The Influence of Socioeconomic and Environmental Factors on Health and Obesity in Rural Appalachia

by

Anura Amarasinghe, Gerard D'Souza,
Cheryl Brown, and Hyungna Oh

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Abstract: A recursive system of ordered self assessed health (SAH) and a binary indicator of obesity were used to investigate the impact of socioeconomic and environmental factors on health and obesity in the predominantly rural Appalachian state of West Virginia. Behavioral Risk Factor Surveillance System (BRFSS) data together with county specific socioeconomic and built environment indicators were used in estimation. Results indicate that an individual's risk of being obese increases at a decreasing rate with per capita income and age. Marginal impacts show that as the level of education attainment increases, the probability of being obese decreases by 3%. Physical inactivity increases the risk of being obese by 9%, while smoking reduces the risk of being obese by 14%. Fruit and vegetable consumption lowers the probability of being obese by 2%, while each hour increase in commuting time raises the probability of being obese by 2.4%. In addition, individuals living in economically distressed counties are less likely to have good health. Intervention measures which stimulate human capital development and better land use planning are essential policy elements to improving health and reducing the incidence of obesity in rural Appalachia.

KEY WORDS: health; obesity; human capital; land use; rural

The authors are, respectively, Graduate Research Assistant, Professor and Assistant Professors in the Agricultural and Resource Economics Program, and the Department of Economics (Hyungna Oh), West Virginia University, Morgantown. D'Souza and Brown are also Faculty Research Associates in the Regional Research Institute, West Virginia University.

INTRODUCTION

Individual health is greatly influenced by myriad observed and unobserved socioeconomic and environmental factors. Poor health not only causes low productivity but also low economic growth, and decreasing quality of life. Over the past few decades, a combination of economic, structural, and behavioral changes have had profound impacts on life style choices, with resulting often adverse impacts on health. Overweight and obesity, diabetes, heart aliments and cancers are some of the noncontagious health disorders that have escalated mostly due to changes in life style and the built environment. The growing epidemic of obesity is one of the major public health issues in the developed world, and is often a consequence of high intake of calories relative to energy expenditure. 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).

Even though there is a growing literature on economic and environmental aspects of such noncontagious health disorders, not many studies have probed into the impacts on rural America and economically disadvantaged communities. West Virginia is one such state that is both rural and economically lagging, and with one of the highest obesity rates in the U.S. The rate of adult obesity in WV is 23%, compared with 20% nationally (WV Dept. of Health and Human Resources, 2002). The obesity rate has increased in virtually all WV counties over the past decade with the highest prevalence found in the southern and western portions of the state, as well as in the eastern panhandle (Department of Health and Human Resources WV, 2002). The objective of this study is to examine the causes and consequences of obesity in West Virginia, with implications for other predominantly rural areas of the U.S.

Before discussing the model and estimation procedure, a brief description of the theoretical framework is presented next. The final section discusses the results and policy implications.

BACKGROUND AND THEORETICAL FRAMEWORK

The seminal contributions of the household production framework and the theory of allocation time of Lancaster, (1966) and Becker (1965), showed that households can invest their time and resources to produce a commodity of good health that enters his/her utility function. These investment decisions can have a direct impact on the outlay of marketed goods and the opportunity cost of time that must be withdrawn from other competing uses. Grossman (1972) extended this framework to investigate the investments in health capital influenced by the own time of the consumer and market goods such as medical care, diet, exercise, recreation and housing as well as exogenous socioeconomic and demographic characteristics (Grossman, 1972).

Health is indeed a multi-attribute and dynamic concept, which encompasses both physical and mental components (Cutler and Richardson, 1998). Birth weight can be a good indicator of a healthy newborn (Rosenzweig and Schultz, 1983). As people get older, an individual's health can be influenced by both observed (e.g., lifestyle choices such as smoking and drinking) and unobserved factors (e.g., unobserved genetic, hormonal and biochemical factors). Belloc and Breslow (1972) and Kenkel (1995) showed that health is affected by several lifestyle choices such as diet, smoking, exercise, alcohol consumption, sleep, weight (relative to height), and stress. Realization of health outcomes may have a stochastic component which represents family specific health endowments inherent to the family but not controlled by them (e.g., genetic traits and environmental factors unknown to the decision maker at a time when decisions are made) (Rosenzweig and Schultz, 1983). Estimates of the technical/biological effects of health inputs (e.g., medical services) on an individual's health have been obtained from "hybrid" health equations that contain prices of inputs, income, and health measures as regressors (Harris, 1982; Edwards and Grossman, 1979) ignoring the fact that self-selected health inputs were endogenous (Rosenzweig and Schultz, 1983). Rosenzweig and Schultz (1983) utilized the instrumental variable (IV) estimation to obtain consistent estimates of a child's health (birth weight) production function recognizing that health input choices influenced by unobserved factors also, in turn, affect health outcomes.

Event though there are different measures of health, self-assessed health (SAH) has been extensively used as a predictor in the previous health economics literature by Kemma (1987), Berger and Leigh (1989), Kenkel (1995) and more recently by Contoyannis and Jones (2004). A multivariate probit (MVP) analysis of British panel data from the Health and Lifestyle Survey (HALS) showed that discrete indicators of lifestyle choices such as sleeping well, exercising, and not smoking may have a positive effect on the probability of reporting excellent or good SAH (Contoyannis and Jones, 2004). The failure of epidemiological analyses to account for unobserved heterogeneity can give biased estimates of the relevant lifestyle choices in the socio-economic status–health relationship (Contoyannis and Jones, 2004). A stochastic dynamic programming framework (Sickles and Yazbeck, 1998) showed that the individual maximizes lifetime utility subject to budget and time constraints by choosing hours of leisure and levels of consumption of health-related and health-neutral goods and services. The estimated health elasticities with respect to leisure ranged between 0.59 to 0.69 with some slight upward trend over time. The elasticity of health-related consumption is also between 0.031 and 0.045 with an upward trend over time. Kenkel (1991) showed that schooling helps people choose healthier lifestyles by improving their knowledge of the relationship between health behaviors and health outcomes, i.e., schooling improves a household's allocative efficiency in producing health.

Obesity has been found to have significant effects on an individual's health and longevity and the economy as a whole (Philipson, 2001). 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). Subsequently, obesity has become a major burden on welfare programs such as medicare and social security (Kuchler and Ballenger, 2002).

Philipson (2001) argued that in an agricultural or industrial society, work tends to be strenuous, and, in turn, the worker is paid to exercise. In most post-industrial and redistributive societies, such as the U.S., most work entails little exercise, and also not working does not lead to starvation or cause reduction in weight, because of food stamps and other welfare programs. As a result, people must pay for undertaking, rather than being paid to undertake, physical activity. Payment is mostly in terms of forgone leisure, because leisure weight control must be substituted for weight control by physical exertion at work (Philipson, 2001). The wage penalty or the opportunity cost of time, time use decisions, and health of a family have become important issues today as more and more women participate in the labor force. The labor force participation rate of women with young children (under 6 years of age) increased from 39% in 1975 to 62% in 1996 (Guthrie *et al.,* 2002). Increased participation of women in the labor force has reduced time available for non-market household activities and motivated people to consume relatively cheap high-caloric foods leading overweight and obesity (Chou *et al.,* 2002). Chou *et al.* (2002) also identified smoking, unemployment and job strenuousness as other factors that could lead to obesity. Investigation of health response to the changes in economic environment (Rhum, 2000) shows that health improves when the economy temporarily deteriorates. Their results also show that smoking and obesity increase when the economy strengthens, whereas physical activity is reduced and the diet become unhealthy. Drewnowski (2003) showed that wealth and poverty have profound effects on diet structure, nutrition and health. His study emphasized that income and the macronutrient composition of diets are linked at the aggregate and most likely at the individual level. In higher income nations, cost per unit of food energy is low such that those nations are associated with high-energy intakes. Accordingly, people in higher income nations consume more added sugars and fats than those in low-income nations. In addition, low-income consumers within rich nations consume lower quality diets than do higher income consumers. Drewnowski and Specter (2004) also suggested that the highest rates of obesity tend to occur among population groups with the highest poverty rates and the least amount of education. Also, poverty and food insecurity are associated with lower food expenditures, low fruit and vegetable consumption, and lower-quality diets (Drewnowski and Specter, 2004). Obesity can also have a negative effect on body image (the mental picture one has of one's body). Philipson (2001) indicated that ones weight could impact the rising social phenomenon of divorces. Body image has the potential to affect physical and mental health diminishing the cognitive functioning and thus academic performance (Rudd and Lennon, 2001). Poor body image also contributes to psychosocial distress (Page, 1991). The greater value of thinness to women than men is reflected in studies that find a greater negative correlation between earnings and being overweight for woman than men (Register and Williams, 1990; Pagan, 1997).

Recent past urban sprawl, characterized by a complex pattern of land use, transportation, and socioeconomic development have had both positive and negative implications on quality of life and public health (Frumkin, 2002). Urban sprawl, characterized by low residential density, low employment density, and poor street connectivity is associated with less walking and bicycling and with more automobile travel than denser communities has profound effects on low levels of physical activity, obesity and public health directly (Ewing *et al*., 2003; Lopez, 2004, Blanchard and Lyson, 1999, Frank *et al*., 2004, Block *et al*., 2004). With this background information, this study investigated how complex socioeconomic and physical environments impact the health and quality of life particularly in a rural setting.

METHODOLOGY

As previously noted, an individual's health can be affected by myriad observed and unobserved heterogeneous factors. Thus, the lifestyle choices which enter into health demand functions are arguably endogenous in nature (Rosenzweig and Schultz, 1983; Contoyannis and Jones, 2004). If the lifestyle choices are correlated with the stochastic error term, the single equation estimations would yield biased and inconsistent estimates.

In order to address this endogeneity issue, a two stage recursive approach was used for this analysis. This analysis follows the two stage estimation techniques proposed by Heckman (1978); Lee (1982); and Rosenzweig and Schultz (1983). In this two stage estimation process, an ordered latent-class variable of self-assessed health is considered to be explained by the individual's socioeconomic, demographic and environmental covariates. Denoting individual *i*'s unobserved latent health status as H^*_i, the model can be written as:

$H^*_i = \varphi' L^*_i + \omega' X + u_i$, where $u_i \sim (0,1)$.

The vectors L^* and X represent lifestyle choices and other socioeconomic and demographic characteristics, respectively. The individual's health status, H_i, is equal to k, if $\mu_{ik} < H^*_i \leq \mu_{ik+1}$ where the parameter *k* = 1, 2, 3, represents three self-assessed health categories, "poor," "fair," and "good" health. The parameter μ_{ik}, which varies from $-\infty$ to $+\infty$, denotes the unknown threshold levels of health categories that are to be estimated together with parameters φ and ω. Thus, the probability, *P*, of having a certain health status can be defined as:

(1) $P\left[H_i = 1 \middle| X, L\right] = \Phi(\mu_k - \varphi' L^*_i + \omega' X)$,

(2) $P\left[H_i = 2 \middle| X, L\right] = \Phi(\mu_k - \varphi' L^*_i + \omega' X) - \Phi(\mu_{k+1} - \varphi' L^*_i + \omega' X)$,

(3) $P\left[H_i = 3 \middle| X, L\right] = 1 - \Phi(\mu_{k+1} - \varphi' L^*_i + \omega' X)$,

where Φ denotes the cumulative distribution function (CDF) of the standard normal distribution. Since the vector of lifestyle choices, L^*_i, is assumed to be endogenous to the system, it could be correlated with the unobserved factors affecting one's self-assessed health

(SAH). In order to overcome such endogeneity bias, a recursive estimation process is used in which the first stage predictions of lifestyle choices are incorporated into the self-assessed health demand. The fully recursive system can then be specified as:

(4) $$H^*_{1i} = \varphi' \hat{L}^*_2 + \omega' X_1 + u_{1i}, \quad u_{1i} \sim \left(0, \sigma_{u_{1i}}^2\right),$$

(5) $$L^*_{2i} = \omega' X_2 + u_{2i}, \quad u_{2i} \sim \left(0, \sigma_{u_{2i}}^2\right),$$

where $E(u_{1i}u_{2i}) = \sigma_{12}$, $i.........I$; $j = 1, 2$, $E(u_{ji}u_{j'i'}) = 0$ for j , j' =1,2, $i \neq i'$, and L^*_{2i} is another latent-class variable of lifestyle choices. For example, obesity, which is used as a proxy for an individual's weight status, is considered a latent-class dependent variable in equation (5) above.

DATA AND ESTIMATION PROCEDURE

Individual data relevant to the state of WV are compiled from the Behavioral Risk Factor Surveillance System (BRFSS) year 2003 micro data files that investigated adult health behavior across the state. County specific land use and other socioeconomic variables were obtained from other secondary data sources (U.S. Census Bureau, 2000; Appalachian Regional Commission, 2005). The Behavioral Risk Factor Surveillance System (BRFSS) is a monthly telephone survey conducted by the CDC that allows states to monitor health behaviors among their adult population (18+). The BRFSS was begun in 1984 with 15 participating states and has monitored obesity since that time, expanding to 52 states and territories in 1997.

The respective variables considered for this study and their definitions are given in Tables 1 and 2. Their summary statistics are presented in Tables 3 and 4. OBESE and OGENHLTH are categorical dependent variables in the recursive system represented by equations 4 and 5. OBESE is a binary dependent variable which indicates whether a person is obese (equal to 1) or not (equal to 0). Individuals whose body mass index (BMI) is greater than or equal to 30, are considered to be OBESE. OGENHLTH is an ordered latent-class dependent variable which indicates the individual's ordered self-assessed health (SAH) responses of "good", "fair" or "poor".

Level of education (LEDUCA) is an ordered categorical explanatory variable which varies from 0 to 5. The resulting six educational categories are: (0) never attended school or kindergarten, (1) attended elementary school, (2) attended some high school, (3) high school graduate, (4) attended college, and (5) college graduate. DSEX is a gender dummy for which female is the base category. Hispanics (HISP), white non-Hispanic (WNONH), black non-Hispanic (BNONH) and other multicultural non-Hispanic (OMNONH) represent the ethnic composition of the sample. Per capita income (PINC) is created by considering the mid-points of the income categories to which an individual belongs. Individuals who have incomes equal to or greater than \$50,000 are assumed to have per capita income of \$50,000. The per capita income (PINC) variable of this study ranges from \$7,500 to \$50,000. The idea of including one income variable rather than categories is to reduce the number of categorical explanatory variables included in the explanatory vector. Employed (EMPLOYD), student (STUDENT), retired (RETD) and other (OTHERE) are dummy explanatory variables which represent employment status of individuals. Other employment (OTHERE), which served as the reference category, includes individuals who are unable to work or are out of work for about one year.

Widowed (WIDOW), married or cohabited (MALT), divorced and separated (DIV_SEP) and never married (NMARRI) represent the marital status of individuals. Sedentary (SEDENT) is a dummy variable which indicates the physical inactivity of an individual. Respondents who report no moderate or vigorous physical activity or exercise are considered to be sedentary or physically inactive. SMOKING is another indicative dummy variable which takes the value 1 if an individual ever smoked 100 cigarettes in his/her lifetime and now smokes every day or some days. SMOKING takes the value 0, if an individual does not smoke now. HCARE, RHEART, RASTHMA, RFDRHV, are also dummy indicator variables which represent whether an individual possesses a health care plan, is at risk of having heart ailments, is at risk of having asthma problems and is at risk of heavy alcohol consumption, respectively. Risk of heavy alcohol consumption (RFDRHV) is determined by whether a male respondent has more than 2 drinks per day, or a female respondent has more than 1 drink per day. FRTINDX is an ordered categorical variable which describes fruit and vegetable consumption of respondents. The fruit and vegetable consumption frequencies, ordered from 1 to 4, represent whether a respondent consumes fruit and vegetables at a level of less than 1 serving per day, 1 to less than 3 servings per day, 3 to less than 5 servings per day, or 5 or more servings per day. Average travel time to work in a county (TRVT) is another continuous explanatory variable that is included to capture the potential influence of the built environment on obesity. TRVT was computed by using information in U.S. Census 2000.

DDISTD is a county specific dummy variable which indicates the economic status of a respondent's county, i.e., whether the county is economically depressed or not. Using the Appalachian Regional Commission classification scheme, the county economic status is classified as depressed if the county's three–year average unemployment rate is at least 1.5 times the national average, per capita market income is no greater than two–thirds of the national average, and the poverty rate is at least 1.5 times the national average; or the county has at least twice the national poverty rate and meets the criteria for either the unemployment or the income indicator.

RESULTS

The first stage binary logit and probit estimations with the risk of being obese as a dependent variable (OBESE), are presented in Table 5. Empirical results show that the level of educational attainment (LEDUCA) has a significant negative impact an individual being obese. A unit increase in educational level would lower the log odds of being obese by 0.184, while other variables in the model are held constant. Out of the ethnic categories, Hispanics (HISP) are less likely to be obese in comparison to the base category of other multicultural non-Hispanics. For a Hispanic, the log odds of being obese is lower by 0.86 units. In order to investigate a nonlinear impact of age (AGE) and per capita income (PINC), the squared terms, age squared (AGESQ) and income squared (INCSQ), are also added as explanatory variables to the model. Their directional impact indicates that the probability of being obese increases at a decreasing rate with both age (AGE) and per capita income (PINC). A $1,000 increase in per capita income would raise the probability of being obesity by about 0.004 units in a log odds scale.

Other results show that students are less likely to be obese than their base counterparts (i.e., those who are unable to work or are out of work for more than one year). The expected probability of a student being obese is reduced by 0.8 units in log odds scale. None of the variables that represent marital status indicate a significant impact on the probability of an individual being obese. Sedentary (SEDENT), smoking (SMOKING), fruit and vegetable consumption index (FRTVINDX), individual possessing a health care plan (HCARE), and risk of heavy alcohol consumption (RFDRHV) are dummy explanatory variables which represent individual risk behaviors. Risk of having heart ailments (HEART) and risk of having asthma problems (RASTHMA) are also dummy indicator variables which represent individual existing health related conditions. Considering risk behaviors, as expected, smoking (SMOKE) and a sedentary lifestyle (SEDENT) show opposite impacts on an individual being obese. While smoking negatively and significantly contributes to obesity, sedentary behavior positively and significantly contributes to obesity. Respondents who smoke reduce the log odds of being obese by 0.8 units. In contrast, respondents with sedentary lifestyles are more likely to be obese with log odds of 0.5 units. The fruit and vegetable consumption index (FRTVINDX), which represents an individual's consumption patterns for these products, is also negatively correlated with obesity. As fruit and vegetable consumption increases, the log odds of being obese decrease by 0.1 units. DDISTD and TRVT are county specific covariates included in the regressions. DDISTD indicates whether a county is economically distressed, or in a transition stage. Although the county economic situation (DDISTD) does not seem to show any significant impact on obesity, the average travel time to work (TRVT) positively contributes to the log odds of being obese. As average travel time to work in minutes attributable to a respondent's residential county increases by one unit, the log odd of being obese increases by 0.07 units. In comparison to the binary logit specification, the binary probit estimation yields similar directional impacts on the odds of being obese with regard to the variables discussed above. In addition, the binary probit specification shows that males (DSEX) are more likely to be obese than females.

Table 6 presents the marginal probabilities of an individual being obese for the variables presented in Table 5. Both logit and probit estimations indicate that as the level of education increases, the probability of being obese decreases by 3%. Hispanics are 16% less likely to be obese than non-Hispanic ethnic groups. Even though per capita income (PINC) has a significant effect on the probability of an individual being obese, its marginal impact is shown to be very small. If the respondent is a student, the probability of being obese is reduced by about 16%. As age increases, the marginal probability of being obese increases (by 2%) at a decreasing rate. While the marginal impact of physical inactivity or a sedentary lifestyle (SEDENT) increases the risk of a person being obese by 9%, smoking reduces the risk of being obese by 14%. An increase in fruit and vegetable consumption significantly lowers the probability of a person being obese by 2%. A one minute increase in travel time would raise the probability of being obese by 0.04%

Table 7 presents second stage ordered maximum likelihood probit and logit estimates of self-assessed health (SAH) in terms of socioeconomic, demographic and risk behaviors and the respondent's residential county specific variables. The dependent variable (OGENHLTH) is an ordered latent-class variable which indicates the ordered self-assessed health (SAH) categories of "good," "fair," and "poor." Corresponding to the ordered logit estimation of SAH, CONSTANT2 and CONSTANT1, are the estimated ordered logit for the adjacent level health category, "good" versus "fair" and "poor," and "good" and "fair" versus "poor," respectively, when the other covariates are evaluated at zero. For example the log odds of "good" versus "fair" and "poor" SAH for a female (i.e., DSEX evaluated at zero) is 1.77. The log odds of "good" and "fair" versus "poor" for a female is 3.34. The socioeconomic variables educational attainment (LEDUCA) and income (PINC) significantly and positively raise the expected SAH. In addition PREDOBE represents the predicted values of the first stage estimation for an individual being obese.

A unit increase in educational attainment would raise the expected SAH in ordered log odds scale by 0.2 units while the other variables in the model are held constant. Similarly, a $1,000 increase in income would raise the value of expected health by 0.1 units. Out of the covariates that describe employment status, those who are employed (EMPLOY) and retired (RETD) are the most likely to show good health. There is no significant contribution by gender to expected health. As age increases, expected SAH in log ordered scale tends to decrease. The behavioral risk factors obesity, sedentary lifestyle and smoking negatively and significantly affect expected health. The expected SAH when one is obese (PREDOBE) decreases by 2.61 units in a log ordered scale. Similarly, having a sedentary lifestyle (SEDENT) would lower expected health by 0.65 units. In addition, smoking (SMOKE) lowers expected health by 0.77 units. Respondents who are at risk of having heart ailments and asthma conditions are less likely to have good health. Risk of being a heart and asthma patient lowers the expected SAH in log ordered scale by about 0.80 units. Contrary to expectations, fruit and vegetable consumption does not show a significant impact on health. Lastly, respondents living in economically distressed counties are less likely to have good health. For a resident of an economically distressed county, the expected SAH in ordered log scale is lower by 0.47 units. None of the categories of marital status shows a significant difference for their expected SAH. In comparison to the ordered logit estimation, ordered probit estimations show similar directional impacts on expected health for the respective variables, except for being a student. The ordered probit estimate shows that students are more likely to have good health relative to the base, their unable-to-work counterparts.

CONCLUSIONS

In this analysis, a recursive system of multivariate ordered probit/logit analysis of self assessed health (SAH) and a binary logit/probit specification for risk of being obese were estimated in terms of socioeconomic, demographic and county specific socioeconomic indicators. Both estimations showed that the level of education has a significant impact on the expected (SAH) health outcome and on the risk of being obese. While education positively and significantly contributes to expected SAH, it significantly and negatively contributes to obesity. This reinforces the result from previous studies (Nayga, 2000; Chou *et al.,* 2004; Kan and Tasi, 2004) which also show that educational attainment has a negative impact on the probability of being obese. Nayga (2000) indicated that not only does diet-disease knowledge decrease the probability of being obese, but also policies to promote diet-disease knowledge could lead to decreasing the incidence of obesity.

Mancino *et al.* (2004) found that women with a college education have a greater feeling of control over their own weight and exercise more frequently. Kenkel (1991) and Grossman (1972) also suggest that schooling improves the choice of health inputs by improving an individual's health knowledge. These findings seem quite relevant for a state like WV, where the educational differences across the state have been persistent over time (Halverson *et al.,* 2004).

Ordered probit/logit estimations show that higher educational attainment significantly increases the probability of reporting better expected health outcomes. Contoyannis and Jones (2004) point out that it is difficult to identify a gradient of different educational categories in evaluating their self-assessed health, while also stating that individuals in lower educational categories have a significantly lower probability of reporting excellent or good health.

In terms of ethnicity, Hispanics are less likely to be obese than their non-Hispanic counterparts. Although this is contrary to previous findings, it could be quite possible in a WV setting. In the past twenty years the Hispanic share of the working class in the U.S. has increased three-fold, from 6% in 1980 to 20% in 2000, primarily due to immigration (U.S. Census, 2000). In WV, although the population with Hispanic origins has increased at a comparatively slower rate, from 0.5% in 1990 to 0.7% in 2000 (WV Department of Health and Human Resources, 2004) the sample considered for this study contained 2.1% Hispanics. A reasonable explanation for this may be that the physical labor-intensive activities of this ethnic group, which constitutes a greater proportion of the "working class," also contributes to their relative lack of obesity. As Philipson (2001) suggested, work tends to be strenuous in an agricultural or industrial society and, in turn, the worker is "paid to exercise." Perhaps this proposition is quite applicable to this ethnic group particularly in WV. None of the other ethnic groups have a significant impact on self assessed health (SAH).

Chou *et al.* (2004) and Nayga (2000) suggest that income negatively and significantly contributes to an individual being obese. Estimations in the current study suggest that the risk of obesity increases at a decreasing rate with household income. This implies that as income increases, the risk of being obese increases up to a certain income level and then, further increases in the level of income lowers the risk of being obese. Drewnowski and Specter (2004) indicate that the highest rates of obesity occur among groups with the highest poverty rates and the least education. As usual, the positive impact of income on health reinforce the fact that the "commodity" good health is a normal good. Lee (1982) showed that demand for health rises with "net family assets," since good health is expected to be a normal good.

Marital status does not significantly contribute either to obesity or to expected self-assessed health. This result is contrary to the recent finding of Gruber and Frakes (2005) that married and widowed individuals have higher body mass index (BMI) and obesity odds, than divorced and never-married individuals. Divorced individuals, in turn, have a lower weight outcome than those who have never married. Binary probit estimations show that males are more likely to be obese than females. However, the impact of gender on obesity cannot be interpreted with great precision as its significance is not consistent across models. The findings of Nayga (2000) reveal that females tend to have more diet-disease knowledge than males and that such knowledge has a significant and negative effect on the probability of being obese.

The quadratic effect of age indicates that the probability of being obese increases with age but at a decreasing rate. Similar age effects are also reported by Chou, Grossman, and Saffer (2004) and Kan and Tasi (2004). Gruber and Frakes (2005) showed that age follows a non-linear relationship with both BMI and the probability of obesity. BMI and obesity appear to rise with age and then peak in the 50s, thereafter going down again for those in their 60s. The negative coefficient of the AGE variable in the health equation suggests that as age increases, the probability of reporting good health decreases. Lee (1982) pointed out that health deteriorates with age, with the rate of health depreciation rising with age for middle-aged individuals.

Results from previous studies are equivocal in terms of risk behavior (i.e., smoking and sedentary lifestyles) impacts on obesity. For example, while Chou, Grossman, and Saffer (2004) argue that smoking lowers the risk of being obese, Gruber and Frakes (2005) claim that smoking increases the risk of obesity. Our results also show that risk behaviors including smoking and a sedentary lifestyle, and risk of having other health-impaired conditions such as heart disease and asthma, as expected, are significantly and negatively correlated with an individual's self-assessed health.

Another interesting finding of this study is that commuting time to work is positively and significantly related to the risk of obesity. This somewhat strengthens the implication of the urban sprawl hypothesis of obesity. Frank *et al.*(2004) suggest that the likelihood of obesity apparently declines with an increase in mixed land use but rises with time spent per day in a car. The authors suggest that the potential path of causality between urban sprawl and disease status is: urban sprawl → increased automobile use → decreased physical activity → obesity → increased cardiovascular disease, diabetes and other health problems. Urban sprawl may also reduce physical activity because parks or fitness facilities are more distant. It also may affect diets by increasing distance to supermarkets or it may increase the cost of nutrition by conversion of farmland to urban uses (Frumkin, 2002). Similar to the urban sprawl hypothesis, residents of rural states like WV depend heavily on automobile travel when there are no economic development activities within their residential counties. Rural residents may travel to more distant areas not only for employment opportunities but also for their daily needs since supermarkets and grocery stores are sparsely distributed. In addition, respondents from economically distressed counties are more likely to have impaired health outcomes than respondents from economically advantaged counties.

Overall this study suggests that not only do individually-centered socioeconomic conditions such as level of education, income, age and risky behaviors contribute to health of WV residents, but also that the surrounding economic environment greatly impacts on their health and quality of life. Previous studies also found that there are disparities among socioeconomic as well as business environments across the state. Findings from this study also shed evidence that urban sprawl is likely a contributing factor to life style choices and, therefore, the health and obesity status of rural people. Although there could be a bias associated in reporting self assessed health, we believe this study provides some useful insights for policy formulation in combating health issues like obesity and promoting wellbeing of WV residents and those in other states with predominantly rural residents. Toward this end, the results suggest that intervention strategies be targeted toward age-specific educational programs focusing on health, in conjunction with state wide income enhancing activities and careful land use planning. More specifically, the results suggest that intervention measures which stimulate human capital development together with better land use planning are more likely to improve health and reduce obesity in rural America.

APPENDIX

Global Null Hypothesis Tests for Probit and Logit Estimations

		Logit			Probit		
		Chi-Square	df	Pr >ChiSq	Chi-Square	df	Pr >ChiSq
Obese	**Likelihood**	153.2600	22	<.0001	154.2987	22	<.0001
	Score	145.0205	22	<.0001	145.0205	22	<.0001
	Wald	133.7706	22	<.0001	141.8433	22	<.0001
Ordered Health	**Likelihood**	731.9117	22	<.0001	744.7313	22	<.0001
	Score	679.3992	22	<.0001	710.7284	22	<.0001
	Wald	529.5456	22	<.0001	612.7364	22	<.0001

Model Comparison Test Statistics for Probit and Logit Estimations

Model	Criterian	Logit	Probit
Obese	**AIC**	2396.766	2395.727
	SC	2526.872	2525.833
	-2LogL	2350.766	2349.727
Ordered Health	**AIC**	2433.836	2421.016
	SC	2570.071	2557.252
	-2LogL	2385.836	2373.016

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Table1. Definition of Variables: Dependent Variable, Educational Level, Gender, Demographic, Income and Employment Categories

Variable	Definition	Source
Dependent Variables		
OBESE	Obesity: indicator	*
OGENHLTH	Ordered health: indicator “good”, “fair” and “poor.	*
Covariates		
Demographic categories		
LEDUCA	Level of education: Ordered categorical variable	*
DMALE	Male (Dummy Variable)	*
OMNONH	Other multicultural non-Hispanic (Dummy)	*
WNONH	White Non-Hispanic (Dummy)	*
BNONH	Black Non-Hispanic (Dummy)	*
HISP	Hispanic (Dummy Variable)	*
AGE	Age (Continuous)	*
AGESQ	Age Squared (Continuous)	*
Income Categories		
PINC	Per capita income (Continuous)	*
INCSQ	Per capita income squared (Continuous)	
DINLT15	Income group less than $15,000 (Dummy)	*
DIN1535	Income group between $15,000 <$ 35,000 (Dummy)	*
DIN3550	Income group between $35,000 < $ 50,000 (Dummy)	*
DINOV50	Income group over $50,000 (Dummy)	*
Employment Status		
OTHERE	Other employment (Dummy)	*
EMPLOYD	Employed (Dummy)	*
STUDENT	Student (Dummy)	*
RETD	Retired (Dummy)	*

* Created by the author using the BRFSS (Behavioral Risk Factor Surveillance System) 2003 Micro Data file

Table 2. Definition of Variables: Marital Status and Other Covariates

Variable	Definition	source
Marital Status		
WIDOW	Widowed (Dummy)	*
MALT	Married or Cohabited (Dummy)	*
DIV_SEP	Divorced or Separated (Dummy)	*
NMARRI	Never Married (Dummy)	*
Other Covariates		
SEDENT	Sedentary (Dummy)	*
SMOKING	Smoking (Dummy)	*
HCARE	Has health care (Dummy)	*
RHEART	Risk of having heart problems (Dummy)	*
RASTHMA	Risk of having Asthma (Dummy)	*
RFDRHV	Risk of Alcohol consumption (Dummy)	*
FRTINDX	Fruit and Vegetable consumption index (Ordered)	*
DDISTD	County economic status : Depressed (Dummy)	B
TRVT	Average travel time (minutes) to work for County	E

* Created by the authors by using BRFSS (Behavioral Risk Factor Surveillance System) 2003 Micro Data file
B: Online Resource Center, Appalachian Regional Commission; http://www.arc.gov
E: U.S. Census Bureau, Decennial Census 2000: Summary Files/Detailed tables
http://factfinder.census.gov/servlet/

Table 3. Descriptive Statistics: Dependent Variable, Educational Level, Gender, Demographic, Income and Employment Categories

Variable	Mean	Std Dev	Min	Max
Dependent Variables				
OBESE	27.69	0.45	0.00	1.00
OGENHLTH	1.622	0.67	0.00	3.00
Covariates				
Demographic categories				
LEDUCA	3.345	1.14	0.00	5.00
DMALE	39.50	0.49	1.00	0.00
OMNONH	4.50	0.21	0.00	1.00
WNONH	91.70	0.28	0.00	1.00
BNONH	1.80	0.13	0.00	1.00
HISP	2.01	0.14	0.00	1.00
AGE	51.00	17.00	18.00	97.00
AGESQ	2039.40	1831.90	324.00	9049.00
Income Categories				
PINC	30460.01	15521.59	7500.00	50000.00
INCSQ	116864.00	94238.00	5625.00	250000.00
DINLT15	18.06	0.38	1.00	0.00
DIN1535	40.75	0.49	1.00	0.00
DIN3550	16.41	0.37	1.00	0.00
DINOV50	24.79	0.43	1.00	0.00
Employment Status				
OTHERE	14.70	0.35	1.00	0.00
EMPLOYD	61.26	0.49	1.00	0.00
STUDENT	2.81	0.17	1.00	0.00
RETD	21.24	0.41	1.00	0.00

Table 4. Descriptive Statistics: Marital Status and Other Covariates

Variable	Mean	Std Dev	Minimum	Maximum
Marital Status				
WIDOW	14.29	0.35	0.00	1.00
MALT	57.22	0.49	0.00	1.00
DIV_SEP	20.40	0.40	0.00	1.00
NMARRI	11.00	0.31	0.00	1.00
Other Covariates				
SEDENT	12.81	0.33	0.00	1.00
SMOKING	26.14	0.44	0.00	1.00
HCARE	83.63	0.37	0.00	1.00
RHEART	37.43	0.48	0.00	1.00
RASTHMA	8.98	0.29	0.00	1.00
RFDRHV	2.68	0.16	0.00	1.00
FRTINDX	2.70	0.85	1.00	4.00
DISTD	23.07	0.42	0.00	1.00
TRVT	25.42	4.42	19.50	36.8

Table 5. Maximum Likelihood Probit and Logit Estimates of Obesity Risk

	Binary Logit			Binary Probit		
Variable	**Estimate**	**Pr>ChiSq**		**Estimate**	**Pr>ChiSq**	
CONSTANT	-3.441000	0.0001	***	-2.055600	0.0001	***
LEDUCA	-0.184000	0.0008	***	-0.110200	0.0007	***
WNONH	-0.258500	0.2597		-0.157600	0.2546	
BNONH	0.166200	0.6806		0.079400	0.7451	
HISP	-0.866300	0.0609	*	-0.524500	0.0497	**
PINC	0.000041	0.0204	**	0.000024	0.0213	**
INCSQ	-0.000000	0.0081	***	-0.000000	0.0082	***
EMPLOYD	-0.261100	0.1138		-0.156300	0.1149	
STUDENT	-0.791200	0.0898	*	-0.446400	0.0813	*
RETD	-0.237400	0.2822		-0.145300	0.2692	
DSEX	0.172600	0.1104		0.108600	0.0912	*
MALT	0.035900	0.8565		0.018800	0.8724	
DIV_SEP	-0.266200	0.2244		-0.161300	0.2110	
NMARRI	0.399700	0.1137		0.230500	0.1242	
AGE	0.140900	0.0001	***	0.083400	0.0001	***
AGESQ	-0.001460	0.0001	***	-0.000870	0.0001	***
SEDENT	0.520100	0.0015	***	0.312600	0.0016	***
SMOKING	-0.808600	0.0001	***	-0.473800	0.0001	***
HCARE	0.033000	0.8279		0.010500	0.9074	
RFDRHV	0.076100	0.8211		0.044600	0.8224	
FRTVINDX	-0.118600	0.0655	*	-0.069300	0.0697	*
DDISTD	-0.086100	0.5035		-0.057300	0.4553	
TRVT	0.021800	0.0720	*	0.013900	0.0532	**

*/**/***: Significant at 10%, 5%, or 1% or higher level. N=2115

Table 6. Marginal Probabilities of Risk of Being Obese

	Marginal Effects	
Variable	Probit	Logit
LEDUCA*	-0.0347	-0.0344
WNONH	-0.0496	-0.0483
BNONH	0.0250	0.0311
HISP*	-0.1649	-0.1620
PINC*	0.0000	0.0000
INCSQ*	0.0000	0.0000
EMPLOYD	-0.0492	-0.0488
STUDENT*	-0.1404	-0.1480
RETD	-0.0457	-0.0444
DSEX	0.0341	0.0323
MALT	0.0059	0.0067
DIV_SEP	-0.0507	-0.0498
NMARRI	0.0725	0.0747
AGE*	0.0262	0.0263
AGESQ*	-0.0003	-0.0003
SEDENT*	0.0983	0.0973
SMOKING*	-0.1490	-0.1512
HCARE	0.0033	0.0062
RFDRHV	0.0140	0.0142
FRTINDX*	-0.0218	-0.0222
DDISTD	-0.0180	-0.0161
TRVT*	0.0044	0.0041

* indicates variables that have significant impact on probability of being obese

Table 7. Ordered Probit and Logit Estimates of Self Assessed Health

	Ordered Logit			Ordered Probit		
Variable	Estimate	Pr>ChiSq		Estimate	Pr>ChiSq	
CONSTANT2	1.7731	0.0157	**	0.9162	0.0260	**
CONSTANT1	3.3478	0.0001	***	1.8006	0.0001	***
LEDUCA	0.2013	0.0015	***	0.1220	0.0007	***
WNONH	-0.0616	0.8195		-0.0337	0.8268	
BNONH	0.1374	0.7641		0.0486	0.8516	
HISP	-0.3690	0.4504		-0.2230	0.4194	
PINC	0.0000	0.0001	***	0.0000	0.0001	***
EMPLOYD	1.4168	0.0001	***	0.8505	0.0001	***
STUDENT	0.7907	0.1535		0.4820	0.0932	*
RETD	1.1810	0.0001	***	0.7280	0.0001	***
DSEX	-0.0184	0.8861		-0.0026	0.9715	
MALT	-0.2256	0.2372		-0.1470	0.1834	
DIV_SEP	-0.1537	0.4496		-0.1005	0.3927	
NMARRI	0.0182	0.9482		-0.0394	0.8029	
AGE	-0.0273	0.0001	***	-0.0149	0.0001	***
PREDOBE	-2.6180	0.0006	***	-1.2876	0.0031	***
SEDENT	-0.6526	0.0001	***	-0.4162	0.0001	***
SMOKING	-0.7766	0.0001	***	-0.4282	0.0001	***
HCARE	-0.1713	0.3040		-0.1054	0.2627	
RHEART	-0.8316	0.0001	***	-0.4951	0.0001	***
RASTHMA	-0.8084	0.0001	***	-0.4559	0.0001	***
RFDRHV	0.0310	0.9380		0.0143	0.9478	
FRTVINDX	0.0614	0.4159		0.0377	0.3752	
DDISTD	-0.4726	0.0002	***	-0.2658	0.0002	***

*/**/***: Significant at 10%, 5%, or 1% or higher level. N=2157