An Examination of Race, Sex and Education Differences in Body Mass Index from 1986-2001 Using a Growth Curve Analysis Approach.

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Introduction

The prevalence of obesity has become a major public health concern in the United States, increasingly being described as an obesity epidemic (Mokdad et al. 2001). Even overweight, which is considered a pre-obese state, is deemed an important issue for public health. For instance, overweight and obesity is one of the Leading Health Indicators in the Healthy People 2010 Initiative, as it was in the year 2000 Initiative. While some of the other health objectives met or came close to meeting the year 2000 targets (or at least were moving in the right direction), overweight and obesity, on the other hand, actually moved away from the year 2000 target, casting serious doubt on the likelihood of achieving the 2010 target (NCHS, 2001). The inclusion of overweight and obesity as one of the Healthy People initiatives is indicative of government concern over the alarmingly high rates of overweight and obesity in the U.S. population. Additional indications of government concern include the 2001 Surgeon General's report highlighting overweight and obesity as serious public health issues (HHS, 2001) and the National Institute of Health initiative to stimulate obesity prevention research by funding twenty pilot studies (Kumanyika and Obarzanek, 2003).

While rates of overweight and obesity are high, it is more distressing that they appear to be increasing over time, particularly over the past twenty years. Substantial increases in overweight and obesity prevalence have been found in both the National Health and Nutrition Examination Survey (NHANES) and the Behavioral Risk Factor Surveillence System (BRFSS), two nationally representative surveys that focus on health issues. The NHANES data show increases in the prevalence of both overweight and obesity in the population aged 20 to 74 since data collection began in 1960. Between

1960 and 1980, the prevalence rates remained fairly stable; however, since 1980 these increases have become much more dramatic (Flegal et al. 1998; Kuczmarski et al. 1994). More specifically, there was an increase in overweight from 46% to 54% between NHANES II[1] and phase I of the NHANES III[2] (Flegal et al. 1998). This trend continued into the next wave of data collection with prevalence of overweight increasing from a reported 56%[3] to 65% between phase I and II of NHANES III[4] , while the trend for obesity showed an increase from 23% 31% between the two phases (Flegal et al. 2002). Similarly, the BRFSS data show a similar increase in obesity from 1991 to 2000, though with a smaller prevalence rate (Mokdad et al. 1999; Mokdad et al. 2001).

These increases in obesity prevalence rates are distressing considering the many serious health implications related to obesity. In fact, obesity is associated with increased risk for cardiovascular disease (Bierman and Brunzel, 1992; Blumberg and Alexander, 1992; Eliahou, Shechter and Blau, 1992; Kenchaiah et al. 2002), respiratory disorders (Visscher and Seidell, 2001), diabetes (Bonadonna and Defronzo, 1992; Must et al. 1999), and some forms of cancer (Vischer and Seidell, 2001). In addition, the more excess weight an individual has, the more likely she or he is to experience joint pain (Allison et al. 1999; Fine et al. 1999) and functional limitations later in life (Peeters et al. 2004). In addition to the associated physical comorbidities, obesity also impacts individuals psychologically. For example, obese individuals tend to experience depression due to poor physical health and social stigma (Ross, 1994; DeJong, 1980; Maddox, Back and Liederman, 1968; Stunkard and Wadden, 1992). Some researchers

[1] Data collection for NHANES II represents the period 1976-1980.
[2] Data collection for NHANES III, phase I, represents the period 1988-1994.
[3] This number is different from the NHANES III prevalence rate reported immediately above because this numbers is age standardized to the 2000 Census population while the previous number is not
[4] Data collection for NHANES III, phase II, represents the period 1999-2000.

have gone so far as to show that obesity in adulthood causes decreases in life expectancy (Allison, 1999; Peeters et al. 2003; Fontaine et al. 2003; Manson et al. 1995). Given the serious health threat posed by obesity and overweight, it is essential that we understand the trend in their prevalence over time.

Taubes (1998) observes that obesity is on the rise in all segments of the population, but there remain important variations by age, sex, race and education. For example, Body Mass Index (BMI) levels are partly dependent on age. Willett argues that it is only in the decades after growth ends (somewhere between 18 and 20 years of age) that, for most people, excess body weight begins to accrue (Willett, Dietz and Colditz, 1999). Kuczmarski et al. (1991) confirm this finding and moreover show that age-specific prevalence of BMI has an inverted U-shape, meaning that BMI is at its lowest point around 20 years of age, increasing steadily until age 50, after which it decreases over time. Age-specific prevalence of obesity, most likely follows a similar distribution.

Obesity prevalence rates also vary by sex. Women tend to have higher prevalence of obesity at nearly all ages than men have and experience a less severe drop-off at the older ages (Flegal et al. 1998; Flegal et al. 2002). This gap in prevalence rates is likely a result of increases over time in excess body weight in women. Indeed, women's weight increased from 143 lbs (65.1 kg) in 1991 to 151 lbs. (68.4 kg) in 1998, a 5.1% increase in just seven years. Men, on the other hand, experienced an increase from 179 lbs (81.5 kg) to 186 lbs (84.4 kg) in the same time period, meaning men's weight increased by only 3.6% (Mokdad et al. 1999). There is a clear difference between the sexes in terms of both obesity prevalence and weight gain. However, these differences are not uniformly experienced among different racial and ethnic groups. For instance, while white men

have higher BMI scores than white women, the opposite is true for blacks and Mexican Americans for whom women have the higher BMI scores (Kuczmarski et al. 1991).

Surprisingly, few studies have looked at differentials in prevalence by education and those that have seemed to find conflicting results. For instance, an examination of the BRFSS data show that there is an education differential in obesity prevalence for adults. Those with less than a high school degree have a much higher prevalence than any other education group and more than double the rate of college graduates. Moreover, obesity prevalence decreases with increasing educational attainment, with college graduates experiencing a prevalence of only 8% compared with high school graduates (13%) and those with some college (11%) (Mokdad et al. 1999). Conversely, another study examined education by BMI categories, and found average education to be similar across BMI categories (Patt et al. 2004). However since this study was focused entirely on older, black women the results suggest only that education may be less significant for this particular group, not necessarily for other groups. On the whole, the lack of attention to education differentials in obesity prevalence is surprising considering the large differences that have been observed between education levels, at least in the general population.

Studies examining trends in overweight and obesity have been limited for the most part to repeated cross-sectional data (Flegal et al. 1998; Flegal et al. 2002; Kuczmarski et al. 1991; Mokdad et al. 1999; Mokdad et al. 2001). While the findings are informative, it is important to examine these trends with longitudinal data as well. While cross-sectional data enable us to look at overall trends at the population level, we are limited in the conclusions we can draw. Longitudinal data, on the other hand, let us

observe the same people over time, allowing more valid conclusions to be drawn about the observed trends. In addition, longitudinal data are ideal for studying change over time, both within and between individual growth trajectories. Differences in both initial BMI status and rate of change over time can thus be detected for subgroups within the population.

This paper improves upon research using cross sectional data by examining trends over time in the same group of people. In this paper, I will analyze data from the American's Changing Lives survey, a panel study that collected data at four points in time from 1986 to 2001/02 to determine if patterns in obesity, measured as BMI, reflect the observed race, sex and class disparities in health. The analysis will focus specifically on differences in baseline status of Body Mass Index (BMI) and the rate of change over time by sex, race and education. The purpose of the following analyses is to determine if there are differences in obesity prevalence rates between different race, sex and education groups. I hypothesize that (1) blacks have higher obesity rates than whites, and that (2) this should hold true for within sex differences, and that (2) initial BMI status and growth in BMI over time will be greater for blacks than for whites, partly because (3) black women have the highest initial BMI, and partly because (4) black women experience more rapid growth in BMI over time. In addition, I hypothesize that (5) obesity rates are negatively associated with level of education by showing that (6) initial BMI status is greatest for the least educated group, and that (7) growth in BMI over time will be greater for those who are less educated.

Methods.

Data

The data used for analysis in this paper are from The Americans' Changing Lives (ACL), a nationally representative, longitudinal survey. The first wave of data was collected in 1986 (W1) with follow-ups occurring in 1989 (W2), 1994 (W3) and 2001/02 (W4). To obtain the W1 sample, a multistage stratified area probability sample of noninstitutionalized adults 25 and over was used. Blacks and those aged 60 years and older were sampled at twice the rate of non-Blacks and individuals younger than 60, respectively. In the initial interview, conducted in 1986, between May and October, 3,617 respondents were interviewed in their homes. The individual response rate was 68%. Of the individuals interviewed in W1, 2,867 (about 79%) were re-interviewed at W2. At W3 2,562 individuals were re-interviewed at either through face-to-face or phone interviews, constituting a 71% response rate at. By W4 1,787 of the original respondents were re-interviewed representing a 70% response rate.

Characteristics of the original ACL sample are presented in Table 1, along with information about body mass index at each wave. Just over half of the sample (53%) is female. Race, which is self-identified, is examined in terms of black and white categories since the vast majority of the sample (95%) falls in these two categories, thus barring any meaningful analysis of other race groups. The average age in the sample is 47 years, with values ranging from 24 to 96. The average level of educational attainment is 12 years, or high school completion. The sample mean for BMI increased by 2.3 points over the 16 year period of the study. The variable for time is of special importance to the analysis. Time can be conceived of in two ways; historical time and individual time, also called

life course. The metric used for time is years, with the first wave representing time = 0 and each subsequent wave measured as the number of years that elapsed since the first wave. The analysis in this paper is concerned with trends in obesity, overweight and BMI over historical time.

Sample weights are applied in all descriptive statistics and analyses. Sample weights, which were constructed for each wave and for the panel, include adjustments for the differential probability of selection and the response rates as well as a post stratification weight.

Measures.

Overweight and obesity are studied using Body Mass Index (BMI). Self-reported measures of height and weight were used to calculate BMI. Height was reported in feet and inches in response to the question: How tall are you without shoes on? Weight was reported in pounds in response to the question: About how much do you weigh? Values for height and weight were then converted into meters and kilograms, respectively. While information on weight was collected at each wave, information on height was only collected at Wave 1. The following standard equation was used to calculate respondent BMI at each wave:

$$\frac{\text{weight (kilograms)}}{\text{height}^2 \text{ (meters)}}$$

While not an exact estimate, BMI is an adequate method for assessing body fat in the general population, though it is less than ideal for assessing body fat in the elderly and in pregnant women. Although BMI is obtained from self-reported measures of height and weight, the estimates are still useful. Since people tend to under-report weight and over-report height, it is likely that if estimates are biased, they are biased downward (Palta et al. 1982; Nawaz et al. 2001), thus producing conservative estimates. Therefore, BMI reported in this paper is likely to yield conservative estimates of prevalence rates for overweight and obesity. Overall, self-reports of height and weight involve such low error that they are reliable estimates of BMI (Bolton-Smith et al. 2000; Willett, Dietz and Colditz, 1999). Since the analysis in this paper is more concerned with changes in rates over time instead of the rates themselves, minor inaccuracies in BMI will not significantly affect interpretation of the analyses.

The classification guidelines used for these analyses are the guidelines issued by the National Institute of Health (NIH) and National Heart, Lung and Blood Institute (NHLBI). BMI is used to classify individuals by the following categories; underweight, normal weight, overweight, obese, and obese I, obese II and obese III. According to these guidelines, a BMI that is less than 18.5 is considered underweight, 18.5-24.99 is considered normal, 25.0-29.9 is considered overweight, and a BMI higher than 29.9 is considered obese. The obese category is further broken down into three classes, the third being extreme or morbid obesity. Class I obesity is a BMI of 30.0-34.9, class II 35.0-39.9 and class III $\geq$40 (NHLBI, 2000).

Descriptive Analysis

Trends in Mean BMI over Time by Age, Sex, Race and Education group

Data on mean BMI are taken from each wave of the Americans' Changing Lives survey and examined in terms of age, sex, race and education groups. As can be seen in Figure 1, BMI has been increasing over time for both white and black men and women. However, there is variation in the initial levels of BMI. White women for instance have the lowest initial BMI. Black women on the other hand have the highest. This relationship between black and white women is maintained at each period of measurement with black women always having the highest BMI and white women always having the lowest BMI. Table 3 shows the point estimates for BMI at each wave of data collection. The last column shows the difference between BMI in 2001/02 and BMI in 1986. The total sample of black and white men and women experienced a 2.0 point increase in BMI, though this increase was not experienced uniformly among the individuals in the sample. For instance, white women experienced a 1.9 point increase in BMI while black women experienced a 3.0 point increase in BMI, a full point above the total and over two points above white women. Notably, there does not appear to be a significant difference in mean BMI at initial status and the change over time between black and white males. Thus it is clear that secular trends in BMI have not affected all demographic groups equally.

BMI also varies by age, as is demonstrated by the age-specific mean BMI shown across waves in Table 4. The relationship between BMI and age is best described by an inverted J-shape curve where people at younger ages have lower BMIs but see increases in BMI as they age into the mid-life, with a steady drop off beginning around the 50's and 60's. A further examination of the columns in Table 3 show increases in BMI over

time for the first three age groups 24-54, a fairly stable BMI for the 55-64 age group and a steady decrease in the last two age groups (65+). These data indicate that BMI is patterned by age.[5]

The relationship between aging and BMI could indicate that the increases we are seeing in the population BMI is the result of the aging of our population. While it is true that the U.S. populations has been aging over the last 20 years (thanks mostly to the Baby Boom generation), it is unlikely that the trends in BMI over that period are the result of an age effect. Figure 2 illustrates the age progression of BMI by cohort. The four points in each line represent the mean BMI of that cohort measured at each wave. Where the points overlap indicates the difference in BMI between adjacent cohorts at the same age point. So, the first broken line represents the four BMI measurements of Cohort 1, people who were age 24-39 in 1986. The next four points represent the same four waves for people who were age 40-54 in 1986. We can see that at age 47, Cohort 1 has a higher BMI that the following cohort did when they were age 47. There is also a large gap between Cohort 2 and Cohort 3, who are people age 55-69 in 1986. The gap between Cohort 3 and Cohort 4 (people age 70 and beyond in 1986) is less pronounced. These gaps indicate that the trend in BMI is not entirely the result of an aging effect. The younger cohorts are experiencing more increases in BMI as they age than the older cohorts. It is possible then that the trend in BMI is the result of a cohort effect. This analysis does no attempt to isolate age and cohort effects in explaining BMI differentials, but it is an important issue to address in research on obesity prevalence.

[5] Additional analysis was done to determine if the trends observed in the data are a reflection of sample attrition from drop out or death. There is little indication that individuals who attrited bias the results obtained from the analyses in the paper.

Mean BMI was also calculated for different education groups. Table 7 includes the mean BMI over time for each of four education groups; less than high school, high school, some college, and college and beyond. BMI was calculated adjusting for age. Those not completing high school consistently have the highest BMI over time. The group of people who attained some college and those who completed college consistently have the lowest BMI (these two groups were not found to be statistically different from each other). It is interesting to note that the high school group experienced the largest increase in BMI points from 1986 to 2001/02, as indicated by the last column. There does not seem to be a clear explanation for this. I speculate that it is this group that is particularly vulnerable to adopting lifestyles that result in obesity, such as consuming processed foods and engaging in little physical activity. Additional analysis needs to be done to examine the effect of educational attainment on initial BMI status and change over time.

Overall Trends over Time for Normal, Overweight and Obese

In the 15 year period of the ACL study, BMI scores increased dramatically overall and increased in varying degrees for white males and females, black males and females, all ages except the oldest old and for different education groups. These increases in BMI are reflected in the changes in prevalence of normal, overweight and obese. Table 5 illustrates these changes for the total population. In 1986, at the first wave of measurement, nearly half of the population (48.6) was considered normal or 'healthy'. But by the fourth wave, this number decreased 31.8%, bringing the prevalence of normal down to 33.1. This is in contrast to the increases in both overweight and obese. Figure 3

illustrates the changes in the prevalence rates across waves. We can see that the 'normal' bars shrink downwards as the 'obese' bars climb. What is happening with overweight prevalence is less clear from this figure. There was an 11.5% increase in the prevalence of overweight from 1986 when it was 34.5 to 2001/02 when it became 38.5. Thus, the prevalence of overweight increased by 4 percentage points over approximately 15 years. This seemingly moderate increase in overweight is overwhelmed by the dramatic increases in obesity prevalence. Prevalence in obesity nearly doubled in only a 15 year period, going from 14.8 to 27.2, an 84% increase overall. This large of an increase in the prevalence of obesity in such a short period of time is alarming. Even more disturbing is that the increased prevalence of obesity seems to have had the largest impact on the morbidly obese category, class III obesity (shown at the bottom of Table 5). Class III obesity prevalence increased much more than either class I or class II obesity, though the actual class III prevalence in 2001/02 was still much smaller than the other two. Figure 4 shows stacked bars representing the increase in obesity prevalence over time with specific focus given to the increase in the three classes of obesity. While prevalence in class III obesity held fairly steadily from 1989 to 1994, it increased quite a bit from 1994 to 2001/02. Examination of Table 5 indicates that there is movement out of the normal and overweight categories and, more troubling, that the movement appears to be directed towards the obese category.

Trends in Overweight and Obesity over Time by Sex and Race

It is important to note how the changes in prevalence rates discussed above is reflected in different groups within the population. Table 6 shows the prevalence rates for

white and black males and females. Overweight prevalence statistics are a bit difficult to interpret. For instance, we can see that blacks experienced a decrease in their prevalence of overweight. However, a closer examination of the table shows that blacks also experienced the highest increases in obesity. What is interesting about the overweight prevalence rates is that white women had the lowest prevalence at each time of measurement, followed by black females. In the rest of the table, black female prevalence rates are the highest at every point of measurement.

Black males experienced an alarmingly high increase in their obesity prevalence of over 141% (see Table 7). This resulted from the more than doubling of their prevalence over the time period (15.3-36.8). Despite the considerable increase in black male obesity prevalence, they still had a lower rate than black females at the final point of measurement. The obese prevalence rate in black females is much higher than it is for the other groups at each time point. By 2001/02, obese prevalence among black females was slightly more than 20 percentage points higher than it was for white females and white males. It is interesting to note that black females had the lowest increase in obese prevalence over the time period. Still, the other groups would have to make great strides to catch up with the black female prevalence rates.

A final look at Table 6 shows the combined trends in overweight and obesity over time. It is helpful to groups these two categories to observe the full magnitude of the obesity epidemic (recall that overweight is considered the pre-obese state). According to the data, 65.7% of the total population was considered overweight or obese in 2001/02. In 1986, nearly 50% of the population was overweight or obese. In the 15 year period of the study, about one-third of the population shifted from the underweight and normal

categories to the overweight and obese categories, or from the overweight into the obese category. As would be expected from the first parts of Table 6, black females have the highest prevalence rates for both overweight and obese. However, the rates of black males are not far behind. It is disconcerting that nearly 82% of black females are either overweight or obese and that black males and, to a lesser degree, white males are not far behind. Even though they have the lowest prevalence, well over 50% of white females are either overweight or obese.

Trends in Obesity over Time by Education group

What is happening with education differences in overweight prevalence is a bit misleading. For instance, according to Table 7, those with less than a high school education experienced a small decrease in overweight prevalence, while those with more educational attainment experienced an increase by as much as 20% for those with a high school education (12 years of education). The numbers would suggest that those with a high school education have higher overweight prevalence at each wave than the other groups, including those with less than a high school education. Furthermore, the lowest prevalence rates are among those who had some college education, lower even that those who have completed college. While these rates seem a bit odd, it is important to evaluate them in light of the trends in obesity prevalence.

According to Table 7, those with less than a high school education had higher obesity prevalence rates than any other education group but increased the least from 1986 to 2001/02. The highest increase occurred among those with more than 16 years of education (139.4%) followed by those with some college (113.9%). The prevalence rate

for those who likely have a college degree (16+ years of education) more than doubled. Obesity is typically thought of as a burden carried by minorities, the poor, or the uneducated. Clearly this is not the case. While most of the obesity burden is carried by those with less educational achievement, the college educated are contributing to this burden as well.

Looking at the combined trends in overweight and obesity reveals that those with a high school degree have had the highest prevalence rates since 1989, above those with less than high school, such that 71% of the high school group are either overweight or obese. This prevalence is just over 5 percentage points above the total population prevalence. The prevalence rates for the education groups do not reflect age adjustments. Therefore, age differences in educational achievement may be affecting some of these prevalence rates. An examination of the age adjusted BMI indicates that the prevalence rates for high school and less than high school may be underrepresented while the rates for the other two groups may be overrepresented.

Analytic Framework and Statistical Methods

In the following analysis, I attempt to determine if differences actually exist between different demographic groups' initial BMI and rate of change over time. Ultimately, I want to determine if the growth trajectories in BMI are different between demographic groups and if those differences get larger or smaller over time. Furthermore, initial BMI, when combined with the growth rate, will illustrate the differences in BMI at the end of the time period. As stated above, I suspect that black females have higher initial BMI's as well as more rapid growth trajectories than white women and either black

or white men. Since I did not see significant differences between black and white men in wither initial BMI or the rate of change over time, I do not expect to see any differences in the analysis. My hypothesis regarding education is that the less educated will have a higher initial BMI as well as higher rates of change over time. To test these hypotheses, I use growth curve analysis within a multilevel model framework.

Growth curve analysis is a useful analytic tool for analyzing rates of change and growth with longitudinal data. The ACL is an ideal study for analyzing change because it has more than three waves of data, BMI changes systematically over time, and it collects data over the course of many years, a sensible metric for clocking time in terms of modeling BMI change (Singer and Willet, 2003). When modeling change over time, there are two key components to model; the initial status and the rate of change. With these two pieces of information, we can create growth curves for individuals or groups and test for the differences between individuals.

Because the data are hierarchical in nature, I conducted multilevel analysis using the HLM software developed by Raudenbush and Bryk. The basic multilevel model for studying individual change is of the form:

$$y_{ij} = a_j + bx_{ij} + e_{ij} \quad ; a_j = a + u_j$$

Where *i* represents a measure within individual *j*. The *a* and *b* terms are the fixed parameters of the model, referred to as the "fixed effects". For simplicity only one explanatory variable is shown x_{ij}, though more are typically included in the model Multilevel models also allow for the inclusion of random error terms at both the level of

the measurement e_{ij} and the individual u_j level. The specific model used in this paper is of the form:

$$BMI= \pi_0+\pi_1+e$$

Where π_0 is the intercept for the initial status of BMI and π_1 is the intercept for the rate of change in BMI. The last term *e* is the error term. The level 1 model used in this analysis is:

$$BMI= \pi_0+\pi_1(TIME)^6+e$$

The level 2 model is constructed such that π_0 and π_1 are a function of the age, sex, race and educational attainment of the individual (the detailed models are in the Appendix). For this analysis, Time is a continuous variable with 0 representing the first wave (1986) and each additional year being equal to1. Age was centered around the mean age of the study population (47 years) to allow for ease of interpretation. Age was centered by deviating each individual's age from the mean age of the sample. In addition, a quadratic term for age is included, reflecting the non-linearity suggested by the U- and inverted J-shaped curves discussed above.

Results

The results of the multilevel HLM analyses are shown in Table 8. Model 1, the empty or null model, is an intercept-only model that shows that in 1986 (Time=0), the average individual had an initial BMI of 25.6 and that as time progressed, the average individual's BMI increases by an estimated 0.12 points.

[6] A measure of historical time, with year as the metric.

Model 2, an examination of race/sex effects, with white men as the reference, shows support for the hypothesis that blacks have higher initial BMI and faster growth rates over time than whites. However, the coefficients for black men are small and non-significant, indicating that the black white differential must be driven by women alone. In fact we see that black women have a much higher initial BMI than either white women or men. Thus, the hypothesis that black women have higher initial BMI than any other group is supported. However, according to this model, black women do not experience the highest growth rates, though it is still much higher than the growth rate for white females. Model 3 controls for the effect of age. Accounting for age has the general effect of increasing 27.55 the initial BMI status. For example, white women's initial BMI status increases from 24.87 to 25.62 with the inclusion of age. While the addition of age has no effect on the growth rate for black women, it increases the white female coefficient, which goes from negative to positive and becomes significant. Finally, including age does little, if nothing, to alter the observed male relationship. Thus, the inclusion of age has varying effects for subgroups.

Model 4 includes the education categories with less than high school as the reference category. The hypotheses regarding education receive mixed support. On the one hand, there is a negative relationship between initial BMI and education level. However, the relationship between the growth rate and education is Positive. This suggests that individuals in lower education groups begin the study period with higher levels of BMI, but make less advances in BMI over the course of the study than those in higher education groups. The relationship between education and BMI growth rates is puzzling. Attempting to better understand these findings, Model 5 controls for the effects

of age, a characteristics that is quite meaningful in analysis concerning education. The inclusion of the age variables has the effect of increasing the initial BMI status for each education level, while still retaining the relationships observed in Model 4. However, controlling for age results in non-significant coefficients for the growth rate, leading me to conclude that the odd relationship between growth rates and education that was observed in Model 4 was being driven by the respondent's and not actual BMI growth rates.

The fully explicated model is found in Model 6, which includes the race/sex categories, education and age. All of the coefficients for initial status in BMI are significant except, again, that of black males. So, the inclusion of education does not affect the significance of the coefficients in Model 3, though it does result in a serious decrease in the initial BMI for black women. I calculate initial BMI by adding the group specific coefficients to the constant, which is treated as the actual value for white men. According to Model 6, black and white men have a starting BMI of 27.9, black females a BMI of 29.1, and white females a BMI of 26.6. In the final model, black women still have a higher initial BMI than the men and a much higher BMI than white women. The coefficients indicating rate of change over time continue to be significant for black and white women and insignificant for black men. In the final model, black women have a growth coefficient (.145) that is higher than that for white women (.106) and nearly double that for white men (.078).

The final model highlights a similar relationship between education and initial status and change in BMI as was found in Model 5. In this model, education level is negatively associate with initial BMI. And though the coefficients for BMI growth are

positive, they are non-significant, indicating that we cannot interpret much from the observed relationship.

Discussion and Conclusion

For the most part, the analysis confirmed the hypotheses set forth above concerning the differential starting point and growth rates between race, sex and education. There are, however, some exceptions. No difference was found between black and white males on either their initial BMI status or their growth over time. And, although the BMI growth coefficients for education were not significant, they were going in the opposite direction than suspected. Models 2, 3 and 6 show clear differences between black and white women and their differences from the men. Black women have the highest initial BMI and the highest annual growth rate, whereas white women have the lowest initial BMI and a lower annual growth rate than black females, though it is still higher than the male rate of change. Annual growth from initial status is plotted in Figure 5. If all race sex groups were to start from a common initial BMI and continue with their unique growth trajectories, black females would grow the fastest, followed by white females and then the males. But this does not represent a real world situation. Black females in fact have the highest initial BMI status which, when combined with the high growth rate, means that black females are doubly disadvantaged in terms of BMI and by implication, their obesity prevalence.

The analysis of education is very much a starting point. As previously noted, there has not been much research done on the educational differentials in BMI and obesity prevalence. This analysis shows that people with less than a high school education have

higher initial BMI than the other education groups; a full point higher than the next group and about a point and a half higher than people with at least some college attainment. However, the annual growth in BMI was not found to be significantly different between the groups. If the coefficients were significant, it would indicate that people with at least a high school education have higher annual growth than people with less than a high school education. Since these coefficients are not significant, we cannot be confident that their values are good estimates. More studies need to be done examining the relationship between education and BMI. Additional analyses should include income as well as education since they might have a joint effect on BMI.

The trends in the descriptive statistics show that BMI, a reflection of obesity prevalence, is increasing over time. Co-currently, the number of people considered in the normal BMI range is decreasing. These trends are indicative of the growing obesity epidemic facing the United States. Interestingly, these trends are not being experienced evenly throughout the population. Black women are carrying the heaviest burden of obesity and if trends continue will increasingly carry this burden as time goes on. But white females and black and white males are also being negatively affected by the obesity epidemic.

If the findings reported above hold true, there are serious implications for prevention and intervention efforts that are being directed towards the overweight and obese in the population. If this problem is not affecting the total population in a uniform manner then interventions and preventative efforts should not be directed at the general population but instead at those groups of people who experience the greatest likelihood of becoming overweight or obese. Further studies of the issue might include a more

extensive analysis of education and income as mentioned above. It may also be valuable to examine contextual effects on BMI and obesity prevalence by taking into account the geographic variation in BMI and obesity patterns for different groups. Finally, an extensive examination of age, period and cohort effects is needed if we want to understand how this epidemic was created and how it spread so rapidly in such a short period of time.

For now, the obesity epidemic shows no signs of diminishing in this country. In fact, trends indicate that it will get worse over the next 20 year. The chances of meeting 2010 Healthy People objectives seems unlikely. However, if we can at least be moving in the right direction it would be promising. Ultimately, more efforts need to be directed at researching the problem and possible strategies for successful interventions and preventative measures.

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Tables and Figures

Table 1. Descriptive information about the sample [a]

Independent Variables		Dependent Variable (BMI)		
Sex		1986	Range	11.5-55.1
Female (1)	52.90%		Mean	25.2
Male (0)	47.10%		Std. Dev.	4.7
Race		1989	Range	13.8-54.9
Black (1)	11.00%		Mean	26.1
White (0)	83.50%		Std. Dev.	4.9
Age		1994	Range	14.2-54.7
Range	24-96		Mean	26.5
Mean	47.1		Std. Dev.	5.0
Std. Dev.	16.4			
		2001/02		
Education			Range	12-57.6
Range	0-17+		Mean	27.5
Mean	12.4		Std. Dev.	5.4
Std. Dev.	3.1			

a. All data are weighted.

Table 2. Mean BMI by race and sex and by education 1986-2001/02[a]

	W1	W2	W3	W4	change
Total	**25.5** (n=3617)	**26.1** (n=2867)	**26.5** (n=2562)	**27.5** (n=1787)	**+2.0**
White	25.4 (2323)	25.9 (1906)	26.3 (1752)	27.3 (1292)	+1.9
male	26.0 (907)	26.6 (720)	27.0 (668)	28.0 (491)	+2.0
female	24.8 (1416)	25.2 (1186)	*25.7 (1084)*	26.7 (801)	+1.9
Black	26.9 (1174)	27.5 (874)	28.1 (739)	29.7 (445)	+2.8
male	26.2 (396)	26.7 (281)	27.3 (226)	28.6 (139)	+2.4
female	27.5 (778)	28.0 (593)	28.6 (513)	30.5 (306)	+3.0
Education[c]					
< High school	27.4 (1349)	28.4 (989)	28.4 (811)	29.5 (419)	+2.1
High School	24.4 (1054)	26.8 (855)	27.5 (769)	28.8 (598)	+4.4
Some college	26.0 (714)	26.6 (590)	27.01 (568)	27.7 (430)	+1.7
≥ College	26.0 (500)	26.6 (433)	27.15 (414)	27.8 (340)	+1.8

a. All data are weighted.
b. Difference in BMI from 1986 (W1) to 2001/02 (W4).
c. Mean BMI for education is adjusted for age.

Table 3. Age-specific mean Body Mass Index (BMI), 1986 to 2001/02[a]

	Age Group					
	24-34	35-44	45-54	55-64	65-74	≥75
Wave 1	24.5	26.7	26.4	26.6	25.0	24.6
n=	740	591	390	685	765	446
Wave 2	25.5	26.3	27.1	26.7	26.0	24.2
n=	585	498	313	575	597	299
Wave 3	26.1	27.2	27.5	26.4	25.6	23.6
n=	567	476	313	508	509	189
Wave 4	27.6	28.3	28.0	26.7	24.9	22.9
n=	486	404	252	361	241	43

a. All data are weighted.

Table 4. Prevalence of normal, overweight, obese and obese I-III

in the total population from 1986-2001/02[ab]

	Wave 1	Wave 2	Wave 3	Wave 4	
n=	3617	2867	2562	1788	
					%change
Normal (BMI 18.5-24.9)	48.6	43.2	39.5	33.1	-31.8
	1617	1207	987	598	
Overweight (BMI 25-29.9)	34.5	37.5	38.1	38.5	+11.5
	1254	1021	922	673	
Obese (BMI 30+)	14.8	17.3	20.5	27.2	+84.0
	660	571	586	485	
Obese I (BMI 30-34.9)	10.6	12.2	14.5	18.7	+75.7
	451	385	399	316	
Obese II (BMI 35-39.9)	2.9	3.3	4.2	5.5	+90.6
	138	121	131	101	
Obese III (BMI 40+)	1.3	1.8	1.8	3.1	+136.4
	71	65	56	68	

a. All data are weighted.

b. Numbers are expressed in percentages.

Table 5. Prevalence of overweight, obese and both overweight and obese by race and sex from 1986-2001/02[ab]

	Wave 1	Wave 2	Wave 3	Wave 4	
n=	3617	2867	2562	1788	
>>Overweight BMI 25.0-29.99<<					%Change
Total	34.54	37.53	38.11	38.52	+11.5
White	34.43	37.31	37.68	38.44	+11.6
	794	679	633	482	
female	27.69	28.15	30.69	30.17	+9.0
	425	351	333	241	
male	41.86	47.45	45.70	48.48	+15.8
	369	328	300	241	
Black	39.44	38.13	39.17	38.08	-3.6
	423	315	262	169	
female	37.09	36.69	34.81	35.88	-3.4
	268	206	166	114	
male	42.56	40.09	45.87	41.35	-2.9
	155	109	96	55	
>>Obese BMI 30+<<					%Change
Total	14.8	17.3	20.5	27.2	+84.0
White	14.3	16.3	19.6	25.3	+77.3
	344	306	332	302	
female	14.4	16.4	19.6	25.2	+75.0
	219	192	204	185	
male	14.1	16.2	19.6	25.4	+80.0
	125	114	128	117	
Black	22.2	26.5	31.8	42.0	+89.3
	300	251	245	173	
female	27.4	29.7	35.9	45.7	+66.9
	237	195	185	129	
male	15.3	22.2	25.6	36.8	+141.1
	63	56	60	44	
>>Overweight and Obese BMI 25+<<					%Change
Total	49.30	54.90	58.60	65.70	+33.2
White	48.69	53.60	57.28	70.24	+44.3
	1138	985	965	784	
female	42.09	44.52	50.31	55.37	+31.6
	644	543	537	426	
male	55.97	63.67	65.30	73.89	+32.0
	494	442	428	358	
Black	61.64	64.61	70.97	80.11	+30.0
	723	566	507	342	
female	64.49	66.36	70.66	81.62	+26.6
	505	401	351	243	
male	57.83	62.24	71.46	78.17	+35.2
	218	165	156	99	

a. All data are weighted.
b. Numbers are expressed in percentages.

Table 6. Prevalence of overweight, obese and both overweight and obese by education from 1986-2001/02[ab]

	Wave 1	Wave 2	Wave 3	Wave 4	
n=	3617	2867	2562	1788	
	>>Overweight BMI 25.0-29.99<<				%Change
Total	34.54	37.53	38.11	38.52	-31.8
<High school	35.3	35.8	30.8	35.1	-0.6
	473	352	256	136	
High school	35.9	40.6	42.9	43.1	+20.1
	367	314	300	248	
Some college	32.2	35.6	38.5	33.8	+5.0
	229	196	214	150	
College+	34.1	37.1	38	39.9	+17.0
	185	159	152	139	
	>>Obese BMI 30+<<				%Change
Total	14.8	17.3	20.5	27.2	+84.0
<High school	20.8	25.0	27.1	31.7	+52.4
	342	267	244	140	
High school	14.8	15.5	19.7	27.9	+88.5
	164	144	161	158	
Some college	12.2	14.9	17.6	26.1	+113.9
	101	99	110	111	
College+	9.9	14.3	18.0	23.7	+139.4
	53	61	71	76	
	>>Overweight and Obese BMI 25+<<				%Change
Total	49.30	54.90	58.60	65.70	+33.2
<High school	56.1	60.8	57.9	66.8	+19.1
	815	619	500	276	
High school	50.7	56.1	62.6	71.0	+40.0
	531	458	461	406	
Some college	44.4	50.5	56.1	59.9	+34.9
	330	295	324	261	
College+	44.0	51.4	56.0	63.6	+44.5
	238	220	223	215	

a. All data are weighted.
b. Numbers are expressed in percentage

Table 8. Initial BMI and Growth Trajectories by race and sex (Model 2), race, sex and age (Model 3), education (Model 4), education and age (Model 5), and race, sex, education and age (model 6). Model 1 is a constant only model.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Initial	Growth	Initial	Growth	Initial	Growth	Initial	Growth	Initial	Growth	Initial	Growth
Fixed Effects												
Intercept	25.62***	.12***	26.03***	.11 ***	26.86***		26.78***	.046**	27.53***	.098***	27.88***	0.078***
	(.11)	(.006)	(.16)	(.01)	(.19)	0.098***	(.22)	(.018)	(.27)	(.02)	(.30)	(.02)
Black Male			.27	.02	0.17	0.02					-0.04	0.026
			(.31)	(.022)	(.30)	(.021)					(.31)	(.021)
Black Female			1.52 ***	.05*	1.46***	.062**					1.19***	.067**
			(.31)	(.023)	(.30)	(.022)					(.3)	(.022)
White Female			-1.16***	-0003	-1.24***	.029*					-1.26***	.028*
			(.23)	(.014)	(.23)	(.013)					(.23)	(.014)
Age					.06***	-.007***			.04***	-.007***	0.05***	-
					(.007)	(.0004)			(.007)	(.0004)	(.007)	0.01*(0.0
Age2[a]					-.03***	.001***			-.03***	-.001***	-.03***	-.001***
					(.004)	(0002)			(.004)	(.0003)	.004	(.0003)
High school							-1.2 ***	.086***	-1.21***	.035+	-1.0**	.037~
							(.28)	(.021)	(.29)	(.02)	(.29)	(.02)
Some college							-1.74 ***	.081***	-1.6 ***	.01	-1.46***	0.013
							(.31)	(.021)	(.33)	(.021)	(.32)	(.021)
College+							-1.71***	.097***	-1.56***	.016	-1.47***	0.023
							(.33)	(.022)	(.35)	(.022)	(.35)	(.022)
Random Effects												
Level 1	5.6		5.04		3.63		4.94		4.37		3.63	
Level 2	20.13		21.78		18.92		22.65		21.79		18.66	

+p<.10; *p<.05; **p <.01;***p<.001

[a] Coefficients and standard errors have been multiplied by 10.

Level 1- occasion/measurement level
Level 2- individual level

Figure 1. Mean BMI by Sex and Race (compared to total population mean)

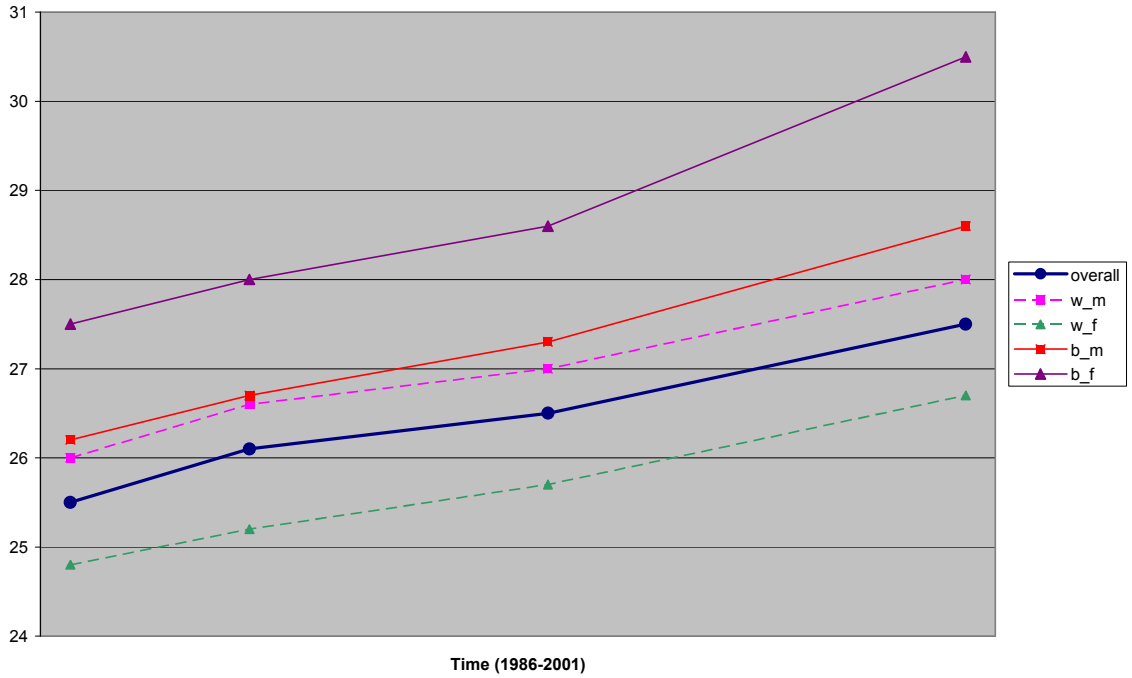

Figure 2. Age Progression of BMI by Cohort

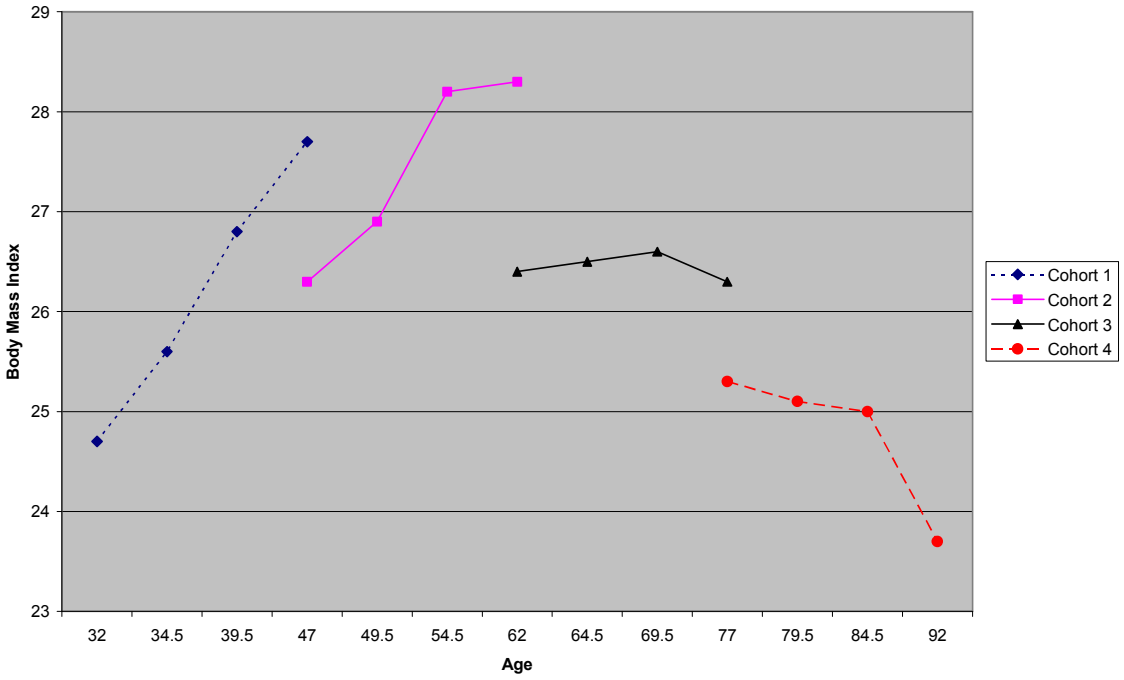

Figure 3. Prevalence of Normal, Overweight and Obese Across Waves

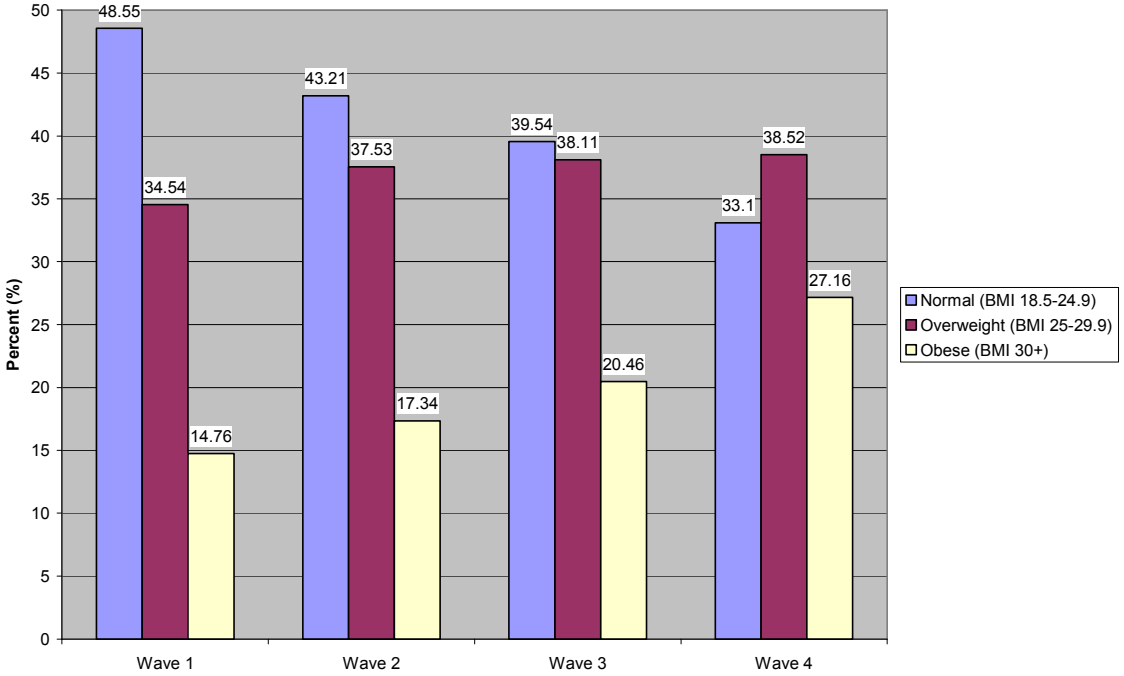

Figure 4. Prevalence of Obese by Obese Categories

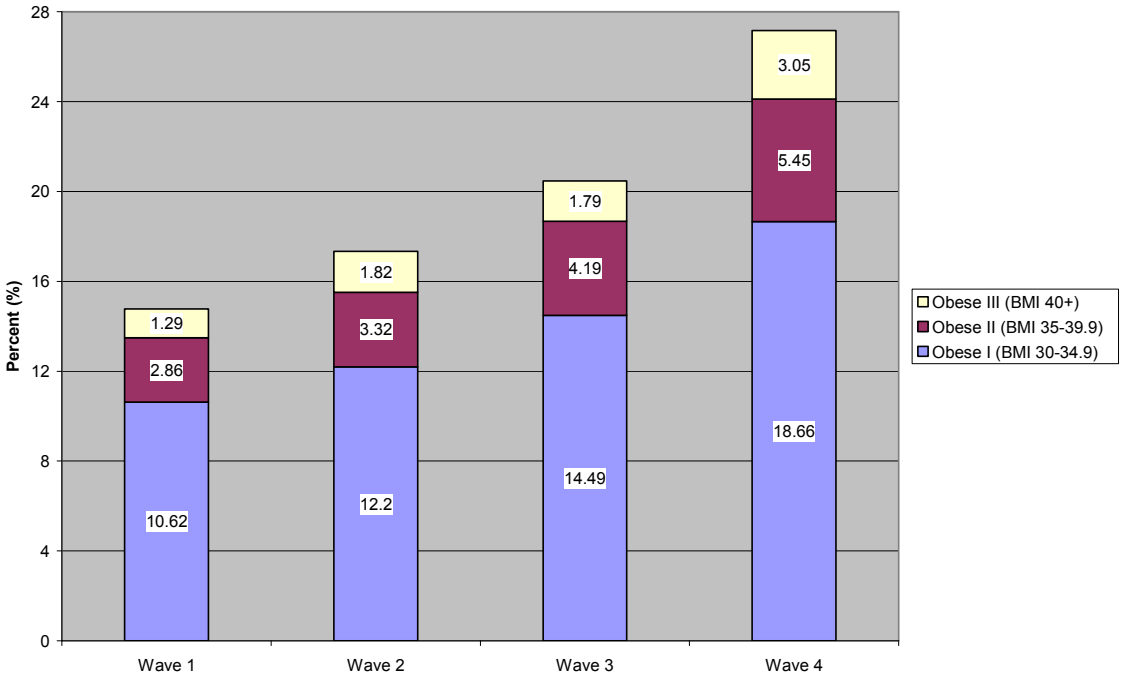

Figure 5. Differences in Growth Trajectories Assuming a Common Initial Status