according to North American Industry Classification System (NAICS) by type --supermarkets, grocery, convenience stores and conveniences stores with gas station, and fast food, and full service restaurants in counties in North Carolina were obtained from the CBP. Fruit and vegetable consumption, socioeconomic information- age, income, education, employment, marital status, race and gender were obtained from the BRFSS. Data on food stores were linked through county codes to individual data from the BRFSS data. The BRFSS is a nationally representative, cross-sectional, continuous annual telephone survey of adults, and conducted by state health departments in collaboration with the Centers for Disease Control and Prevention (CDC). Data are collected from a probability sample of non-institutionalized adults for each state through random-digital dial telephone surveys. Data on food stores obtained from the CBP were linked through county codes to individual data from the BRFSS data. The sample size for FV was 11,575 after excluding missing values, and non-responses.

Fruit and vegetable consumption

Fruit and vegetable consumption per day was calculated as the sum of respondent's consumptions per day of fruit juice, fruit, green salad, potato, carrot and vegetable (BRFSS 2006 codebook). In the BRFSS survey fruit, and vegetable intakes were assessed by asking "Not counting juices, how often do you eat fruit? Similarly for vegetables, "Not counting potatoes, carrots or salad how many servings of vegetables do you eat? (Example: A serving of vegetable at both lunch and dinner would be two servings)". For fruit juices, the question was asked: "How often do you drink fruit juices such as orange, grapefruit or tomato?" Consumption of salads, potatoes, and carrots were assessed by the following questions: "How often do you eat green salad?"; "How often do you eat potatoes, not counting french fries, fried potatoes, or potato chips?" and "How often do you eat carrots?"

Food Environment Variables

A measure of food store availability at the county level was computed as total number of four food store types (Supermarket and larger grocery stores, smaller grocery stores, convenience stores and convenience stores with gas stations) per 10,000 of the population. The category supermarkets and larger grocery stores was based on NAICS code 445110, excluding stores with less than 50 employees. Smaller grocery store category is based on NAICS code 445110, excluding stores with 50 or more employees. Store types classified as convenience stores, and gasoline stations with convenience stores correspond to NAICS codes 44512 and 44711 respectively. Table 1 shows that the mean per 10,000 capita supermarkets outlets was 0.6. The store density per 10,000 capita for smaller grocery store, convenience stores, and gasoline stations with convenience stores were 1.43, .89, and 4.68 respectively. Full service and fast food outlets mean densities per 10,000 person were 7.3, and 7.1 respectively.

Socioeconomic Variables

Socioeconomic variables include individual level variables comprising age (mean age 54.4 years), race (white 77.8%, black 14%, Hispanic 4% and other 4.2%), education (less than high school, graduated high school, attended college or technical school, and graduated from college), income (less than $15000, $15,000 to less than $25,000, $25,000 to less than $35,000, $35,000 to less than $50,000, and $50,000 or more), and binary gender, and employment status (employed and not employed) variables (Table 1). An indicator of rurality and urbanization of the county was derived from USDA Beal Rural Urban Continuum codes (USDA, ERS (2003)). Table 1 shows that 67.7 percent of the sample resided in metro counties, 29.1 percent in urban and only 3.2 percent in rural counties. Furthermore, we include a measure of overall physical activity levels as explanatory variable in fruit and vegetables consumption models. Only 10.8 per cent respondents met the recommendation for moderate and vigorous activity, 42 per cent had insufficient activity to meet moderate and vigorous recommendations and 16.8 per cent had no physical activity.

Model

The data for this study were obtained at two levels: individual level (survey data on fruit and vegetable consumption, and socioeconomic variables) and county level (food store density). Individuals at level one are nested within counties at level two. Food environment characteristics at

the county level are modeled as level two variables. Thus we adopted multilevel modeling estimation approaches. Multilevel modeling allows an examination of both individual and contextual level variables on an outcome (Gelman A. Hill, 2007). We fitted two level linear regressions, with a random intercept for each county, in the multilevel model in SPSS 18, using the maximum likelihood estimation method. A stepwise approach is taken, where we estimate a number of models designed to assess influences of individual level variables, physical activity, smoking, and food environment variables, respectively on fruit and vegetable consumption. The objective of this analysis centered on the estimation of the association between the food environment as evidenced by the density of food store outlet types, and fast food and full service food establishments densities and adult fruit and vegetable consumption. The considered hypotheses are: that a greater density of larger food store types e.g. supermarkets, within a county will be associated with increased availability of fruits and vegetables and will facilitate their consumption. On the other hand a greater availability of smaller food store types would be associated with lower consumption of fruits and vegetables. Similarly, increased availability of fast food eating places will be associated with lower consumption of fruits and vegetables and vice versa for full service eating places.

In the multilevel modeling framework, we first estimate an empty model (model 1) that includes only the intercept term which is allowed to vary across counties (random intercept model). The estimated unconditional intraclass correlation (ICC) from this model indicates the proportion of the variation in fruit and vegetable consumption due to between county variations. The remaining variation is between individuals. Model 2 is estimated by adding individual level demographic and socioeconomic variables, as well as physical activity and smoking status variables. Next, county level food environment variables-food store types and fast food and full service eating establishments are included in the model of fruit and vegetable consumption.

These models can be summarized as follows.

$FV_{ij} = \beta_{oj} + \varepsilon_{ij}$ ---------- *(1) Null model*

$FV_{ij} = \beta_{oj} + \beta_{o1} NV_{ij} + \beta_{o2} PA_{ij} + \beta_{o3} SM_j + \varepsilon_{ij}$ ---------- *(2)*

$FV_{ij} = \beta_{oj} + \beta_{o1} NV_{ij} + \beta_{o2} PA_{ij} + \beta_{o3} SM_j + \beta_{o4} ST_{ij} + \varepsilon_{ij}$ ----------*(3)*

FV_{ij} = individual i fruit and vegetable consumption in county j;

NV_{ij} = represents a vector of individual level socioeconomic and demographic variables

SM_j = represents a vector of individual level smoking status in county j;

PA_{ij} = represents a vector of individual level physical activities in county j;

ST_j = represents a vector of area food store and eating places variables in county j;

β_{oj} is a county specific mean;

ε_{ij} is an individual specific random error, assumed to be distributed $N(0, \delta^2)$;

δ^2 is the between county variance;

The ICC was calculated for each model. Furthermore, changes in the β coefficients for the food environment variables, as a result of the sequential addition of, individual socioeconomic and demographic variables and physical activity, were assessed. The results of the sequential analyses are shown in table 2.

Results

The result of the null model indicates that less than 1% of variation in fruit and vegetable consumption is due to county level variations. This small proportion in the total fruit and vegetable consumption is though statistically significant, and warrants introduction of county level variables in the model of fruit and vegetable consumption. Model 2 that included only individual level characteristics variables show that Hispanics and other races consumed more daily servings of fruit and vegetables than did whites. Fruit and vegetable intake was similar between whites and Blacks.

Individual demographic and socio economic variables were also important influences on FV consumption. Females, older age, higher education and income were all positively associated with fruit and vegetable consumption. Marital status was however not statistically significantly different from zero and was dropped from the next model. In model 3 and subsequent model, we included food environment indicators firstly, density of food retail sources and subsequently eating places. In model three, supermarket density per 10,000 persons was positively associated with fruit and vegetable consumption. A one unit increase in the density of supermarkets in a county resulted in about ¼ increase in servings of fruits and vegetables consumed per day. Although higher numbers of full service eating places did seem to be positively associated with fruits and vegetable consumption, the effect size was extremely small and not statistically significant at the 5% level of significance. A negative influence, albeit pretty small effect is shown for fast food outlet availability. The inclusion of county level food store and eating places variables in the models resulted in a decline in the county ICCs. Thus most of the remaining variance in fruit and vegetable consumption after adjusting for individual level variables is accounted for by the supermarket outlet and eating places variables included in the full model.

Discussion

Results of the study indicate that availability of supermarkets and full service restaurants are associated positively with fruits and vegetable consumption while fast food outlets are negatively associated. Other smaller store type retail store did not show statistical significance. Individual factors including age, being female, employed, income and education all were positively associated with fruits and vegetable consumption. The significant positive association of area level food environmental factors with the consumption of fruits and vegetables indicates a complementary role for interventions directed at improving the availability of supermarket type stores so as to impact healthy food purchases and consumption.

A number of limitations to this study relate to the choice of neighborhood –county level, and the crosssectional nature of the data. In regard to the choice of geographical unit various choices have been made in the literature with differing results, and in studies where contextual factors did not seem to explain the variance in F&V, it has been explained away as due to the insensitivity of the chosen area size. We chose to measure contextual variables at the county level data because the relevant data was available at the county level, we also rationalized that if the level of context was extended to

more distal levels, then if significance was obtained for area levels variables one could conclude that at more proximal levels greater significance would be achieved. The second limitation relates to the cross-sectional data which precludes establishing cause and effect relations from the results of the analyses.

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Table 1: Descriptive Statistics of Individual Fruit and Vegetable Consumption, Socio-Demographic and Food Environment Variables in North Carolina.

Variables	Mean or Percentage	Standard Error for Continuous Variable
Fruits and vegetable serving per a day	3.76	2.07
Socio-Demographic Characteristics		
Mean Age -years	54.4	16.63
Gender		
Men	36%	
Women	64%	
Race		
White	77.80%	
Black	14%	
Hispanics	4%	
Others	4.20%	
Income		
Less than $15,000	11.90%	
$15,000 - >$25,000	18.60%	
$25,000->$35,000	12.70%	
$35,000 - >$50,000	16.60%	
$50,000 and more	40.20%	
Education		
Did not graduate High School	14%	
Graduated High School	29.80%	
Attended College/Tech. Sch.	25.90%	
Graduated College/Tech. Sch.	30.30%	
Employment Status		
Employed	49.90%	
Not Employed	50.10%	
Marital Status		
Married-Cohabiting	58.30%	
Divorced/Widowed/Separated	31.60%	
Never Married	10.60%	
Urbanization		
Metro	67.70%	
Urban	29.10%	
Rural	3.20%	
Mean number of Food Store Type per 10,000 capita		
Supermarkets and Larger stores (50 or more employees)	0.60	0.22
Grocery stores (Less than 50 employees)	1.43	0.49
Convenience Stores	0.87	0.42
Gas Stations and Convenience Stores	4.76	1.25
Full Service Restaurants	7.36	3.08
Fast Food Eating Places	7.10	1.72

Table 2: Estimated Effects of Socio-Demographic, Food Store Type and Food Service Types Variables on Fruits and Vegetable Consumptions in North Carolina

Variables	Model 1		Model 2		Model 3		Model 4	
	Estimates	Sig.	Estimates	Sig.	Estimates	Sig.	Estimates	Sig.
Intercept	3.833	0.000	3.198	0.118	3.060	0.000	3.109	0.000
Race								
Other			0.296	0.113	0.302	0.008	0.309	0.006
Hispanic			0.209	0.110	0.215	0.050	0.220	0.045
Black			0.001	0.062	0.006	0.923	0.016	0.794
White			0.000	.	0.000	.	0.000	.
Gender								
Male			-0.448	0.042	-0.440	0.000	-0.441	0.000
Female			0.000	.	0.000	.	0.000	.
Education								
Did not graduate from High Sch.			-0.836	0.080	-0.823	0.000	-0.826	0.000
Graduate High School			-0.550	0.057	-0.542	0.000	-0.546	0.000
Attended College/Tech. Sch.			-0.313	0.054	-0.307	0.000	-0.310	0.000
Graduated from Coll./Tech. Sch.			0.000	.	0.000	.	0.000	.
Income								
Less than $15,000			-0.388	0.086	-0.415	0.000	-0.422	0.000
$15,000->$25,000			-0.163	0.068	-0.179	0.005	-0.184	0.004
$25,000->$35,000			-0.240	0.069	-0.253	0.000	-0.259	0.000
$35,000->$50,000			-0.135	0.059	-0.142	0.016	-0.147	0.013
>$50,000			0.000	.	0.000	.	0.000	.
Employment								
Employed			0.192	0.048	0.199	0.000	0.198	0.000
Not Employed			0.000	.	0.000	.	0.000	.
Marital Status								
Married-Cohabiting			0.002	0.074				
Divorce/Widowed/Separated			-0.056	0.079				
Never Married			0.000	.				
Smoking Status								
Current Smoker-everyday			-0.405	0.059	-0.410	0.000	-0.411	0.000
Current Smoker-Smokes some days			0.018	0.100	0.009	0.925	0.009	0.927
Former Smoker			-0.080	0.047	-0.082	0.081	-0.082	0.080
Never Smoked			0.000	.	0.000	.	0.000	.
Physical Activity								
Moderate and Vigorous Activity			1.326	0.081	1.322	0.000	1.322	0.000
Vigorous Activity			0.956	0.087	0.952	0.000	0.955	0.000
Moderate Activity			0.793	0.067	0.792	0.000	0.792	0.000
Insufficient Mod. & Vig. Activity			0.336	0.060	0.335	0.000	0.336	0.000
No moderate or Vigorous Activity			0.000	.	0.000	.	0.000	.
Age			0.014	0.002	0.013	0.000	0.013	0.000
Supermarket					0.258	0.018	0.239	0.046
Full Services Restaurants							0.001	0.100
Fast food outlets							-0.002	0.061
ICC	0.0086		0.0280		0.0020		0.0014	

Note: Reference categories for categorical variables: Whites, Female, Graduated from College/Tech. School, >$50,000, Not Employed, Never Married, Never Smoked and No Moderate or Vigorous Physical Activity.