Association Between the Food Environment and Obesity in North Carolina: A Multilevel Analysis of the Role of Food Retail Sources and Obesity

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Background

North Carolina is the tenth most obese state in the US. The link between energy imbalances is established as the cause of the obesity epidemic that is sweeping the United States. Even though the beneficial health effects of the consumption of less energy dense foods particularly fruits and vegetables is well established consumption of these healthful foods is low in the US. In North Carolina, only 22% of adults and 15% of youth (9th -12th grade) claim eating fruits and vegetables at least five times per day. Individual factors relating to nutrition knowledge and health considerations are noted to influence dietary intake (Baranowski et al. 1999). Ecological approaches to public health also suggest that the neighborhood food environment exerts considerable influence on individual dietary habits (Dubowitz et al. 2008). Furthermore, differences in numbers and types of food retail outlets available to consumers within the community, as well as the actual availability of healthful food within the different types of stores (Bodor et al., 2008) influence what foods are consumed. Thus, differential access to health promoting food resources, serve as either impediments or enhancement to healthy eating, especially in rural areas (Casey et al., 2008). The food environment in North Carolina has in recent years, undergone rapid changes that have implications for access to food. In particular, large food store chains have withdrawn from entire regions of the state, as well as from parts of local communities. This trend may have deleterious effects on healthy food access and impact obesity rates in the state.

Objective of Study

To examine the association between individual, socioeconomic characteristics, fruit and vegetable intake, and food environment factors and adult BMI in North Carolina.

Model Specification and Estimation

Obesity is modeled as a function of individual level characteristics, and food environment factors measured at the county area level. Because of the hierarchical nature of the obesity predictors, we estimated a random intercept model. From a general model of obesity

$Y_{ij} = \boldsymbol{\beta}_{oj} + \boldsymbol{\beta X}_{ij} + \gamma K_j + \varepsilon_{ij}$ where $\boldsymbol{\beta}_{oj} = c + V_j$

$Y_{ij} = c + \boldsymbol{\beta X}_{ij} + \gamma K_j + V_j + \varepsilon_{ij}$

The intercept $\boldsymbol{\beta}_{oj}$ is made up of a constant overall intercept c for all counties and a random part V_j denoting county j's departures from the overall intercept.

Y_{ij} = BMI of individual i

$\boldsymbol{X}_{ij}$: is a vector individual characteristics (race, age, employment, income, education, smoker status, overall physical activity levels and daily fruit and vegetable servings).

K_j : a vector of county level area food environment characteristics (food retail outlets densities - supermarkets, grocery stores, convenience and gas stores, convenience stores, fast food outlets and farmer's markets.)

$(V_j + \varepsilon_{ij})$: the error terms of the model. $\varepsilon_{ij} \sim N(0,\delta^2)$ and $V_j \sim N(0,T^2)$

Assumptions: i) Cov ($\boldsymbol{X}_{ij}$, V_j) = 0. ; ii) Cov (K_j , ε_{ij}) = 0

Violation of assumption i) and ii) results in endogeneity . A Hausman test confirms level 1 variables- fruit and vegetables, smoking status, and physical activity levels are correlated with V_j . To correct for the endogeneity problem, we employed group mean centered variables for the affected variables in the models (Grilli and Rampichini (2011) in estimating the multilevel models. Furthermore, estimation of an unconditional model confirmed the appropriateness of multilevel modeling. All estimations were done using Stata *xtmixed* procedure.

We estimated two level random intercept models, sequentially modeling level 1 and level 2 predictors of obesity. First, a null model which shows the impact on BMI in absence of any other factor. 2) A model analyzing the effects of individual level socioeconomic and demographic, fruits and vegetables consumption, smoker status, and physical activity on BMI and Models 3 and 4) Adjusting Model 2 for food retail outlet densities-supermarkets, grocery stores, convenience and gas stores, convenience stores, fast food outlets and farmer's markets. The results of the sequential analyses are shown in Table 1.

Data Description

Data for this study were obtained from three sources:

1) 2006 U. S. Census Bureau, County Business Patterns (CBP),-- Number of food store outlets classified according to North American Industry Classification System (NAICS) by type --supermarkets, grocery, convenience, and conveniences stores with gas station, fast food, and full service restaurants in counties in North Carolina.

2) 2006 Behavioral Risk Factor Surveillance Survey (BRFSS) - age, income, education, employment, marital status, race and gender, and fruit and vegetable servings, smoker status, and physical activity. The BRFSS is a nationally representative, cross-sectional, continuous annual telephone, probability sample survey of non-institutionalized adults, and conducted by state health departments in collaboration with the Centers for Disease Control and Prevention (CDC).

3) 2009 State Indicator Report on Fruit and Vegetables, Farmers' Markets data.

Area food retail outlet numbers were converted to per 10,000 capita densities.

Data on food retail sources were linked through county codes to individual data from the BRFSS data. The sample size was 11,575, after excluding missing values, and non-responses.

Results

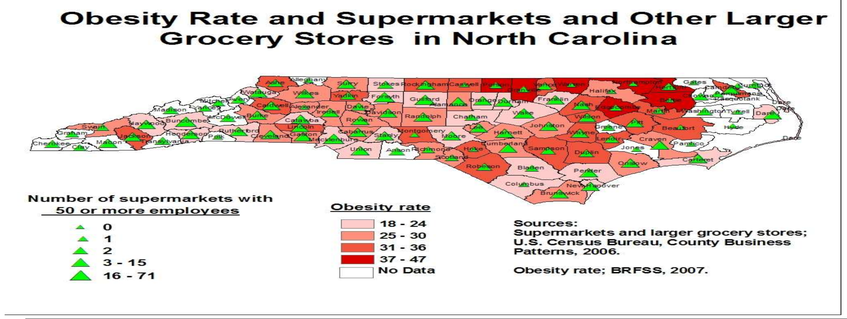
Results of the series of multilevel regression analyses predicting obesity are presented in Table 1. The null model 1 indicates statistically significant variations in obesity both at the individual level and across county levels, with over 9% of the variation due to variation across counties. Adjusting the null model for individual level covariates showed strong and statistically significant association of socioeconomic and demographic variables, fruit and vegetable consumption, smoking, and physical activity with obesity. Model 2 showed that race is associated with obesity- blacks were 2.4 times likely to be obese than whites, whilst Hispanics were less likely to be obese than whites. Obesity was also associated with having low income, lower educational attainment, and being female. Higher daily consumption of fruits and vegetables, and meeting moderate and vigorous physical activity requirements were negatively associated with being obese. Smoking as well was statically significant and negatively associated with obesity.

Including food-at-home retail sources as predictors to model 2, we find that higher densities of larger food store types e.g. supermarkets and grocery stores, as well as availability of farmers markets were negatively related to obesity. A one unit increase in the per 10,000 capita densities of supermarkets, and farmers' markets resulted in a one unit, and 0.8 units respectively in BMI reduction. On the reverse, there was a strong positive association of increased availability of gas and convenience combo stores with obesity. In the full model 4 where food away from home sources- fast food and full service restaurants- were included as predictor variables in addition to food for home consumption retail sources, supermarket losses its statistical significance, although it retains its negative relationship with obesity. Furthermore, the magnitude of the negative impact of fruits and vegetables consumption on obesity becomes quite negligible. Nevertheless, the negative and statistical significance of farmers markets is retained and remained a strong predictor of obesity.

Conclusion and Recommendations

This study may be one of the few multilevel studies on determinants of obesity that have included a more comprehensive list of food environments variables as predictors in modeling obesity. In particular the inclusion of farmers markets as predictor of obesity is an improvement in modeling environment influences on obesity. Our results corroborates the beneficial influences of larger food retail outlet access on obesity found in other studies. Policy levers to enhance access to nutrient dense foods have focused on promoting alternative food sources to include farmers markets, and community food systems. Results of this study that greater access to farmers markets impact negatively on obesity strengthen the push for local communities to promote farmers markets.

Maps of North Carolina



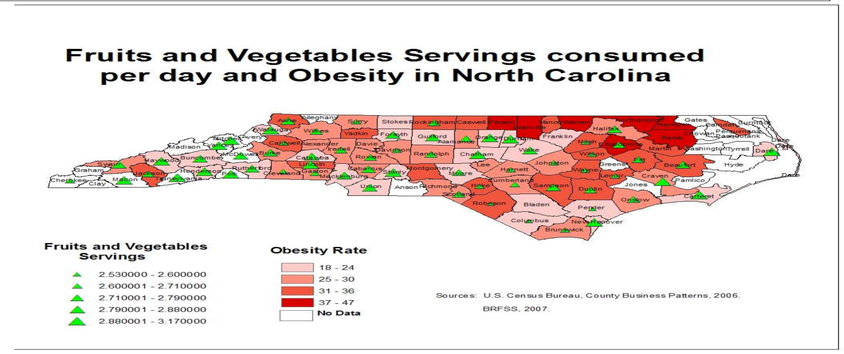


Table 1: Effects of Socio-Demographic, Community Food Store and Food Service Restaurants Variables on Obesity in North Carolina.

Variables	Model 1 Estimates	Model 1 Sig.	Model 2 Estimates	Model 2 Sig.	Model 3 Estimates	Model 3 Sig.	Model 4 Estimates	Model 4 Sig.
Intercept	27.81	0.000	31.53	0.000	31.37	0.000	31.46	0.000
Black			2.42	0.000	2.33	0.000	2.34	0.000
Hispanic			-1.06	0.001	-1.00	0.003	-0.99	0.019
Other			0.42	0.166	0.01	0.976	0.02	0.947
Female			-0.55	0.000	-0.58	0.000	-0.58	0.000
Age			-0.03	0.000	-0.03	0.000	-0.03	0.000
Education			-0.34	0.000	-0.34	0.000	-0.34	0.000
Income			-0.14	0.040	-0.13	0.011	-0.13	0.014
Employment			0.06	0.667	0.08	0.593	0.08	0.597
Smoking Status			0.42	0.000	0.39	0.000	0.38	0.000
Physical Activity			0.69	0.000	0.68	0.000	0.68	0.000
Fruit & Vegetables Servings			-0.001	0.040	-0.001	0.072	-0.001	0.069
Supermarket					-1.06	0.002	-0.62	0.193
Farmer Market					-0.77	0.005	-0.76	0.005
Grocery Stores					-0.15	0.405	- 0.04	0.836
Gas & Convenience					0.27	0.000	0.26	0.000
Convenience Stores					0.22	0.203	-0.16	0.376
Full Services Restaurants							-0.07	0.217
Fast food outlets							-0.01	0.767
ICC	0.010		0.006		0.001		0.001	

Note: Reference categories for categorical variables: Whites and Male.

Baranowski, T., K. Weber Cullen, and Baranowski, J. (1999) Psychosocial correlates of dietary intake: advancing dietary intervention. Annual Review of Nutrition, 19: 17–40.

Bodor J, Rose D, Farley T, Swalm C, Scott S.2008. Neighborhood Fruit and Vegetable Availability and Consumption: The Role of Small Food Stores in an Urban Environment. *Public Health Nutrition* 11:413-20

Casey A.A., M.Elliott, K.Glanz , D. Haire-Joshu, S.L Lovegreen, B.E.Saelens, J.F.Sallis, R.C Brownson. 2008. Impact of the Food Environment and Physical Activity Environment on Behaviors and Weight Status in Rural U.S. Communities. *Preventive Medicine*, 47:600-604.

Dubowitz, T, M. Heron, C. E. Bird, N. Lurie, B. K. Finch, R Baurto-Davila, L Hale, and J.J. Escarse. (2008). "Neighborhood Socioeconomic Status and Fruit and Vegetable Intake among Whites, Blacks and Mexican Americans." American Journal of Clinical Nutrition 87: 1883-91

Grilli L. & Rampichini C. (2011) The role of sample cluster means in multilevel models: a view on endogeneity and measurement error issues. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences*. Vol. 7(4):121–133.

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