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A Spatial Analysis of Obesity in West Virginia

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Abstract: A spatial panel data analysis at the county level examines how individual food consumption, recreational, and lifestyle choices — against a backdrop of changing demographic, built environment, and policy factors — leads to obesity. Results suggest that obesity tends to be spatially autocorrelated; in addition to hereditary factors and lifestyle choices, it is also caused by sprawl and lack of land use planning. Policy measures which stimulate educational attainment, poverty alleviation, and promotion of better land use planning and best consumption practices (BCPs) could both reduce obesity and result in sustainable development of regions where obesity is prevalent and the economy is lagging.

JEL classification: *R11; H75*

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Introduction

Natural amenities impact regional economies through aggregate measures of economic performances such as population, income and/or employment growth, and housing development (Kim, Marcouiller, and Deller, 2005, Deller et al., 2001). Also, there are increasing concerns that the built-in environment, a component of the natural environment, has substantial influence on people's quality of life and health (Freudenberg, Galea, and Vlahov, 2005; Frumkin, 2002). Natural amenity led rural economic growth may yield higher levels of local unemployment, lower income levels and generally lower overall economic well being (Marcouiller and Deller, 1996). Previous studies (Fukuda et al., 2005; Lin, 2003; Fukuda, Nakamura, and Takano, 2004) have demonstrated the relationships between human mortality and regional characteristics related to the environment, health-related behavior, and economic and demographic factors. Moreover, epidemiological and geographic health research has shown that non-contagious diseases such as heart ailments and cancer are spatially clustered. (Lin, 2003; Halverson et al., 2004; Fukuda et al., 2005).

Overweight and obesity have increased the risk of having most prevailing diseases, including diabetes (Egede and Zheng, 2002), cardiovascular diseases (Wang et al., 2002), and cancer (Bianchini et al., 2002). Obesity, defined in terms of Body Mass Index (BMI), is escalating in epidemic proportions across the U.S., and more prominently in economically lagging regions such as Appalachia. According to National Institute of Health (NIH) guidelines, a BMI ≥ 30 is defined as obese, and a BMI between 25 and 29.9 is considered as overweight. For this study, we select as our study area the state of West Virginia (WV), the only state wholly within the Appalachian region. The incidence of obesity in WV is consistently higher than for the U.S. and is about 23%, compared with 20% nationally (WV Dept. of Health and Human Resources, 2002). The consequences of obesity are manifested in soaring health care costs, which, in the U.S. were estimated to be $117 billion/year, with approximately 300,000 direct and indirect deaths per year attributable to the problem (Kuchler and Ballenger, 2002). Subsequently, obesity has become a major burden on welfare programs such as medicare and social security (Kuchler and Ballenger, 2002).

Rapid suburbanization is hypothesized to be associated with rising obesity, decreased physical activity, increased social isolation and the breakdown of social capital (Freudenberg, Galea, and Vlahov, 2005). Since the attributes associated with the built environment and natural amenities are spatially located, it is reasonable to hypothesize that health disorders like obesity are spatially clustered based on neighboring socioeconomic, demographic and environmental attributes. Even though, there are growing concerns of spatial phenomena on public health, not many existing studies empirically test the impact of agglomeration economies on public health, particularly in rural settings. Thus the goal of this study is to examine causes, and subsequent policy issues of spatiotemporal developments in the rural economic structure on the growing public health problem of obesity. The next section explores developments in the economics, health and urban planning literature on public health issues such as obesity. This sets the stage for discussion of the methodological approach and the data used in this study. The final section presents the results and policy implications.

Background

Urban sprawl, characterized by a complex pattern of land use, transportation, and socioeconomic development, has both positive and negative implications for quality of life and public health (Frumkin, 2002). While sprawl is a somewhat imprecise and difficult to measure phenomenon, it is often characterized by low-density urban development that consumes land faster than the growth of the population. Simply put, it is poor accessibility, with nothing within easy walking distance of anything else. Thus, urban sprawl is associated with more automobile travel than for denser communities. Transportation, which is a key factor of everyday life, could also be a decisive factor of changes in physical activity as small shifts in travel modes noticeably alter energy expenditure. Thus, urban sprawl which increasingly relies on vehicular travel, is found to have profound effects on physical activity, obesity and public health (Sturm, 2004, Ewing et al., 2003; Lopez, 2004, Blanchard and Lyson, 1999, Frank et al., 2004, Block et al., 2004).

The influence of transportation on energy expenditure is mainly transmitted through the built environment in which the cities and transportation corridors are planned and developed (Pratt et al., 2004). Ewing et al. (2003) showed that residents of sprawling counties were also more likely to walk less during leisure time, weigh more, and have a greater prevalence of hypertension than residents of compact counties. Lopez (2004) found that a higher level of urban sprawl was associated with an increased risk of being obese. Urban sprawl may reduce the time available for physical activity because parks or fitness facilities are more distant. Frank, Anderson, and Schmid (2004) pointed out that the likelihood of obesity apparently declines with an increase in mixed land use, but rises with time spent per day in a car. They found that a 25% increase in mixed land use decreases the risk of being obese by 12%, while each additional hour spent in a car raises the likelihood of obesity by 6%. Also, each additional kilometer walked per day was found to be associated with a 5 % reduction in the likelihood of obesity. Salens et al. (2003) indicated that a more walkable environment has been found to be associated with higher physical activity and lower obesity levels. Handy et al. (2002) stated that a combination of urban design, land use patterns, and transportation systems that promote walking and bicycling will help create more active, healthier and livable communities. Rosenberger, Sneh, and Phipps (2002), showed that the rates of physical inactivity of WV counties are positively related to expenditures on health care treatments for diseases and disorders of the circulatory system. Increasing recreation opportunities have the potential to decrease health care expenditures and rates of obesity through increasing rates of physical activity.

Urban sprawl not only contributes to physical inactivity, but also affects diets by increasing the distance to supermarkets or by the increased cost of nutritious foods caused by the conversion of farmland to urban areas (Frumkin, 2002). Derry (2004) emphasized that the built environment may play a major role in controlling weight by shaping food access and availability. Recent research suggests that supermarkets are more likely to be located in wealthier neighborhoods and that fruit and vegetable intake is positively associated with the presence of a supermarket, even after controlling for personal economic factors (Morland et al., 2002). Blanchard and Lyson (2003) indicated that the establishment of "supercenter" retail grocery stores tends to create food deserts for the rural population. When a supercenter is opened in a non-metropolitan county, it draws customers from a wide radius such that existing small retailers in these areas go out of business due to loss of customers. This places low-income earners at a disadvantage when it comes to finding low cost grocery stores. A study by Block, Scribner, and DeSalvo (2004) showed that there is a geographic correlation between exposure of black and low-income neighborhoods to fast food restaurants. It reveals that predominantly black neighborhoods have 2.4 fast food restaurants per square mile compared to 1.5 restaurants in predominantly white neighborhoods. A study which addressed fast food restaurant density and median individual income in Melbourne, Australia showed that residents of low income neighborhoods have 2.5 times more exposure to fast food restaurants than those living in affluent neighborhoods (Reidpath et al., 2002).

The consequences of urban sprawl not only include increased reliance on automobile transportation and decreased ability to walk to destinations, but also decreased neighborhood cohesion, high traffic fatality rates and environmental degradation (Ewing, Schieber, and Zegeer 2003; Freeman, 2001). Redistribution of the American population to suburbs and away from central cities and rural areas has given rise to undesirable impacts including the destruction of open space and farmland, increased automobile congestion and pollution, the geographic isolation of low-income and minority residents, and a mismatch between the location of jobs and the residences of workers, especially, low-skilled, low-income workers (Foster-Bey, 2002). Drewnowski and Specter (2004) find evidence that population groups with the highest poverty rates and the least education have the highest obesity rates. The authors argue that less expensive energy dense foods relative to their caloric content are low cost options for lower income consumers. Thus, the selection of energy sources by food insecure, low-income consumers may represent a deliberate strategy to save money. Also, poverty and food insecurity are associated with lower food expenditures, low fruit and vegetable consumption, and lower-quality diets (Drewnowski and Specter 2004). Other studies (Philipson and Posner, 2003; Ruhm, 2000; Cutler, Glaeser, and Shapiro, 2003; Variyam, 2005) have linked economic growth and technological change to obesity, suggesting that obesity has been accompanied by innovations that economize on time previously allocated to the non-market or household sector. New innovations have reduced the time spent on food preparation at home through the introduction of convenience foods at low cost for home consumption and also through the increased number of fast food and full-service food outlets. With this background information, this study seeks to investigate how complex spatiotemporal developments impact health and quality of life in rural areas.

Methodology

We hypothesize that obesity is a spatiotemporal phenomenon, clustering according to the distribution of the built environment, together with socioeconomic and demographic factors of geographic units. The spatiotemporal phenomena could be a result of spatial dependence or the spatial heterogeneity of geographic units. In the event of spatial dependence and spatial heterogeneity, the BLUE properties of OLS estimation are violated and, in turn, produce biased and inconsistent estimates (LeSage and Pace, 2004, Anselin, 1988). Previous studies which use spatial and spatiotemporal samples often relied on dichotomous explanatory variables to control either spatial or temporal effects. However, the spatiotemporal modeling using dichotomous variables must account for both spatial and temporal dichotomous variables leading to a large number of estimated parameters. Like temporal autoregressive approaches, spatial and spatiotemporal autoregressive processes often result in more parsimonious and better fitting models than those that rely on dichotomous variables (LeSage and Pace, 2004). Following the theoretical representations of spatial panel data approaches (Elhorst, 2003; Baltagi, 2001), this study utilizes spatial panel autoregressive techniques to investigate the random and fixed effects contributing to the prevalence of obesity at the county level. Spatial dependence can be caused by trans-boundary spillovers among counties in which the activities in one county have a direct influence on activities in other counties. Spatial interdependence of county incidence of obesity can be represented by fixed effect spatial autoregressive model (FSAR) as:

(1) $$H_{it} = \rho W H_{jt} + \beta' X_{it} + \alpha' d + \gamma_t + \varepsilon_{it}, \quad i=1,2,\ldots,N, \quad i \neq j, \quad \varepsilon_{it} \sim \left(0, \sigma^2 I_{NT}\right),$$

The dependent variable, H_{it}, denotes prevalence of obesity in the i^{th} county for time period *t*. where H_{it} is an *NT* x 1 vector of dependent variables representing prevalence of obesity in the i^{th} county for time period *t*. In this study, N denotes the number of counties in WV (55), and T denotes the number of time periods (2). ρ is an *NT* x 1 vector of spatial autoregressive coefficients to be estimated that indicates contiguity between counties, and thus the spatial autoregressive relationship; *W* is the spatial weights matrix (*N* x *N*) where elements $W_{ij} > 0$ and $W_{ii} = 0$. The explanatory variable, H_{jt}, is the weighted average of the prevalence of obesity in neighboring counties as specified by the spatial contiguity matrix *W*. β represents a *K* x 1 vector of parameters to be estimated, and X_{it} is the observation for county *i* for each of *K* explanatory variables which may change across *t* but not *i*, or vice versa. The term *d* represents the vector of regional specific dummy variables relevant to the unobserved fixed effect parameter vector, α. The scalar γ_t represents the fixed time effects on the model.

Stochastic disturbances, ε_{it} , are assumed to be independently and identically distributed (ε_{it}~IID$(0,\sigma_{\varepsilon}^{2})$).

The degree of spatial autocorrelation could also depend on the potential correlation of the error term across counties. The spatial autocorrelation of the error structure can be incorporated by specifying the error term as $\varepsilon_{it} \sim \lambda W \varepsilon_{it} + \eta_{it}$, where λ is the spatial autocorrelation coefficient, and $\eta_{it} \sim \left(0, \sigma_{\eta}{}^{2} I_{NT}\right)$ such that the fixed effects spatial error model (FSEM) for county prevalence of obesity can be specified as :

(2) $$H_{it} = \beta X_{it} + \alpha d + \gamma_{t} + \varepsilon_{it}, \;\; \varepsilon_{it} \sim \lambda W \varepsilon_{it} + \eta_{it}, \;\; \eta_{it} \sim \left(0, \sigma_{\eta}{}^{2} I_{NT}\right),$$

where the other variables and parameters are as previously defined. In the case of random effect models, it is assumed that fixed effects vectors are other unobserved factors affecting H_{it} that are not systematically related to the observable explanatory variables whose effects are of interest. Thus, random effects spatial error autoregressive (RSAR) can be specified as

(3) $$H_{it} = \rho W H_{jt} + \beta' X_{it} + v_{it} \;\; \text{with vector } v = \left(\tau_{T} \otimes I_{N}\right) d + \left(I_{T} \otimes I_{N}\right) \varepsilon,$$

where τ_{T} is a (Tx1) vector of unit elements. Therefore, the covariance matrix of the composite error term, $\mathrm{E}(v_i v_i')$, equals $\Omega = \sigma_{d}^{2}(\tau_{T}'\tau_{T} \otimes I_{N}) + \sigma_{e}^{2}(I_{T} \otimes I_{N})$. The random effect spatial error model (RSEM) is simply the exclusion of the right hand side H_{jt} term, which is the weighted average of the prevalence of obesity in neighboring counties as specified by the spatial contiguity matrix *W*.

Data and Estimation

Data complied for the empirical investigations are gathered from various secondary data sources. The county prevalence of obesity in the years 1992 and 1997 and the associated data for the explanatory variables relevant for these time periods were pooled across the 55 counties of WV. A description of the variables used in this analysis and their sources are in Tables 1 and 2. Descriptive statistics for the variables are in Tables 3 and 4. Obesity prevalence in WV counties for 1992 and 1997 were obtained from the County Health Profiles published by the WV Department of Health and Human Resources (2000). Socioeconomic data relevant to these two time periods were obtained from state and federal agencies including the Appalachian Regional Commission (ARC), WV Bureau of Employment, Natural Resource Analysis Center of West Virginia University, and the U.S. Census Bureau.

The percentage of county prevalence of obesity (OBESITY) is the dependent variable for both spatial random and fixed effect models. Population density (PPSM), poverty rate (PR), per capita income (PINC), percentage of the population who has completed a college education (AE), unemployment rate (UR), and average annual wage (WAGE) are considered as socioeconomic and demographic explanatory variables in the models. The percentage of the population who smokes (PSMOKE), and the percentage of the population which does not have health insurance (PNHINU) are variables which reflect county behavioral patterns. Representing fiscal policy measures are social security program beneficiaries per thousand (SSPB), and federal food stamp (PAFSTS) and Medicare benefits (PMCAREB) allocated per thousand people in a county. The total number of business establishments (TESTB), food stores (FSTOR), eating and drinking places (EDPLA), health care service businesses (HESER), and physical fitness activity places available (PPFAC), per thousand people in a particular county, are explanatory variables representing the built environment, along with TVTRT, which is a measure of mean travel time to work for county residents.

The built environment variables in Table 3, except for travel time to work, were obtained from the County Business Patterns (CBP) of the Economics Census, U.S. Census Bureau. The Standard Industrial Classification codes (SIC) for the relevant built environment variables are Total number of Business Establishments (TESTB) (SIC52); Food Stores (FSTOR), (SIC5400); Eating and Drinking Places (EDPLA) (SIC5800); Physical Fitness Activity Places (PPFAC) (SIC7991); and Health Care Services (HESER) (SIC8000)[1]. Total Establishment counts (TESTB) represent the number of locations with paid employees at any time during the year. The SIC codes for Food Stores (FSTOR) encompasses a broad range of retail stores that sell food products, mainly grocery stores and other stores that sell food for home preparation and consumption. The eating and drinking places (EDPLA) SIC includes retail establishments engaged in selling prepared food and drinks for consumption on the premises of these establishments.

[1]County Business Patterns reflect economic activities of counties. An establishment is a single physical location at which business is conducted or services or industrial operations are performed. It is not necessarily identical with a company or enterprise, which may consist of one or more establishments. When two or more activities are carried on at a single location under single ownership, all activities generally are grouped together as a single establishment.

Also included are caterers which serve prepared food other than at the place of business and lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption. The Health Care Services (HESER) group includes those primarily engaged in the provision of medical, surgical, and other health services. The average travel time to work (TVTRT) is attributable to U.S. Census Bureau data for 1990 and 2000. North (N), Northeast (NE), Northwest (NW), Central (C), West (W), Southwest (SW) and Southeast (SE) are regional dummy variables which capture regional fixed effects. In fixed effects estimation, the dummy variable representing the central (C) region serves as the base category. The MATLAB codes for spatial modeling approaches were obtained from LeSage (1999).

Results

Table 5 presents the empirical results obtained for the random effects spatial error model (RSEM) and spatial autoregressive (RSAR) or spatial lag model. The significant spatial autocorrelation coefficient (λ) of the RSEM implies that county incidence of obesity is spatially auto correlated. In addition, the RSEM results show that county prevalence of poverty (PR), percentage of residents with at least a college education (AE) and average annual wage (WAGE) are significant socioeconomic factors affecting obesity. A 1% increase in poverty in a county would raise the county prevalence of obesity by 0.13%. The percentage of the population with a college education completed (AE) has a significant negative impact on obesity. A 1% increase in the percentage of the population with a completed college education reduces the county obesity rate by 0.2%. A $1,000 increase in the annual county per capita wage would raise the county obesity rate by 0.3%.

A unit increase in the number of business establishments per thousand population (TESTB) would raise the county obesity rate by 0.2%. In contrast, a unit increase in the number of food stores per thousand population would reduce obesity by 3%. A one minute increase in mean travel time to work will raise county incidence of obesity by 0.3%. In comparison to RSEM, the significant spatial autoregressive coefficient (ρ) of the RSAR estimation implies that county prevalence of obesity is not only spatially autocorrelated but also has a significant impact on the incidence of obesity in neighboring counties. The RSAR estimation yields similar results to the RSEM estimation with regard to other significant covariates affecting obesity, except for the variable percentage of smoking (PSMOKE) in a county. The latter has a significant positive impact on county prevalence of obesity in the RSAR estimation, but is insignificant in the RSEM estimation.

Having considered the spatial random effects, both RSEM and RSAR are extended to investigate spatial fixed effects. County specific spatial fixed effects are ignored due to the incidental parameter problem of a larger number of cross sectional units relative to the time series; instead, regional spatial fixed effects, which include regional and time dummies, are investigated. The results obtained for the regional fixed effects spatial error model (FSEM) and regional fixed effects autoregressive model (FSAR) are given in Table 6. The FSEM shows that PR, AE, TESTB, FSTOR, WAGE are significant socioeconomic and built environment covariates affecting obesity. As poverty increases by 1%, the county prevalence of obesity decreases by 0.1 %. Similar to previous modeling approaches, the impact of education (AE) is negative and significant; a 1% increase in AE would lower the incidence of obesity by 0.2%. The FSEM also indicates that neither

TVTRT nor PSMOKE has a significant effect on the obesity rate. Total number of business establishments per thousand population (TESTB) has a significant positive impact on obesity. A one unit increase in TESTB would raise the county obesity rate by 0.3%. Negatively significant FSTOR implies that a unit increase in FSTOR would reduce obesity by about 3%. Significant dummy covariates for time (DT) and the northeast (DNE), southeast (DSE) and southwest (DSW) regions imply that there are significant differences in obesity rates in the aforementioned regions for the two time periods. Obesity prevalence in the base central region in 1992 is significantly lower by 3% than that for 1997. Also, during 1997, the prevalence of obesity in all three regions mentioned is significantly higher, by about 2%, than the base central region. In addition, the significant λ is evidence for spatial autocorrelation at the county level.

In comparison to the FSEM results, those from the FSAR estimation indicate that only education (AE), total number of business establishments (TESTB), number of food stores (FSTOR) per thousand population and WAGE are significant variables affecting county level rates of obesity. The significant ρ indicates that count prevalence of obesity has a significant impact on the obesity prevalence of neighboring counties. However, the restricted F-test presented in Table 7 indicates that both random effects spatial models, RSEM and RSAR, are superior to the fixed effect spatial models; FSEM and FSAR. In terms of the number of covariates that are significant, the random effects spatial autoregressive (RSAR) model is superior to the random effects spatial error model (RSEM).

Policy Implications

The spatial distribution of obesity rates in WV for the two specific time periods (1992 and 1997) is mapped in Figures 1 and 2. These spatial patterns show that obesity existed in relatively higher proportions in almost all counties in 1997 compared to 1992. Initial geospatial investigation shows that county prevalence of obesity tends to be a spatial non random event with positive spatial autocorrelation effect.[2] Spatial patterns indicate that obesity tends to cluster in the southern part of West Virginia relative to other regions.

Multivariate regression also indicates that county educational level has a significant impact on county prevalence of obesity. It shows that the number of residents with at least a college education is negatively and significantly correlated with the county prevalence of obesity. This finding is similar to that of Nayga (2000) who showed that knowledge is inversely related to the probability of a person being obese. Other studies (Kenkel 1991; Grossman, 1972; Berger and Leigh, 1989) show that schooling improves choice of health inputs by improving one's knowledge, which also helps one to choose a healthier lifestyle. Halverson et al. (2004) state that despite the improvement of educational attainment across WV counties, the relative differences appear to persist over time, more prominently in the southern part of WV. The pattern is illustrated in Figures 3 and 4, further explaining the geographic distribution of people with at least a college education and the county prevalence of obesity.

[2]Global moran's I statistic for county prevalence of obesity for the period of 1997 is 0.40 in comparison to 0.04 in 1992.

Our results also suggest that as the average annual wage of a county increases the county prevalence of obesity increases. Economic theory suggests that wage is a proxy for the opportunity cost of time or price for leisure; the higher the opportunity cost of time, the lower the incentive to substitute leisure for work. Philipson and Posner (2003) indicated that an unintended consequence of increased labor force participation in advanced economies is the unintended public health consequence of obesity. This economic reasoning seems to be quite applicable for WV's high prevalence of obesity. Mean annual per capita wages for WV counties for the period 1992 to 1997 ranged form $16,839 to $24,991. This mean annual wage may not be high enough for average WV residents to meet their needs. Thus, economic incentives may induce WV residents to work more, perhaps in sedentary environments, and also to engage in less leisure time and physical actives, at the expense of their own health outcomes. On the other hand, one could argue that higher wages could lead to a higher income, thus better food choices reducing obesity. However, high quality expensive food items may not be the option for rational consumers who works long hours to earn limited income. Instead, households may consume convenience foods which also are cheaper relative to their caloric content, contributing to obesity. Neither RSEM nor RSAM indicate that per capita income has any significant impact on county prevalence of obesity. Collinearity diagnostics indicate that wage and income are not highly correlated, precluding any multicollinearity issues.

Estimations also indicate that county poverty rates have a significant, positive impact on obesity. As other economic health studies have suggested, poverty is an important determinant of many pressing socioeconomic and public health issues

(Drewnowski, 2003; Mokdad, Ford, and Bowman, 2003; Basiotis and Lino, 2002; Adler and Ostrove, 1999). Adler and Ostrove (1999) indicate that residents living in wealthier communities having more income, more years of education, and a more prestigious job, have lower obesity as well as better health outcomes. Studies by Drewnowski and Specter (2004); Mokdad, Ford, and Bowman (2003); Basiotis and Lino (2002) offer evidence to link poverty and food insecurity to obesity. Drewnowski and Specter (2004) indicated that obesity apparently occurs in populations with the highest poverty and the least education. The spatial distribution of poverty versus obesity rates in 1992 and 1997 is shown in Figures 5 and 6, respectively. The figures show that the southern counties have a higher percentage of obesity and relatively higher percentage of poverty.

In addition, the results show that built environment covariates including TESTB, FSTOR and TVTRT are significantly influencing county prevalence of obesity. Results indicate that total number of business establishments per thousand population (TESTB) in a county is positively and significantly correlated with county prevalence of obesity. As this variable reflects the presence of economic activity in a particular county, we can conclude that as the economy thrives, more and more people engage in longer hours of work, perhaps in sedentary environments and may be contributing to the higher prevalence of obesity. The positive correlation of TESTB and obesity could also be due to the proposed dilemma of urban sprawl. As the number of establishments per 1,000 population increases, widely dispersed business developments in suburban areas of WV may have induced people to drive more and engage in less biking or walking. This increased reliance on less energy-expending physical activities may have caused WV residents to gain body weight and become obese. This is further evidenced by the positive and significant effect of mean travel time to work (TVTRT) on the obesity rate, which implies that obesity increases as mean travel time to work increases. As previously stated, Frank, Anderson, and Schmid (2004) point out that the likelihood of obesity apparently declines with an increase in mixed land use, but rises with the time spent per day in a car. Perhaps, in a predominantly rural state like WV, residents living in rural areas may have to travel to distant locations for employment or meeting their food and recreation needs, since there are no thriving business/economic development activities within their own county.

The results also indicate that as the total number of food stores per thousand population increases, obesity tends to decrease. This finding is an indication of a food accessibility problem in some WV counties. As the number of grocery stores increases, people have improved opportunities for finding better quality foods. In addition, an increasing number of grocery stores creates competition, which, in turn, motivates these businesses to provide better quality food at lower prices. Halverson et al. (2004) indicated that many counties in WV do not have enough grocery stores. Counties with the least favorable grocery store to population ratio occur largely in the southern part of the state. Morland, Wing, and Roux (2002) indicate that fruit and vegetable intake is positively associated with the presence of a supermarket, even after controlling for personal economic factors. It seems that these hypotheses are also quite applicable to a rural state like WV, with a high prevalence of obesity. RSAM suggest that the behavioral risk factor, percentage of smoking (PSMOKE), has a significant positive impact on obesity. Gruber and Frakes (2005) observed that smoking could also lead to weight gain, thus contributing to a higher prevalence of obesity.

We conclude that obesity is a complex socioeconomic phenomenon which tends to be spatially autocorrelated; in addition to hereditary factors and lifestyle choices, it is also caused by sprawl and lack of land use planning. Policy measures which stimulate educational attainment, promote better land use planning, and lead to "best consumption practices" (BCPs) could both reduce obesity and result in sustainable development of regions that are both obese and economically lagging.

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Table 1. County Socioeconomic and Demographic Variables

Variable	Definition	Source
Dependent variable		
OBESITY	% of obesity	A
Socioeconomic and Demographic factors		
PPSM	Population density (persons/square mile) 1990 and 2000	B
PR	% of population below poverty line	B
PINC	Average per capita income 1990-94 and 1995-99 in $	C
AE	% of population who completed college	B
UR	% of unemployment	B
SSPB	Social Security program beneficiaries per 1000 population	C
WAGE	Average annual wage 1992 and 1998	C
PAFSTS	Food stamp benefits per thousand population ($1000) 1992 and 1997	C
PMCAREB	Medicare benefits per thousand population ($1000) 1992 and 1997	
PSMOKE	% of population who smoke 1992 and 1997	A
PNHINU	% of population with no health insurance 1992 and 1997	A

A: Department of Health and Human Resources, West Virginia Health statistics, Bureau of Public Health; http://www.wvdhhr.org/bph/oehp

B: Online Resource Center, Appalachian Regional Commission; http://www.arc.gov

C: Bureau of Economic Analysis, U.S. Department of Commerce: CA35 personal income transfer receipts http://www.bea.gov/regional/reis/

Table 2. Built-Environment Variables

Variable	Definition	Source
TESTB	Total number of establishments per 1000 population 1993 and 1997	D
FSTOR	Total number of food stores per 1000 population 1993 and 1997	D
EDPLA	Eating and drinking places per 1000 population 1993 and 1997	D
HESER	Health care services per 1000 population 1993 and 1997	D
PPFAC	Physical fitness activity places per 1000 population 1992 and 1997	D
TVTRT	Average travel time to work 1990 and 2000	E
DT	Dummy Time (1=1997 and 0=1992)	*
DN	Dummy North	*
DNE	Dummy Northeast	*
DSE	Dummy Southeast	*
DSW	Dummy Southwest	*
DWT	Dummy West	*
DC	Dummy Central	*
DNW	Dummy Northwest	*

D: U.S. Census Bureau, Economic Census 1992, 1993 and 1997

E: U.S. Census Bureau, Decennial Census 1990 and 2000: Summary Files/Detailed tables http://factfinder.census.gov/servlet/

* Created by the author from information from WV Department of Health and Human Resources and per capita income data from the Bureau of Economic Analysis, U.S. Department of Commerce http://www.bea.gov.

Table 3. Descriptive Statistics: Socioeconomic and Demographic Variables

Variable	Mean	Std Dev	Minimum	Maximum
OBESITY	18.92	4.2	10.2	30.3
PPSM	94.66	101.16	9.58	479.01
PR	20.32	6.36	9.30	39.20
PINC	15438.23	3006.40	9848.98	24363.89
AE	11.10	4.57	4.60	32.40
UR	7.57	3.03	2.4	17.1
SSPB	211.83	30.37	135.00	308.00
WAGE	20915.87	4076.85	14434.63	32826.85
PAFSTS	142.07	51.89	57.70	278.90
PMCAREB	3862.56	19021.40	355.50	195588.57
PSMOKE	26.01	4.82	18.40	40.20
PNHINU	23.23	5.60	10.70	36.10

Table 4. Descriptive Statistics: Built-Environment Factors

Variable	Mean	Std dev	Minimum	Maximum
TESTB	20.48	5.84	7.75	37.36
FSTOR	0.88	0.27	0.27	1.78
EDPLA	1.38	0.64	0.30	4.37
HESER	1.36	0.72	0.135	3.96
PPFAC	0.04	0.07	0.00	0.58
TVTRT	26.12	5.77	17.10	36.10
DT	0.50	0.50	0.00	1.00
DN	0.11	0.31	0.00	1.00
DNE	0.16	0.37	0.00	1.00
DSE	0.15	0.35	0.00	1.00
DSW	0.13	0.33	0.00	1.00
DWT	0.15	0.35	0.00	1.00
DC	0.20	0.40	0.00	1.00
DNW	0.11	0.31	0.00	1.00

Table 5. Random Effects Spatial Error (RSEM) and Spatial Autoregressive (RSAR) Estimation

	RSEM			RSAR		
Variable	Coeff.	Pr>|z|		Coeff.	Pr>|z|	
CONSTANT	-2.12763	0.633		4.46105	0.416	
PPSM	-0.00405	0.410		-0.00215	0.674	
PR	0.13452	0.073	*	0.14016	0.068	*
PINC	0.00040	0.142		0.00024	0.415	
AE	-0.24738	0.012	***	-0.27919	0.007	***
UR	0.11080	0.449		0.06090	0.681	
SSPB	-0.00366	0.739		-0.01122	0.317	
WAGE	0.00026	0.010	***	0.00022	0.036	**
PAFSTS	-0.01040	0.308		-0.00822	0.429	
PMCAREB	-0.00001	0.695		-0.00002	0.244	
PSMOKE	0.07546	0.309		0.15212	0.035	**
PNHINU	-0.02761	0.680		-0.07957	0.224	
TESTB	0.23983	0.050	**	0.26033	0.037	**
FSTOR	-2.90923	0.016	***	-2.56161	0.041	**
EDPLA	-0.09428	0.895		-0.57729	0.436	
HESER	-0.39789	0.632		-0.36532	0.656	
PPFAC	-3.70153	0.314		-1.28640	0.729	
TVTRT	0.30803	0.000	***	0.16616	0.079	*
λ	0.61000	0.000	***			
ρ				0.15400	0.003	***

Number of cross sections: 55, Length of the time series: 2, No of Observations: 110.

*/**/***: Significant at 10%, 5%, or 1% or higher level

Table 6. Fixed Effects Spatial Error (FSEM) and Spatial Autoregressive (FSAR) Estimation

	Fixed SEM			Fixed SAR		
Variable	Coeff.	Pr>|z|		Coeff.	Pr>|z|	
CONSTAT	7.002524	0.267		-1.173769	0.866	
PPSM	-0.002231	0.679		-0.002466	0.648	
PR	0.140892	0.089	*	0.138022	0.105	
PINC	0.000167	0.571		0.000260	0.389	
AE	-0.228564	0.034	**	-0.253478	0.024	**
UR	0.134895	0.392		0.112935	0.494	
SSPB	-0.007866	0.497		-0.010933	0.350	
WAGE	0.000198	0.057	*	0.000197	0.065	*
PAFSTS	-0.005400	0.634		-0.004016	0.729	
PMCAREB	-0.000012	0.416		-0.000015	0.341	
PSMOKE	0.073505	0.373		0.091165	0.254	
PNHINU	-0.035378	0.612		-0.037041	0.598	
TESTB	0.311200	0.012	***	0.297258	0.019	**
FSTOR	-3.378136	0.018	**	-2.908835	0.048	**
EDPLA	-0.256930	0.729		-0.323029	0.680	
HESER	-1.001809	0.254		-0.830886	0.355	
PPFAC	-3.567365	0.329		-2.282894	0.534	
TVTRT	0.158643	0.119		0.155526	0.127	
DT	-3.362627	0.011	**	4.085395	0.240	
DN	1.111596	0.332		1.379088	0.209	
DNE	2.288043	0.087	*	1.756787	0.175	
DSE	1.963887	0.086	*	1.616045	0.146	
DSW	2.201709	0.078	*	1.772235	0.131	
DWT	1.193585	0.318		0.649354	0.579	
DNW	1.858562	0.162		1.370587	0.293	
λ	0.508968	0.001	***			
ρ				0.34499	0.027	**

Number of cross sections: 55, Length of the time series: 2, No of Observations: 110.

*/**/***: Significant at 10%, 5%, or 1% or higher level.

Table 7. Restricted F-tests for Regional Random and Fixed spatial approaches

Model	R-Squared	Number of Restrictions	Number of Parameters	F-test
RSEM	0.599	7	18	0.873*
FSEM	0.626		25	
RSAR	0.593	7	18	0.898*
FSAR	0.621		25	

* not significant at the 10% level.

Figure1. Obesity Prevalence, WV, 1992

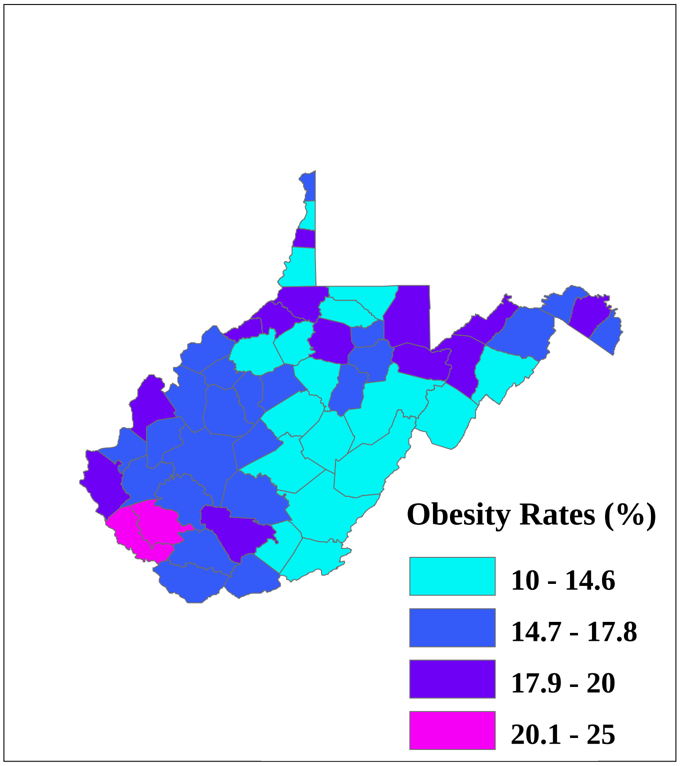

Figure 2. Obesity Prevalence, WV, 1997

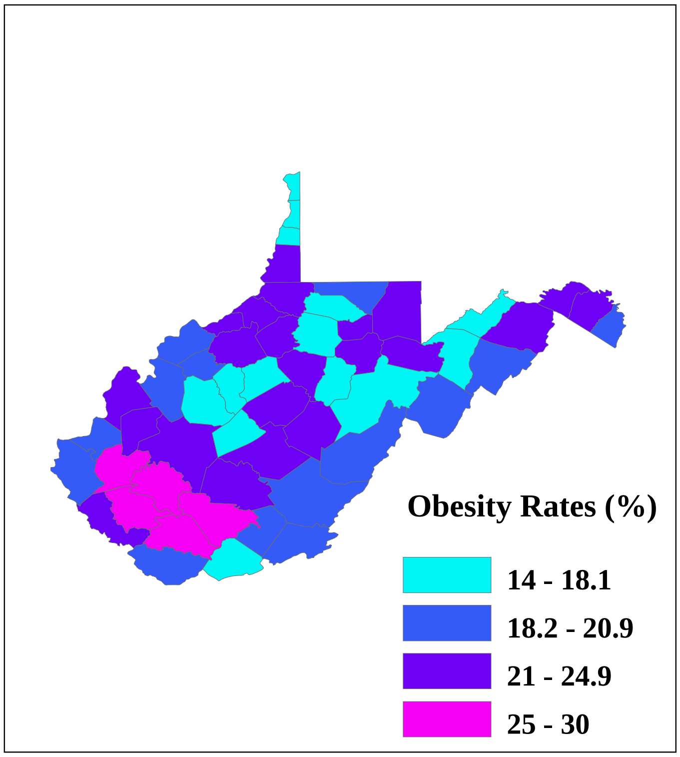

Figure 3. Obesity Rates versus Average College Education Completed, WV, 1992

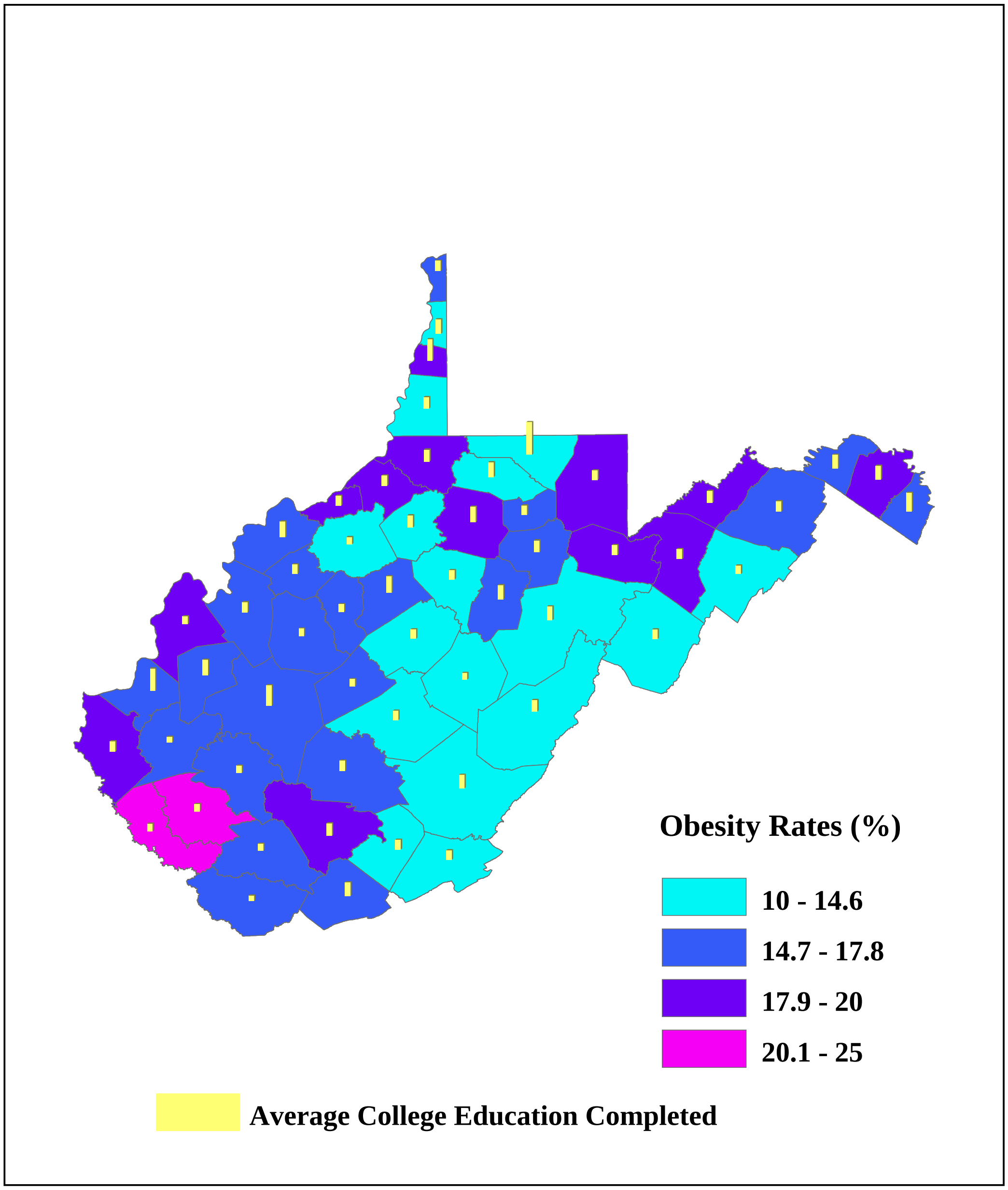

Figure 4. Obesity Rates versus Average College Education Completed, WV, 1997

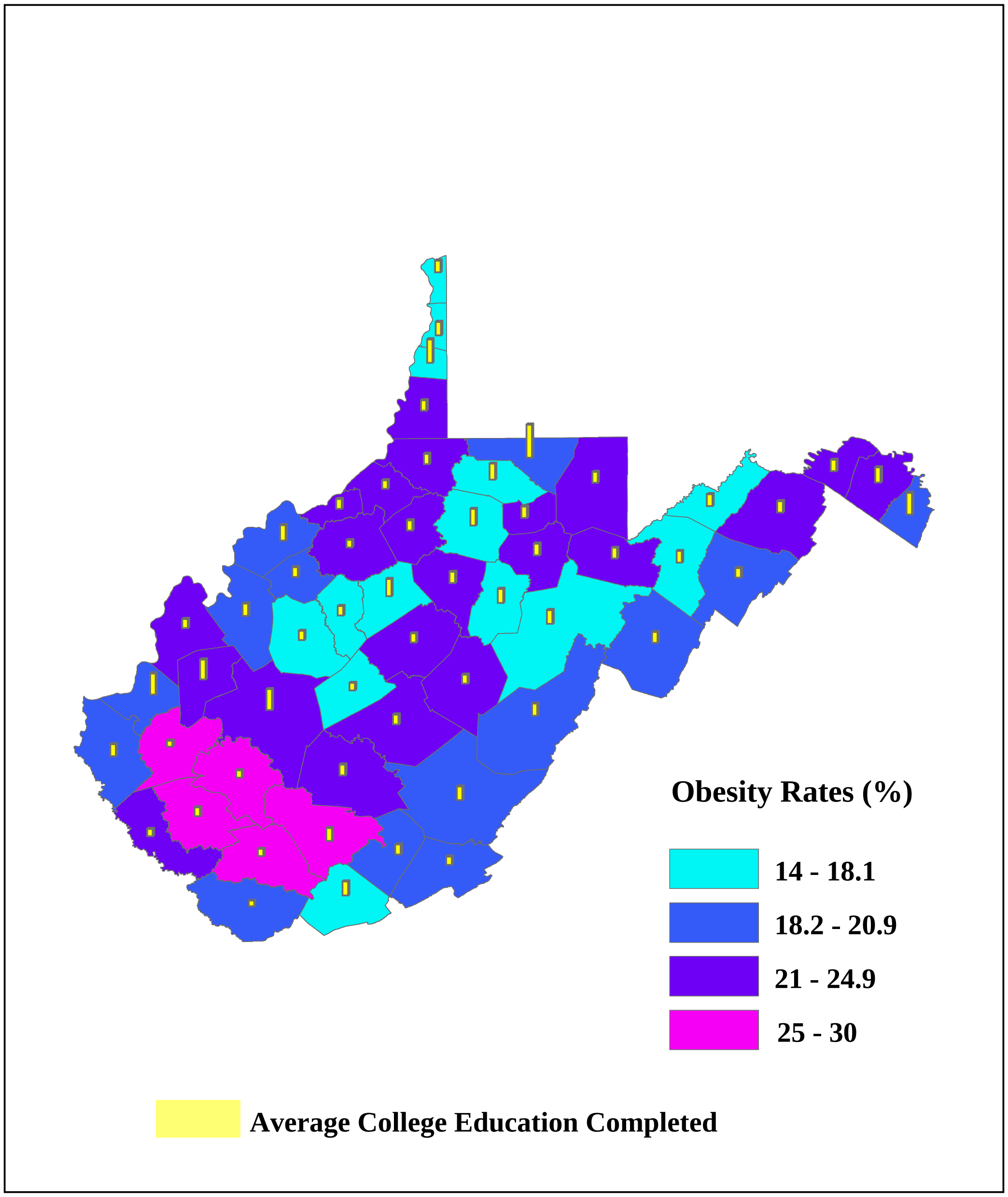

Figure 5. Obesity and Poverty in WV, 1992 (numbers show poverty rate by county)

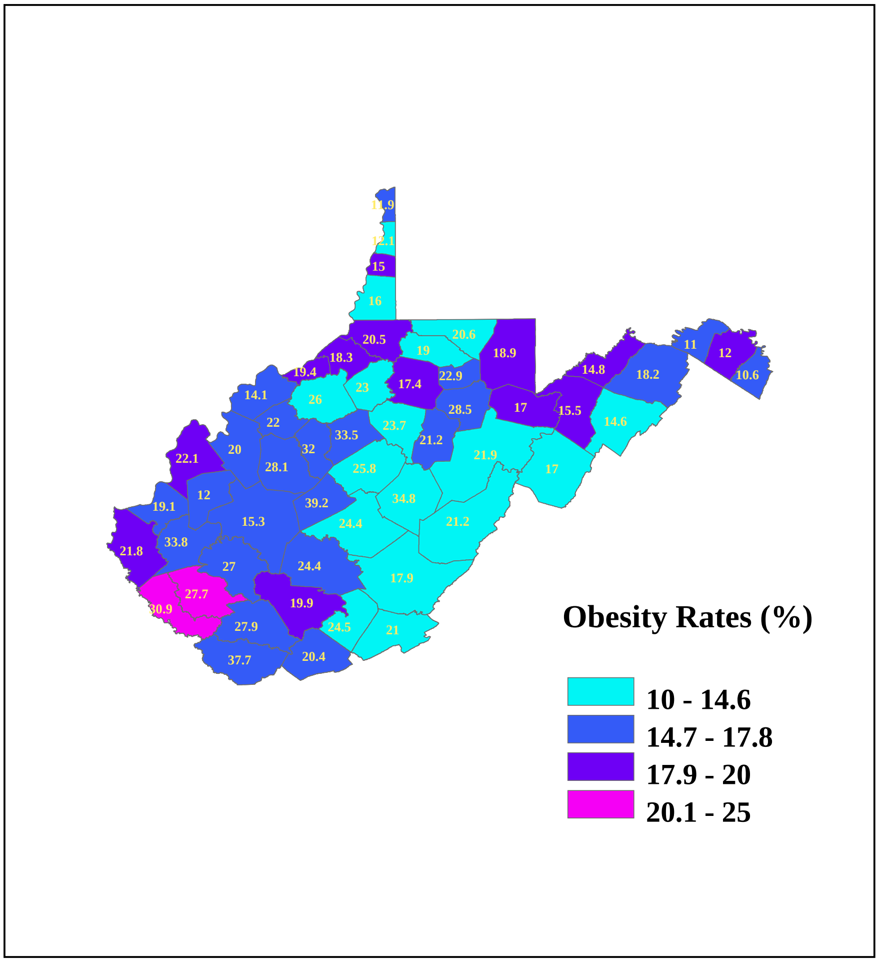

Figure 6. Obesity and Poverty in WV, 1997 (numbers show poverty rate by county)