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Examining Rural-Urban Obesity Trends among Youth in the U.S.: Testing the Socioeconomic Gradient Hypothesis

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ABSTRACT

Adolescent obesity has increased three-fold in the U.S. during the last three decades. While this trend is well-known, relatively little is known about differences in obesity across the rural-urban continuum. This research addresses that gap by testing for such a relationship across time while accounting for variations in familial socioeconomic status. Using 1986-2004 Monitoring the Future (MTF) survey data, we estimate recent trends in rural-urban body weight, also testing for potential differences among the rural, small town, and urban high school seniors along socioeconomic gradients. Statistically significant differences disfavoring rural high school seniors in their BMI, their risk for the onset of obesity, and obesity itself over the past decade are identified, with significant interactions between demographics and parental education levels driving the largest disparities. These findings are rich and speak directly to the allocation of public health resources aimed at addressing issues associated with the adolescent obesity epidemic.

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1.0 INTRODUCTION

Much attention has been given to the recent obesity epidemic in the US and worldwide and reports document that the percentage of overweight children has more than tripled in the last three decades (CDC 2006a). In a national sample over a decade old now, 11 percent of children were obese and an additional 14 percent were at risk of being obese (Troiano and Flegal, 1998). A more recent report by the CDC indicates that as of 2008, nearly 20 percent of all six to eleven year old children were obese as were about 18 percent of all twelve to eighteen year old children. Furthermore, the report highlights

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the importance of the issue stating that since 1980 (a span of almost 30 years) childhood obesity has increased three-fold during this period. These trends are of national concern given the important stages at which these trends have been documented in relation to the social, emotional and physical development of children and adolescents during this period.

To some extent, this realy is not an issue until you begin to understand the grave physical, mental, and emotional health consequences associated with obesity. (Granberg and colleagues, 2008, 2009) report relationships of depression among African American adolescents that is associated with body size. Similarly, (Kowaleski and colleagues, 2010) find a significant linkage between body weight and depression. Another work has focused directly on racial and ethnic differences in perceptions of body weight (Haff, 2009). Still others have focused on what motivates youth to become, and remain, physically active (see Newton, 2006 and Cho, 2004 for examples). The implications are profound. The effect of childhood obesity and overweight directly impacts, both, mental health of adolescents in a time of important social and emotional development and is further compounded by the linkages of mental health to issues of deteriorating physical health.

Childhood obesity not only adversely affects emotional and social health through stigmatization, discrimination, and social marginalization, but it also has negative impacts on physical health (Dietz 1998; IOM, 2004). Immediate physical consequences of childhood obesity include glucose intolerance and insulin resistance, Type 2 diabetes, hypertension, dyslipidemia, hepatic steatosis, cholelithiasis, sleep apnea, menstrual abnormalities, impaired balance and orthopedic problems and may cause further complications in adulthood (i.e. metabolic syndrome, arthritis, and some types of cancer) (Dietz 1998; IOM 2004). Further, research has shown that 9.4 percent of youth that enter adulthood being obese remain obese (Gordon-Larsen et al., 2004). Thus, it is reasonable to conclude that childhood obesity may likely reduce the quality and length of adult life expectancy (IOM, 2005).

Of import here is the fact that this reduction in quality of life is taking place unequally across geographic location. One important distinctive pattern in some studies of obesity is the rural-urban difference favoring those living in cities (e.g. Patterson et al. 2004; Sobal et al., 1996). As we show in our review, in spite of the documented high rates of obesity in urban centers (e.g. Dietz and Gortmaker, 1984; Maddock, 2004) disparate studies suggest that rural persons are either at-risk or suffer from obesity to a greater extent than more urban individuals but the reasons are not yet fully identified (McMurray et al., 1999; Nelson et al., 2006; Patterson et al., 2004; Register and Williams, 1990; Sobal et al., 1996). We know that social conditions have been found to be underlying sources of disease and illness (Link and Phelan, 1995) and that there is an average socioeconomic difference among rural and urban households (Beaulieu, et al., 2003). This may be an important source of obesity affecting rural youth. If so, then obesity, as a health risk would be another component of the "socioeconomic gradient" in health outcomes, including having a healthy body weight, which recognizes that persons with more resources will have better health than their otherwise equal who has fewer resources (see Deaton, 2002; Willms, 2003). Other influences such as dietary intake patterns and organized physical recreation activities will likely be different between rural and urban youth due to limited access of recreational facilities and grocery stores and likely influence body weight (Boehmer et al., 2006; McIntosh and Sobal, 2004; Morton et al., 2004).

In this study, we focus on the recent trends in obesity profiles of rural and urban high school seniors over an eighteen years span (1986-2004). In this comparison, we further examine the socioeconomic gradient hypothesis to see whether rural-urban differences in parental educational statuses account for the gap in obesity measures, after other key demographic variables are controlled. We do this through the use of nationally representative data from the Monitoring the Future data collection effort.

2.0 OBESITY ACROSS THE RURAL-URBAN CONTINUUM

Obesity is the accumulation of excess body weight in proportion to one's height (IOM, 2005). The Body Mass Index (hereafter referred to as BMI) is the ratio of body weight in kilograms to height in meters squared (kg/m^2) and is one common measure used to calculate obesity (CDC, 2005). One major criticism of using the measure BMI is that it fails to distinguish between fat mass and bone and muscle which presuppose that variations in BMI are a result of accumulated fat mass rather than differences in body type (Eisenmann et al., 2000). This shortcoming is particularly observable during childhood and adolescence due to rapid changes that occur through the growth cycle and provides evidence that obesity definitions need to be age- and sex-specific (Eisenmann et al., 2000; Troiano and Flegal, 1998). In efforts to compensate for such variations, the Centers for Disease Control and Prevention (CDC) have categorized children as being "at risk" of obesity when they are calculated to have a BMI that is in the 85th percentile and up to the 95th, and obese when their BMI is in the 95th percentile or greater (2006b).

In combination with much of the work on social group differences as determinants of obesity variations, there is evidence that rural persons across all age groups have a higher risk for obesity than more urbanized individuals. National and regional studies have shown that rural children and youth are much more likely to suffer from obesity than their urban peers (Dietz and Gortmaker, 1984; Lewis et al., 2006; McMurray et al., 1999; Nelson et al., 2006). Other national studies show that young adults and adults are similarly at greater risk for obesity (Duelberg, 1992; Patterson et al., 2004; Register and Williams, 1990; Sobal et al., 1996) and, regardless of race, are more likely to be physically inactive than their urban counterparts (Patterson et al., 2004). Despite these studies documenting that rural persons have a higher risk of obesity than urban individuals, it is still not well understood as to *why* rural-urban differences exist. However, researchers do theorize that lower levels of SES and a cultural lag of adopting healthy behaviors contribute to the rural-urban patterns of health (Pearson and Lewis, 1998; Sobal et al., 1996).

2.01 OBESITY AND THE SOCIO-ECONOMIC GRADIENT IN THE RURAL-URBAN CONTINUUM

The association between socioeconomic status and health has been well established with health gains being particularly noticeable among those with higher SES while smaller improvements have been observed among those with lower SES (U.S. Department of Health and Human Services, 2000). In fact, it has been said that "SES is the fundamental cause of disease" (Link and Phelan, 1995:87) because it is a product of access to resources that help reduce the risk of acquiring a disease or aid in minimizing the negative effects of disease and is the most important socio-demographic determinant of the BMI (Baecke et al., 1983).

In a review of the literature, (Sobal and Stunkard, 1989) report that among U.S. women, socioeconomic status (SES) is shown to have inverse affects on body weight, though this relationship is less clear among men and children. Among black adult males under the age of thirty, SES has been shown to have a positive association with obesity; in contrast, among black women of the same age, SES was shown to be negatively associated with body weight (Zhang and Wang, 2004). On the other hand, SES was negatively associated with lower body weight among white males and females in this study. In sum, these studies show that the relationship between SES and obesity differs by sex, race, and age. According to the socioeconomic gradient hypothesis, the higher the SES level a person has, the better their health. Conversely, the greater the inequality attributed to SES, the more variation of health outcomes will exist (Willms, 2003). However, research has shown that the relationships between income and mortality/morbidity are curvilinear and at the high end incomes do not provide additional benefits against mortality or morbidity (Ecob and Smith 1999; Finch, 2003). This having been said, those at the far right of the income distribution do not suffer from material deprivation but they may suffer from a relative deprivation that contributes to adverse outcomes in mortality and morbidity (Finch, 2003).

(Robert and Reither, 2004) assert that living in a disadvantaged community affects one's risk for obesity because it may lack resources for healthy lifestyles and have norms and values that encourage unhealthy dietary and exercise habits. Therefore, some of the rural-urban differences in body weight may arise in effect to rural residents having a relatively lower SES than many of their urban equals. For example, low levels of education have been linked to increased risk of obesity (e.g. Patterson et al., 2004; Pearson and Lewis, 1998; Sobal et al., 1996). Moreover, it is known that in spite of the education gap between rural and urban residents decreasing, rural residents are particularly less likely to have higher education than urbanites (Beaulieu et al., 2003; Bushy, 1997). Additionally, earnings are also typically lower in rural areas which result in about "40 percent of all rural families fall into the category of working poor" (Bushy, 1997). (Pearson and Lewis, 1998), support the argument that the high rates of chronic diseases such as obesity, among rural populations may be due to a cultural lag. They speculate that rural residents may have been "slow adopters" in implementing unhealthy cultural and lifestyle changes such as smoking that heightened cardiovascular risk (Pearson and Lewis, 1998:950). However, as urban residents began adopting healthful lifestyle changes including smoking less, modifying diets, and participating in physical activity, cardiovascular risk became less common among urban persons and more prevalent among rural residents who were, again slower to make such healthful changes.

While many urban minorities are obese (e.g. Maddock, 2004; Patterson et al., 2004; Sobal et al., 1996), and often have low levels of SES, we hypothesize that rural youth have a higher risk for obesity. This is because rural residents have a lower average level of SES and may also be "lagging behind" in adopting healthful lifestyles. Further, because rural residents already have a higher risk of obesity than urban peers, rural minorities who typically have lower SES than rural whites and will likely have the greatest risk of obesity (Patterson et al., 2004) due to the socioeconomic gradient. At this time, there have been few studies that have specifically examined the impact that rural neighborhood characteristics have on obesity among rural adolescents using current nationally representative data, resulting in a failure to clearly identify the rural-urban patterns of obesity (McIntosh and Sobal, 2004; Nelson et al., 2006).

3.0 RESEARCH METHODS

3.01 SOURCE OF DATA

Data for this investigation were taken from the 1986-2004 Monitoring the Future survey series (MTF). This is a nationally representative cross-sectional trend study of high school seniors that has been conducted annually since 1976 by the Institute for Social Research at the University of Michigan. Each year, MTF interviews approximately 15,000 high school seniors from about 133 schools with a response rate of about 83 percent (Johnston et al., 2004). See (Bachman and colleagues, 1976) for documentation on the dataset and sampling techniques and (Winship and Radbill, 1994) for information on weighting and consequences associated with not including weights in regression models using this data. We do include the provided weights for all models in our analysis.

This study uses data gathered from Form 1 since that is the only source of the requisite height and weight variables necessary for the calculation of the Body Mass Index over the time period (see below). However, MTF staff ceased to release the height and weight variables in 1992. Upon special request, MTF staff kindly computed the BMI for us for years 1991-2004. The final sample size for this study is 37,774.

3.02 MEASUREMENT OF VARIABLES

Dependent variables: There are three dependent variables used to profile obesity patterns. The Body Mass Index (BMI) was computed as the ratio of body weight in kilograms to height in meters squared (kg/m^2) (CDC, 2005) and transformed by taking the natural logarithm to correct for a positive skew. The CDC uses guidelines to assess the obesity status of adolescents. The 85th percentile of the year's (untransformed) BMI variable is a threshold for being "at-risk" for obesity while the 95th percentile is the cutoff for being labeled obese. We constructed two dummy variables to reflect the respondent's being "at-risk" or "obese" using these respective percentile thresholds.

Independent variables: The main independent variable for this study is residential location. The MTF variable on residence is collected from the self-reported question "Where did you grow up mostly?" Our final version of the variable includes three potential responses: rural (rural farm and rural non-farm =8,387), small town (=13,806), and urban (medium city to very large city and their suburbs =21,816).

Socioeconomic status is measured by parental educational attainment. Father's (FED) and mother's (MED) education is coded into a set of ranks: some high school (=1), high school graduate (=2), some college (=3), college graduate (=4), and graduate school (=5), with grade school completion or less being the omitted referent group. Also, mother's paid employment frequency was coded no (=1), sometime (=2), most of the time (=3), and all the time (=4). The number of siblings reported by the respondent was coded none (=0), one (=1), two (=2), or three or more (=3).

Three additional controls include gender (males=1), race and year. Due to concerns of identification, MTF only releases the variable race as white, not-white, or missing (1986-1989) and white, African American, or missing (1990-present). Therefore, we have categorized these data as white (=0) and non-white (=1).

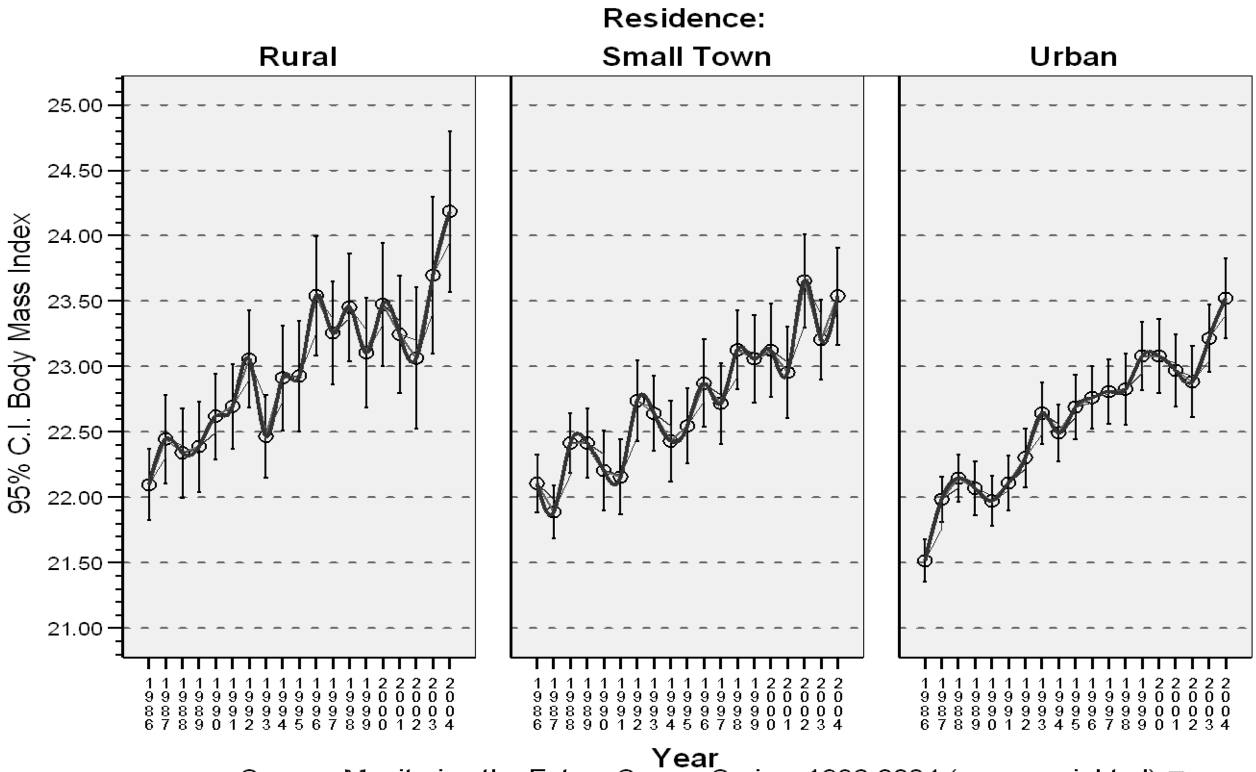
3.03 ANALYTICAL PROCEDURES

To illustrate the residential and temporal patterns in the data, we use line charts of annual means or proportions. To assess the statistical significance of obesity profiles by residence, we use two-way ANOVA with residence and year as factors and the natural log of the BMI as the dependent variable. Since these results will confirm a continuation of the rural-urban obesity pattern noted in the literature review, we test the socioeconomic gradient hypothesis through regression models using the BMI and the two dummy variables for CDC's obesity status characterization as dependent variables. OLS regression is used for the continuous BMI variable with parental education and the other demographic controls entered in stages so as to separate the effects of rural residence and survey year from the other variables in the model. Logistic regression models, paralleling those for the BMI variable, are used for the two binary obesity status variables of at-risk for obesity and actual obesity.

4.0 RESULTS

Reflecting on the results of previous studies that document rural-urban differences in body weight (e.g. McMurray et al., 1999; Nelson et al., 2006; Patterson et al., 2004; Register and Williams, 1990; Sobal et al., 1996), the trends illustrated in Figure 1 confirm a clear continuation of these residential distinctions. There is a consistent upward trend in the BMI across the rural, small town, and urban high school seniors from 1986 through 2004. Rural high school seniors have a small but consistently higher BMI at virtually each survey year. Table 1 summarizes a formal statistical test of these patterns. The ANOVA results show that both year and residence have significant main effects on BMI. Moreover, the interaction term is not significant, suggesting that the rural difference with each survey year does not lessen in any significant way. Thus, the rural disadvantage in body mass has continued relatively unabated, at least among high school seniors.

Figure 1. Trends in Average Body Mass Index Scores with Standard Errors by Residence, U.S. High School Seniors, 1984-2004



Source: Monitoring the Future Survey Series, 1986-2004 (cases weighted)
Sample sizes: Rural (n=7,340), Small Town (n=11,948), Urban (n=18,486)
Error bars based upon srs standard errors

Table 1. Summary of ANOVA for log Body Mass Index (BMI) by Residence and Year for High School Seniors, Monitoring the Future Survey Series, 1986-2004 (cases weighted)[a]

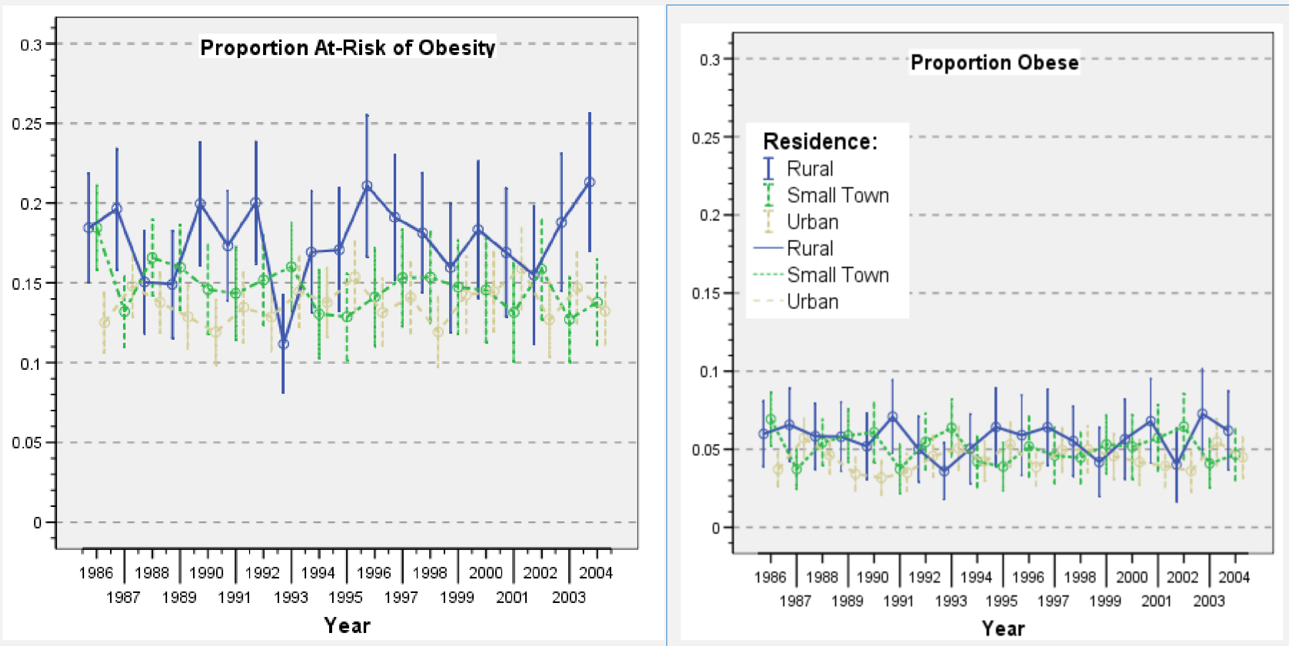
			ANOVA Summary Tests				
			Sum of Squares	df	Mean Square	F	Sig.
Ln of BMI	Main Effects	(Combined)	15.028	20	.751	31.358	.000
		Rural-Urban Residence[b]	1.382	2	.691	28.837	.000
		Year	13.680	18	.760	31.717	.000
	2-Way Interactions	Rural-Urban Residence * Year	.876	36	.024	1.016	.442
	Model		15.905	56	.284	11.852	.000
	Residual		884.258	36902	.024		
	Total		900.163	36958	.024		

a. Measures of association: Eta's for Residence (= .039) and Year (= .123).

b. Rural-Urban residence categorized as: Rural (=5,742); Small Town (=10,763); Urban (=20,454); see text for more detail.

Turning to the CDC-based obesity characterizations, Figure 2 shows that while the absolute BMI levels have undergone a clear secular upward trend in Figure 1, the proportions of high school seniors who are either at-risk for (85^{th} BMI percentile) or are obese (95^{th} percentile) have remained rather stable over the past two decades. Rural high school seniors, however, tend to maintain their higher at-risk status (left panel) and this difference may be growing during the post-2000 period. The estimated obese populations among high school seniors, however, do not appear to exhibit as great a rural difference (right panel).

Figure 2. Trends in Proportion of At-Risk and Obese U.S. High School Seniors with Standard Errors by Residence, 1986-2004



Source: Monitoring the Future Survey Series, 1986-2004 (cases weighted).
Sample sizes: Rural (n=7,340), Small Town (n=11,948), Urban (n=18,486).
Error bars based upon *srs* standard errors.

Thus, rural high school seniors in the U.S. have tended to maintain their small but consistently higher BMI scores and are at higher levels of being at-risk for obesity during high school than small town or more urbanized high school seniors. There does not appear to be significant differences in estimated obesity status, however, between rural and other residential groups. What this means is that the rural disadvantage in relative body weight is not present at the most extreme end of the body mass index continuum but is clearly observed otherwise.

The hypothesis that these differences may be due to the lower socioeconomic composition of the rural population---yet another manifestation of the "socioeconomic gradient" in health (see Deaton, 2002; Willms, 2003; Sobal and Stunkard, 1989) ----is where we turn now through the use of regression models. There are four specific model specifications in this phase of the analysis. Model 1 contains only two dummy variables reflecting rural or small town residence vs. the omitted urban reference category. Model 2 adds the year of survey accounting for the upward trend by year. Model 3 includes the parental education levels, and other socioeconomic-related demographic controls. This set of parental education effects, net of other variables including residential location, constitutes the key test of the socioeconomic gradient hypothesis. Model 4 adds controls for the main effects of gender and race to complete the model specifications. If rural location maintains a significant positive effect, as evidenced in Figures 1, 2, and Table 1, then the measured socioeconomic differences will not have accounted for all of the residential effects associated with rural residence. Because of the results reported in the literature review and on the advice of anonymous reviewers, we also tested for interaction effects of gender, race, and residence. We report these results in the narrative below where appropriate due to issues of space.

Beginning with the Body Mass Index, we regressed the BMI variable on successive sets of independent variables in Models 1-4. In Table 2, both rural and small town high school seniors have significantly higher logged BMI scores, although accounting for only a small portion of the variation in this obesity measure (less than 1 percent). These differences are not associated with the consistent annual effects of the survey year shown in Model 2 since the coefficients for the two residence dummies do not change once survey year is controlled.

Table 2: Regression of Body Mass Index on Residence, Socioeconomic and Demographic Factors, and Survey Year, Monitoring the Future Survey Series, 1986-2004

Independent Variable:	Model: 1	2	3	4
Rural	.016***	.017***	.010***	.011*** ǂ (-)
Small Town	.006**	.006**	.003 n.s.	.007***
FED: Some High School	---	---	-.014*	-.011 n.s.
FED: High School	---	---	-.022**	-.018*
FED: Some College	---	---	-.033***	-.027** † (-)
FED: College	---	---	-.042***	-.036*** † (-)
FED: Graduate School	---	---	-.044***	-.034***
MED: Some High School	---	---	-.010 n.s.	-.010 n.s. ǂ (-)
MED: High School	---	---	-.014 n.s.	-.014* ǂ (-)
MED: Some College	---	---	-.016*	-.016** ǂ (-)
MED: College	---	---	-.018**	-.030** ǂ (-)
MED: Graduate School	---	---	-.022**	-.035** ǂ (-)
Mother's Employment	---	---	.004***	.002**
Siblings	---	---	.003***	.001 n.s. † (+) ╞ (+)
Sex (1=male)	---	---	---	.062***
Race (1=non-white)	---	---	---	.050***
Year	---	.003***	.003***	.003*** ǂ (+)
R^2	.002	.016	.025	.071

Note: Dependent variable is the natural log of BMI. See text for a fuller explanation of independent variables. FED and MED are abbreviations for Father's and Mother's education level with the category of grade school being the reference group. Significant race and sex interactions with the independent variables are indicated with the legend shown below with white males being the referent group (see text). Standard errors are based on jackknife estimates.

* $p < .05$
** $p < .01$
*** $p < .001$
† (+) = slope is significantly higher at $p \leq .05$ for white females
† (-) = slope is significantly lower at $p \leq .05$ for white females
ǂ (+) = slope is significantly higher at $p \leq .05$ for minority females
ǂ (-) = slope is significantly lower at $p \leq .05$ for minority females
╞ (+) = slope is significantly higher at $p \leq .05$ for minority males
╞ (-) = slope is significantly higher at $p \leq .05$ for minority males

In terms of socioeconomic effects, parental education variables are both significantly associated with lower BMI scores with all levels of education being statistically significant ($p \leq .05$), excluding the lowest levels of mothers completed education (some high school; high school). Father's education has slightly stronger influences than does mother's education levels. As expected, the more siblings and the more that mothers worked during a high school senior's younger years, the higher the BMI score. With parental education and the other variables controlled, however, high school seniors in small towns are no longer significantly higher in average body mass than urban high school seniors. Thus, these results suggest that the rural disadvantage in relative body weight is linked to socioeconomic and household organization factors.

With the addition of gender and race to the model, the explained variance increases to slightly more than seven percent (7.1%). As expected, non-whites had significantly higher BMIs as did males. Controlling for gender and race also shows the differences between the lowest level of father's education (completed some high school) and the number of siblings to no longer being significant. The significant main effects of both gender and race (white vs. non-white) are among the most powerful in the model. However, they do not "wash-out" the effects of rural or small town residence as these dummy variables maintains their significant influence on BMI scores.

The interaction tests for the gender, race, and residence dummy variables did show several statistically significant interaction effects. These significant effects are indicated in the legend of Table 2. We summarize them as follows. The effect of rural residence interacts with race and gender in that the effect of rurality is lower for minority females than white males. The parental education effects only have significant interaction effects among females but more so involving mother's education than father's completed schooling. The effect of father's education dummies for "some college" and "college" are significantly lower for white females. In contrast, all of the dummies for mother's education are significantly lower for minority females. Thus, the socioeconomic gradient hypothesis results are slightly weaker for women than men. Other significant interaction terms include the effects of a number of siblings for minority males and white females. The number of siblings, reflecting a meal management issue in the household, has greater effects on BMI scores for these two groups. Finally, the time trend effect obtained for the year variable is significantly higher for minority females, suggesting that the average growth trend for this group is higher than for the other race-sex groups included in the study.

We now examine how these factors affect being at the margin of the BMI distribution, the 85th percentile of the annual BMI distribution which CDC signifies being at-risk for obesity. Table 3 summarizes the results of a logistic regression model, patterned after the OLS regression specification, for the binary outcome of the obesity at-risk variable. The odds-ratios shown in the table suggest that rural high school seniors are a third more likely to be at-risk (e^{β}=1.351, $p < .001$) than urban high school seniors. By comparison, small town high school seniors have only slightly higher odds of being so (e^{β}=1.101, $p < .05$). The annual trends were random (the variable year was not significant) and did not change these rural and small town effects as shown in Model 2.

Table 3: Logistic Regression of At-Risk for Obesity Status on Residence, Socioeconomic and Demographic Factors, and Survey Year, Monitoring the Future Survey Series, 1986-2004

Independent Variable:	Model: 1	2	3	4
Rural	1.351***	1.351***	1.181***	1.250*** ǂ (-)
Small Town	1.101*	1.101*	1.029 n.s.	1.111*
FED: Some High School	- - -	- - -	.850 n.s.	.842 n.s.
FED: High School	- - -	- - -	.738**	.729**
FED: Some College	---	- - -	.590***	.592***
FED: College	- - -	- - -	.519***	.529*** † (-) ╞ (+)
FED: Graduate School	- - -	- - -	.492***	.537***
MED: Some High School	- - -	- - -	.928 n.s.	.962 n.s. ╞ (-)
MED: High School	- - -	- - -	.815 n.s.	.810 n.s. ╞ (-)
MED: Some College	- - -	- - -	.764*	.743 n.s.
MED: College	- - -	- - -	.707**	.718*

MED: Graduate School	---	---	.648**	.613**
Mother's Employment	---	---	1.059***	1.047** † (+)
Siblings	---	---	.997 n.s.	.967* ╞ (+)
Sex (1=male)	---	---	---	1.876***
Race (1=non-white)	---	---	---	1.775***
Year	---	.999 n.s.	.998 n.s.	.997 n.s.
-2 LL	-15478.904	-15478.873	-14012.887	-11208.593
Pseudo R^2 (McFadden's)	.002	.002	.014	.031

Note: Column entries for independent variables are odds-ratios (e^{β}). Dependent variable is a dummy variable indicating whether the respondent meets the 85th percentile of the BMI in the survey year. See text for a fuller explanation of independent variables. FED and MED are abbreviations for Father's and Mother's achieved education level with the category of "grade school" being the reference group. Significant race and sex interactions with the independent variables are indicated with the legend shown below with white males being the referent group (see text). Standard errors are based on jackknife estimates.

* $p < .05$
** $p < .01$
*** $p < .001$
† (+) = slope is significantly higher at $p \leq .05$ for white females
† (-) = slope is significantly lower at $p \leq .05$ for white females
‡ (+) = slope is significantly higher at $p \leq .05$ for minority females
‡ (-) = slope is significantly lower at $p \leq .05$ for minority females
╞ (+) = slope is significantly higher at $p \leq .05$ for minority males
╞ (-) = slope is significantly lower at $p \leq .05$ for minority males

Parental education variables reduce the odds of a high school senior being at-risk as seen in the results for Model 3. The odds ratios for the mother's education are on average, slightly higher than for father's completed schooling in this equation The effects of parental education are similar to those with a BMI score. For example, all levels of parental education except the lowest levels among mothers (some high school; high school) and fathers (some high school) have a significant ($p \leq .05$) negative effect on body weight. Thus, the socioeconomic gradient also affects being at-risk for obesity and may explain why small town high school seniors are at greater risk than urban students. Consistent with the results obtained with the full range of BMI scores, the difference between small town and urban high school seniors is no longer significant with the additional controls in the model. While the number of siblings does not significantly increase the risk of obesity, mothers' frequency of employment in previous years of the high school seniors' life does significantly ($p < .001$) increase it.

Both gender and race have significant and larger effects on being at-risk for obesity. Males are 1.876 ($p < .001$) times more likely than females to be at-risk while non-whites are 1.775 ($p < .001$) times more likely than whites to be so. Controlling for gender and race also suppresses the effect of mothers having attended "some college," while uncloaking the positive influence of the number of siblings on being at-risk for obesity. With controls for these and other demographics, survey year, and parental education, rural high school seniors are 1.250 ($p < .001$) times and small town high school seniors are 1.111 ($p < .05$) times more likely to be at-risk for obesity than are urban high school seniors. The total rural-urban gap in being at-risk for obesity based upon comparing the odd ratios from Model 1 to those for Model 4 is reduced by these controls for parental education and other variables. However, this reduction is small for rural high school seniors and is actually raised slightly for small town high school seniors versus urban ones.

The interaction tests for the gender, race, and residence dummy variables produced results somewhat similar to those in the BMI model. They are noted in the legend for Table 3. The effect of rural residence on the odds of being at-risk for obesity is lower for minority females. The parental education effects exhibit fewer interactions in this model. However, these do include higher effects of the father's "college" education dummy for minority males but lower effects for white females. The "some high school" and "high school" dummies have lower effects in the at-risk model for minority males. Higher effects of the extent of mother's employment are obtained for white females as do minority males for the effects of the number of siblings. Thus, the results for the at-risk of obesity model do exhibit different effects of parental education for minority males with one observable effect for white females. As such, the socioeconomic gradient may work differently for minorities and by gender.

Table 4: Logistic Regression of Obesity Status on Residence, Socioeconomic and Demographic Factors, and Survey Year, Monitoring the Future Survey Series, 1986-2004

Independent Variable:	Model: 1	2	3	4
Rural	1.320***	1.320***	1.144 n.s.	1.247*ǂ $_{(-)}$ ╞ $_{(+)}$
Small Town	1.176*	1.176*	1.079 n.s.	1.184*
FED: Some High School	---	---	.804 n.s.	.927 n.s.
FED: High School	---	---	.680*	.737 n.s.
FED: Some College	---	---	.482***	.522** † $_{(-)}$
FED: College	---	---	.428***	.495**
FED: Graduate School	---	---	.383***	.468***
MED: Some High School	---	---	.838 n.s.	.721 n.s.
MED: High School	---	---	.749 n.s.	.686 n.s.
MED: Some College	---	---	.706 n.s.	.601*
MED: College	---	---	.599**	.562*
MED: Graduate School	---	---	.559**	.509*
Mother's Employment	---	---	1.074**	1.043 n.s.
Siblings	---	---	1.023 n.s.	.960 n.s.
Sex (1=male)	---	---	---	1.046 n.s.
Race (1=non-white)	---	---	---	1.986***
Year	---	.999 n.s.	1.000 n.s.	.997 n.s.† $_{(+)}$ ǂ $_{(+)}$
-2 LL	-7218.2582	-7218.2458	-6449.6902	-5107.3112
pseudo R^2 (McFadden's)	.002	.002	.019	.024

Note: Column entries for independent variables are odds-ratios (e^{β}). Dependent variable is a dummy variable indicating whether the respondent meets the 95th percentile of the BMI in the survey year. See text for a fuller explanation of independent variables. FED and MED are abbreviations for Father's and Mother's achieved education level with the category of "grade school" being the reference group. Significant race and sex interactions with the independent variables are indicated with the legend shown below with white males being the referent group (see text). Standard errors are based on jackknife estimates.

* $p < .05$
** $p < .01$
*** $p < .001$
† $_{(+)}$ = slope is significantly higher at $p \leq .05$ for white females
† $_{(-)}$ = slope is significantly lower at $p \leq .05$ for white females
ǂ $_{(+)}$ = slope is significantly higher at $p \leq .05$ for minority females
ǂ $_{(-)}$ = slope is significantly lower at $p \leq .05$ for minority females
╞ $_{(+)}$ = slope is significantly higher at $p \leq .05$ for minority males
╞ $_{(-)}$ = slope is significantly lower at $p \leq .05$ for minority males

High school seniors are actually meeting or exceeding the CDC-criterion for obesity status are examined in Table 4. As is the case in the previous model, both rural and small town high school seniors are significantly more likely to fall into the obese category than urban high school seniors (see Model 1). As was apparent from Figure 2, the annual trends are largely an insignificant random "walk" over time as the survey year variable is not significant (see Model 2).

The influence of parental education levels is also negative in this model, consistent with the socioeconomic gradient thesis. However, with only "some high school" not having a significant effect among fathers compared to "some high school," "high school," and "some college" among mothers, father's education has the stronger influence on reducing the odds of a high school senior meeting or exceeding the obesity criterion. As was also the case in the previous model for at-risk status, mother's frequency of paid employment outside the home enhances those odds. The number of siblings does not manifest a significant effect in Table 4.

Unlike the results for the at-risk variable, gender does not have a significant effect on obesity. In contrast, race has a large effect: non-whites are almost twice as likely as whites to meet or exceed the CDC obesity criterion (e^{β}=1.986, $p < .001$). Additionally, after controlling for gender and race, small town residence regains its significant status. The effect of rural residence (e^{β}=1.247, $p < .05$) is second only to that for race in Model 4 and shows the small but enduring association that rurality has with obesity profiles of high school seniors in the U.S.

The interaction tests for gender, race, and residence dummy variables in the obesity status model obtained the fewest significant results (see legend in Table 4). The effect of rural residence is lower for minority females as it was in the models for BMI and at-risk status. In contrast, however, the rural effect is higher for minority males. The parental education relationship to obesity status has only one significant interaction, the significantly lower effect of father's education for white females. This result parallels those for the BMI and at-risk models for white females. These results add further evidence to the notion that the socioeconomic gradient may work differently for minorities and by gender. Finally, the annual trend effect of the year variable is significantly higher for both white and minority females.

5.0 DISCUSSION

We examined high school seniors over time as a way to increase our understanding of the rural obesity disadvantage. Our purpose was to see if this pattern at the national level has continued, ceded, or grown larger during the past two decades. Moreover, the hypothesis of whether the socioeconomic gradient accounts for part or all of the rural-urban difference in obesity profiles was tested through controlling for parental education and other demographic factors likely to be related to being overweight. It cannot be generalized directly, but the findings here could be expected to be representative of discrepancies that might take place across rural and urban locations in the international context. Of course, these comparisons must always take into account the cultural context in which they are generalized prior to the assessment of their utility.

The findings of this study show that rural high school seniors have significantly higher BMI scores, are at greater risk for obesity later in life, and have significantly higher odds of meeting CDC-criteria for being obese as a young adult (see Gordon-Larsen et al., 2004; IOM, 2005; St-Onge et al., 2003). There are indeed significant effects of both parents' education levels in reducing these obesity profiles but these socioeconomic effects do not fully account for the rural differences observed in these data. Thus, it could be that other dimensions of SES, such as household income or occupational status, would effectively narrow the gap between rural and urban high school seniors. Future work on the socioeconomic gradient in obesity should examine household income and occupational prestige of parents and their net effects on obesity profiles. Until then, however, we show that the parental education is indeed linked to lower BMI scores among high school seniors.

While the socioeconomic gradient, and any alternate theoretical perspectives, should be examined for its applicability to obesity, there are other conceptual issues that must be undertaken as well. Our examination of gender and ethnic minority status shows that both exhibit some interaction effects with and independent of rural residence. Thus, the socioeconomic gradient thesis appears to work differently for whites and minority groups. For example, a consistent finding was that father's education has smaller effects on reducing obesity characteristics for white females. In contrast, minority females had significantly lower effects from mother's education. Neither effect differed significantly among male high school seniors. These and a small number of other race and gender interaction effects suggest that the theoretical commonality implied by the socioeconomic gradient approach might need to be reworked if these results were to be replicated in future research.

One line of thinking on the rural obesity results is that the lifestyle dimensions of rural residence are important foci for additional study. Dietary intake behavior should be studied for whether they account for the rural-urban differences in obesity. While researchers have found some evidence that dietary practices do differ by residence, it is still not well understood as to *why* these variations exist (McIntosh and Sobal, 2004). One thesis for varying dietary behaviors is that agrestic areas are often located in places that have limited access to low cost quality food, known as "food deserts," and therefore are at a higher risk of not having food security (Blanchard and Lyson, 2006; Morton et al., 2004). Therefore, rural persons may have different dietary habits that result in increased odds of obesity than urban persons due to these structural limitations. Another avenue of inquiry is the availability of physical activity resources in rural and urban locales. Researchers have also shown that neighborhoods with short distances between homes and parks, recreational facilities, and bike/walking trails increase the participation in physical activity among children and adults (Boehmer et al., 2006; Roemmich et al., 2006; Roemmich et al., 2007) and should have an effect on lowering body weight. Thus, it may be that urban high school seniors have greater access to parks, facilities, and sports equipment that increase opportunities to participate in organized physical activities than their rural counterparts.

In conclusion, the purpose of this study was to expound what we know about rural-urban obesity profiles among U.S. high school seniors. The trends in the well-being of youth are an important demographic indicator for social change. Since 1986, the rural health trend of rural persons being relatively overweight has continued and appears to be getting larger among high school seniors since 2000. Further, after controlling for socioeconomic status, differentials between rural and urban high school seniors, while narrowed, still remain. How socioeconomic effects on obesity characteristics may function differently for minority groups should be examined both theoretically and through empirical means since our results were consistently suggestive of such outcomes. Moreover, gender proved to be another factor shaping how both minority status and rural residence are linked to obesity profiles. We conclude that these differences may be explained through structural and institutional settings that affect dietary and lifestyle behaviors. Future studies should proceed to unravel how the impact of the "socioeconomic gradient" unfolds on obesity profiles, especially as it involves rural people and their relative health status.

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