Contextual Influences on Obesity Prevalence: A Spatially Explicit Analysis
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Extended Abstract for the Population Association of America meeting in San Francisco (CA), 2011

Abstract

This study examines contextual influences on obesity in the United States. Using several secondary data sources, I constructed a dataset with a rich set of county-level contextual variables. This study employs a spatially explicit perspective. I also use traditional regression methods, along with exploratory spatial data analysis and geographic weighted regression. Results from OLS show that rural counties do not significantly differ from urban counties, whereas minority composition, features of the environment and physical inactivity among adults are all significantly associated with obesity. Also, income inequality was found to provide a protective barrier against higher obesity prevalence. This finding suggests that the relationship between inequality and health should be further explored. Furthermore, GWR confirms that place matters and the relationship between contextual influences and obesity prevalence varies substantially across place. GWR provides an empirical basis for public health interventionists to target predictors of obesity at the local level.

Background

The stratification of health in the United States places individuals at risk of exposure to poor health-causing agents. Health disparities not only persist across individuals, but also across places (Geronimus, Bound, and Waidmann 2001). The social patterning of disease is evident in obesity incidence and prevalence across race, gender, and socioeconomic status (Flegel et al. 2002). The implications of obesity also have serious consequences for well-being and life expectancy. Obesity is positively associated with other chronic illnesses, thus placing individuals with obesity at higher risk of a variety of chronic diseases such as cardiovascular disease, strokes, diabetes, hypertension, and certain cancers (Malnick and Knobler 2006). The excess deaths associated with obesity may lead to an actual decline in life expectancy and longer years of life with disability (Olshansky et al. 2005).

While personal health behaviors are linked to increased trends in obesity, emerging evidence implicates contextual features and structural forces as influences on health behaviors and outcomes (Link and Phelan 1995). Place is a salient determinant of health; therefore, features of the built and natural environment have important implications for health outcomes (Macintyre, Elleway, and Cummins 2002; Poudyal et al. 2009). Thus, the interrelationships among structural forces, place, and population health should be further examined.

Summary of Research Questions and Hypotheses

In this study, I test a) how residence status, macro social processes, environmental features, and lifestyle behaviors at the county level predict adult obesity prevalence; and b) how the effects of these predictors vary spatially. I predict that rural residence, income inequality, food access, and physical inactivity among adults have positive effects on obesity prevalence, while controlling for other variables. In contrast, I predict that access to natural amenities serves as a protective barrier against high obesity prevalence. Furthermore, I predict that the effects of parameters are heterogeneous across place.

Data and Methods

I extracted data from the United States Department of Agriculture Food Environment Atlas Dataset, The U.S. Census County Business Patterns data, and the Centers from Disease Control and Prevention National Diabetes Surveillance System. All counties or county-equivalents with complete data (n=3108) were included in the analysis.

Ordinary least squared (OLS) regression, Moran's I, and geographically weighted regression (GWR) are employed in this ecological study. OLS is a conventional approach; several assumptions of OLS regression must be met to calculate unbiased regression coefficients. OLS model assumes that the conditions in each county observed are independent of proximal counties. However, counties that are neighbors, and share similar compositional and contextual characteristics are likely to exhibit spatial dependence, or to be spatially correlated. Thus, spatial dependence violates the OLS assumption of homoscedasticity or uncorrelated error terms, and the parameters calculated by the OLS will likely be biased, and generate low estimates of the confidence intervals and real variance (Ward and Gleditsch, 2008).

I use the Moran's *I* to test for spatial autocorrelation. A significant Moran's *I* in the dependent and independent variables suggests spatial dependence and a violation of OLS assumptions. I assume the mechanisms that operate on obesity outcomes within each county are not likely stationary across place. A priori assumptions of spatial dependency and non-stationarity lends to the inclusion of a GWR model. One of the main differences between OLS and GWR is that OLS produces a global model that predicts the outcome variable across the entire study area, while GWR generates a local model for each observation in the sample (Fotheringham, Brundson, and Charlton 2002).

Results

The global (OLS) model (table not presented) shows that obesity prevalence is not significantly different between rural and urban counties. All of the race variables in the model are significant. Counties with low income inequality have an adult obesity prevalence that is .40 percent higher than counties with medium or high income inequality. This result contradicts the premise that low inequality, relative to medium and high inequality, is a safety net for poor health outcomes.

The results of the access and proximity variables show that an increase in no car ownership and residents more than one mile to a grocery store is associated with a 1.46% increase in adult obesity at the county level. However, as the percentage of the county population whom lack a car, and live more than 10 miles from a grocery store increases by one percentage point, the percentage of obese adults decreases by .36%.

Counties that had a per capita loss in the number of grocery stores reported obesity prevalence .26% higher than counties that did not experience a net change or a net gain in the number of grocery stores per capita. It is expected that counties that witnessed a decrease in the number of convenience stores will expect to have a lower prevalence of obesity. However, results from the global model reveal the opposite. Counties that witnessed a per capita loss in the number of convenience stores have estimated obesity prevalence .19% higher than counties that did not experience a net change or a net gain in the number of grocery stores per capita. These findings may suggest that convenience stores are just as imperative to the food retail landscape as larger grocery stores and supermarkets.

The amenity scale reveals a negative and significant effect on adult obesity. A one point increase on the amenity scale is associated with a .78% decrease in adult obesity. While having access to natural resources has a negative effect on obesity prevalence, the largest effect on obesity is observed by counties with lower rates of physical inactivity. Adult residents of counties who reported the highest rates of physical activity have obesity prevalence that is almost 3% lower than counties with lower percentages of physically active adults.

Figure 1 reveals that the explained variance in the model varies greatly from about 30% to approximately 88%. However, the global "stationary" model predicts a single adjusted r-square of .58. The map shows that the model predicts adult obesity relatively poorly in much of the Appalachia region, the Midwest, and the Pacific Northwest. In contrast, the model is very predictive of adult obesity in the Southeast, in several of the Plain States, and in the Southwest.

Furthermore, the Monte Carlo significance test of the local (GWR) model indicates that most of the parameters in the model are non-stationary across space, and the 5- number summary reported in Table 1 details the effect of each predictor across the study area. The global (OLS) model explains 58% of the total variance in the percentage of adults who are obese with an AIC of 14,115.13. The AIC in the GWR model is 12,635.10, and the adjusted r-square indicates that the model explains 78% of the variance, both of which confirm the local model is a better fit than the global model. Mapping the GWR estimates of non-stationary variables reveals where the values of parameters are significant. For example, Figure 2 shows that higher income inequality has a significant and negative association with obesity prevalence in much of West Virginia; in stark contrast, income inequality has a positive effect on obesity prevalence in the West. Other independent variables that tested significant for non-stationarity also had varying significant effects across the United States (maps not presented).

Figure 1: Local r-square of GWR model

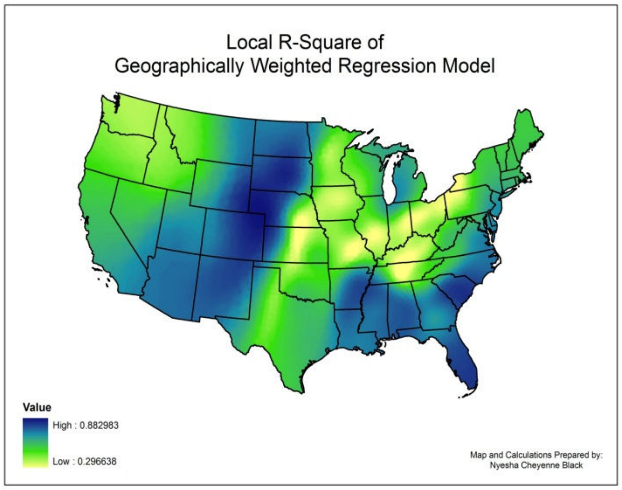

Figure 2: GWR estimates of income inequality

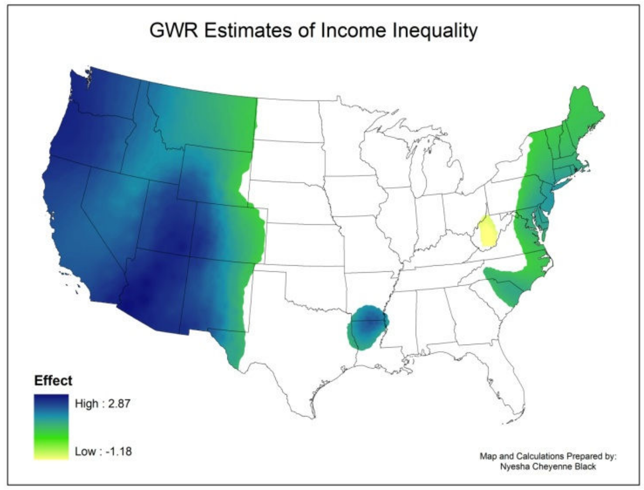

Table 1: Geographically Weighted Regression 5 number parameter summary results and Monte Carlo significance test for spatial variability of parameter (N=3,108)

	Minimum	Lower Quartile	Median	Upper Quartile	Maximum	Monte Carlo Testing Status
Intercept	21.00	26.86	28.26	29.54	34.03	Non-stationary***
Urban/Rural Continuum	-2.29	-0.40	-0.12	0.15	1.85	Stationary
Total Population	-2.00e-05	-3.00e-06	-1.00e-06	0.00e+00	1.10e-05	Non-stationary***
Black (%)	-0.57	0.06	0.10	0.13	1.57	Non-stationary***
Hispanic (%)	-0.27	-0.04	-0.00	-0.03	0.16	Non-stationary***
Asian (%)	-3.61	-0.34	-0.18	-0.06	0.89	Non-stationary***
Native Americans (%)	-1.18	0.07	0.13	0.28	4.67	Non-stationary***
Gini †	-1.19	-0.39	0.34	0.84	2.87	Non-stationary***
HH with no car, > 1mile to grocery store (%)	-0.66	0.01	0.38	1.08	3.22	Non-stationary***
HH with no car, > 10 miles to grocery store (%)	-2.17	-0.40	-0.15	0.14	1.31	Non-stationary*
Δ in # of Grocery stores/capita†	-1.73	-0.16	0.07	0.38	1.74	Stationary
Δ in # of Convenience stores/capita †	-1.28	-0.16	0.04	0.07	0.34	Stationary
Amenity Scale	-2.29	-0.69	-0.34	-0.02	0.07	Non-stationary***
Physical Inactivity †	-7.38	-3.17	-2.25	-1.55	3.51	Non-stationary***
Adjusted R-Square	.78					
Akaike Information Criterion	12635.10					

*$p \leq 0.05$; ** $p \leq 0.01$; ***$p \leq 0.001$*

*††**Dummy Variables**: Gini (1=low inequality); Δ in # of Grocery stores/capita (1=loss of grocery stores); Δ in # of Convenience stores/capita (1=loss of convenience stores); and Physical Inactivity (1=low physical inactivity)*

Conclusions

Most studies that have examined obesity prevalence have assumed that the relationship among the independent and dependent variables are consistent or stationary across place. Traditional (global) methods do not adequately capture the salience of place. Therefore, policy solutions gleaned from such studies may not effectively address the factors that are contributing to obesity at the local level. In this study, GWR has been proven as a useful technique for identifying regional and sub-regional variations in the relationship between obesity prevalence and several contextual covariates. This spatially explicit approach may potentially inform policy that is tailored to the idiosyncrasies of places.

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