Obesity in America, 1960-2000: Is it an Age, Period, or Cohort Phenomenon?

Rebecca Utz
University of Utah

DRAFT
Submitted for Consideration
PAA 2005

Increasing rates of obesity have sparked tremendous public concern because excess body weight is linked to a host of mortality, morbidity, and disability outcomes. Using five waves of data from the National Health and Nutrition Examination Survey (NHANES), this project privides a four-decade picture of body weight trends among American adults age 20-74. Specifically, this paper asks whether some birth cohorts have been more affected by these secular changes than others. It then considers the implications of these trends on future health and mortality. A series of graphical approaches provide the necessary background to estimate an age-period-cohort model of these trends. Results suggest that the Obesity Epidemic has occurred after the late 1970s, that the prevalence of obesity increases across the various stages of the adult life course, and that those cohorts born after 1915 have successfully higher rates of obesity at every stage of the life course.

This chapter is the second (of three) to present detailed prevalence data on adult body weight from 1959-2002. This chapter has conceptually reorganized the time-series data presented in Chapter 4 to explore 1.) whether the prevalence of obesity differs across the various stages of the adult life course and 2.) whether the Obesity Epidemic has affected some birth cohorts more than others. By stratifying the trends according to these various notions of "time," this chapter provides a more meaningful set of data that can be used to make informed projections about the potential consequences of the Obesity Epidemic in America.

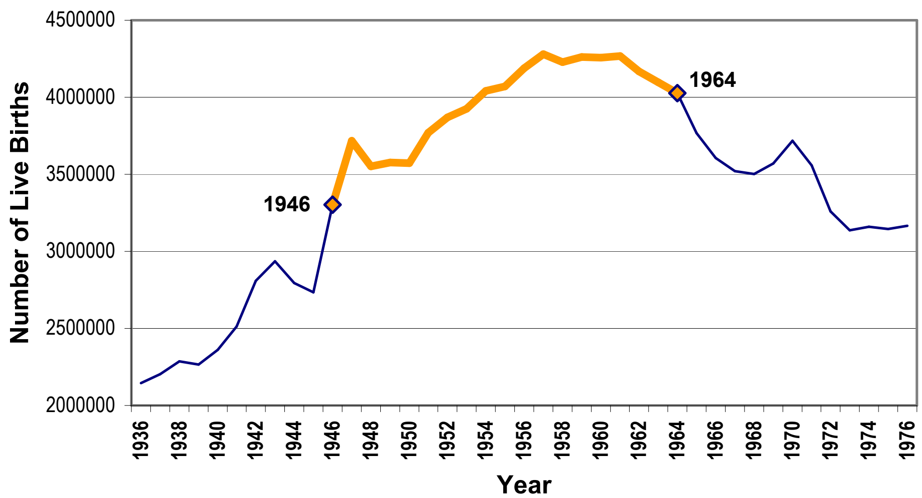
The Multiple Dimensions of Time

For purposes of this chapter, time has been conceptualized in terms of three intertwined continuums: *Historical time* corresponds to calendar years. *Life course time* corresponds to the span of time between birth and death. Then, because life course time is completely enmeshed within historical time (Mills, 1952), a third dimension of time is needed to identify the potential interaction between the first two dimensions. *Cohort time,* which is identified by birth year or cohort membership, corresponds to specifically to the historical time one experienced the stage of the life course. Body fat is hypothesized to vary within and across each of these three measures of time.

Theories & Hypotheses About Time: Average levels of body weight and the prevalence of body fat have increased across recent historical time periods (Flegal, Caroll, Ogden, & Johnson, 2002; Hedley et al., 2004 for example; Mokdad et al., 2003; Williamson, 1995). This existence of a secular trend is undeniable; however, the causes of the trend are debatable. Chapter 1 hypothesized how the recent increase in obesity is the apparent result of cultural modernization. That is, the emergence of the modern American lifestyle has created a tendency for the American population to gain weight (Beller, 1977; Brown, 1991; Shell, 2002). Then, in Chapter 4, it was suggested that the Obesity Epidemic was the result of adopting new measurement standards, which classified greater proportions of the population as obese than previous measurements had (Jolliffe, 2004; McKay, 2002). The latter hypothesis did not receive any empirical support, while the first hypothesis about cultural modernization has not been explicitly tested because determining the cultural etiology of obesity is beyond the scope of this project.

A third hypothesis for the existence of a secular trend may actually be related to the second notion of time, *life course time*. A large body of research has found that body weight fluctuates throughout the various stages of the adult life course, usually increasing throughout early adulthood and midlife and then slightly decreasing at the later stages of the adult life course (Ferraro & Booth, 1999; Flegal et al., 2002; Gallagher et al., 1996; Launer, Harris, Rumpel, & Madans, 1994; Stevens et al., 1998; Taylor & Ostbye, 2001). It is an effect of metabolic changes, combined with differences in activity patterns and dietary that vary across the life course. As the population aged during the past several decades (refer back to Figure 3.1), greater proportions of the population occupied middle ages, the life stage that is associated with the highest rates of obesity. Thus, one could speculate that the aging of the population, especially the middle aging of the unusually large baby boom cohort (see Figure 5.1), could be the driving force behind the American Obesity Epidemic that has occurred during the 1980s and 1990s. This time-based hypothesis, while plausible, is not necessarily a factor in these analyses. All estimates, regardless of the historical moment they were collected, have been adjusted to reflect a standard population composition (Klein & Schoenborn, 2001). Appendix C reports both adjusted and unadjusted rates, while all prevalence data reported in the text are adjusted to a common population standard.

Figure 6.1 Number of Live Births per Year in the United States, 1936-1976. The baby boom occurred between 1946-1964. Data come from the United Nations *Demographic Yearbooks,* Number of Live Births by Year.



When offering hypotheses for how “time” may impact the adult body weight trends, it is also important to consider how an individual’s exposure to secular changes may impact the likelihood that he or she will be obese. To do this, it is necessary to consider how birth year, historical time, and aging all interact to produce a unique set of experiences that is shared by similarly-born peers, but not necessarily with those born during other time periods (see Table 5.1)

Table 5.1 Birth Year, History, and Life Course

	How old in…		
	1960	**1980**	**2000**
If born in **1900**	60	80	100
If born in **1920**	40	60	80
If born in **1940**	20	40	60
If born in **1960**	0	20	40
If born in **1980**		0	20

According to a body of theoretical writings (Mannheim, 1952; Ryder, 1965), birth year or cohort membership dictates the cultural opportunities and constraints imposed on individuals. For example, the persons who are middle-aged in 2000 were born right after the end of WWII. They experienced their childhood in the 1950s and came of age during or after the 1960s and 1970s. As a result of their shared historical experience, these men and women are, on average, more educated, have higher labor force participation rates (particularly the women), and practice vastly different familial forms than generations born before them (Bumpass, 1990; Easterlin, Schaeffer, & Macunovich, 1992; Owram, 1997; Thornton, 1989). They also have lived through an era where communication advances, new medical technology were widespread (Berger, 2000; Fishwick, 2002; Wyke, 1997). Cohorts born during other time periods will not necessarily encounter better or worse opportunities, just a different set of constraints and privileges which will ultimately impact the nature and direction of their shared life course experiences.

Drawing from this general explanation of how cohort membership stratifies social opportunities (Mannheim, 1952; Ryder, 1965), I argue that in order to understand the true impact of the Obesity Epidemic, it is imperative to consider how one's body weight across the *life course* is constrained by the *historical* period in which he or she was born. For example, are some cohorts more likely to be obese than others simply because they were born during eras where obesity was more or less common. Thinking about these cohort differences from a cumulative risk perspective makes the issue even more important to consider (Crystal & Shea, 1990; Ferraro & Kelley-Moore, 2003; Vita, Terry, Hubert, & Fries, 1998). Say, for example, the cohorts born later in the twentieth century exhibit higher prevalence rates at early ages than those cohorts born earlier in the twentieth century. When these differences are compounded out across the entire life course (assuming that there is indeed some sort of age-effect associated with obesity), the Obesity Epidemic will leave a far greater impact on these cohorts than it has on previously born cohorts. To my knowledge, no study has documented the prevalence of obesity at the level of cohorts.

Empirically Estimating the Effect of Time: A common approach to disentangling the unique effects of "time" is through the use of an Age-Period-Cohort (A-P-C) statistical model (Alwin & McCammon, 2001 for example; Arbyn, VanOyen, Tibaldi, & Molenberghs, 2002; Avila & Walker, 1987; Mason, Mason, Winsborough, & Poole, 1973; O'Brien, 2000; O'Malley, Bachman, & Johnson, 1988; Palmore, 1978; Portrait, Alessie, & Deeg, 2002; Reynolds, Crimmins, & Saito, 1998; Ryder, 1965; Vinh-Hung & Storme, ; Wilmoth, 1990; Yang, Fu, & Land, 2003). Although this type of analysis is ideally situated to measure how these various dimensions of time have contributed to a certain trend, the estimation of the A-P-C models is plagued by a serious identification problem.

The three dimensions of time: *age* (years lived), *period* (current year), and *cohort* (year born), although conceptually distinct, are not operationally independent.

Age = Period – Cohort

Period = Age + Cohort

Cohort = Period – Age

As measured, the concepts are inherently confounded and perfectly linear, making the estimation of an A-P-C model very problematic. A large literature dating back to the 1970's has examined the methodological limitations associated with A-P-C models (Fienberg & Mason, 1979; Glenn, 1976; Hobcraft, Menken, & Preston, 1982; Mason et al., 1973; Mason & Fienberg, 1985; Wilmoth, 1990; Yang et al., 2003). Neverrtheless, methodologists have explored various ways to estimate these models, despite their inherent problems with multicollinearity.

Most agree that in order to identify an A-P-C model, the analyst must place restrictions on the parameters of the model (Mason & Wolfinger, 2002 for review). In practice, parameter restriction has typically been achieved in one of the following ways: First, one of the three variables can be dropped from the analysis, if it is assumed to not affect the outcome of interest (Alwin & McCammon, 2001; Reynolds et al., 1998). Second, a certain set of parameters may be constrained to be equal (Mason et al., 1973). For example, based on some theoretical argument, the analyst assumes that the parameters associated with two particular time periods should be set equal to one another. By constraining a portion of the variation in one variable, the model can be estimated. The third common approach assumes that the effect of one variable is proportional to some other substantive variable (Heckman & Robb, 1985). For example, an apparent cohort effect may be drive by the different size of particular cohorts, or a period effect might be proportional to the shifting unemployment rate or educational level associated with each cohort (Alwin & McCammon, 2001; Portrait et al., 2002). This third type of approach will drop one of the three time-based variables and replace it with the other substantive variable that is correlated with it.

Despite these novel methodological approaches, a number of problems are still associated with the identification of an A-P-C model. Beyond saying that parameter restrictions are needed, the literature has yet to provide a general framework for thinking about how A-P-C models might be identified (Mason & Fienberg, 1985). Oftentimes, the choice of which parameter to constrain is not clearly motivated by a priori theory, which leaves the analyst to pick and choose which of the three factors is most important. Furthermore, the empirical results obtained from these different modeling approaches are quite malleable depending on which parameter restrictions are made and, as such, are sensitive to misspecification of those restrictions (Yang et al., 2003). If the restrictions are altered only slightly, this can have a major effect on parameter estimates and substantive conclusions drawn from those estimates. Although the A-P-C analyses hold great promise for estimating the effects attributable to the various dimensions of time, the limitations of these statistically derived models often minimize their ability to answer substantive questions.

I wish to note an additional limitation I discovered when trying to estimate the A-P-C models using repeated cross-sectional data: because sample weights are calculated at each individual wave, I was unable to meaningfully weight the individual NHANES samples when the data were combined into one combined data file. This means that I was unable to control for possible fluctuations that were due to sampling differences and changing population characteristics, if I wanted to use an A-P-C model to estimate these time-based trends at the level of the population.

Analytic Plan

In order to explore the unique effects of age, period, and cohort, I have synthesized five waves of NHANES data into a single data file with approximately 60,000 cases. Each case was given a unique value for *age* (at time of data collection), *period* (midpoint of data collection: 1961, 1973, 1978, 1991, or 2000), and *cohort* (year of birth). I used these dimensions of time to stratify the prevalence data. Although the cohort hypotheses are a primary motivation for these analyses, I also address how body weight has shifted across life course time (age-effect) and the effect of historical time (period-effect). This helps establish a context from which the cohort effects can be discussed.

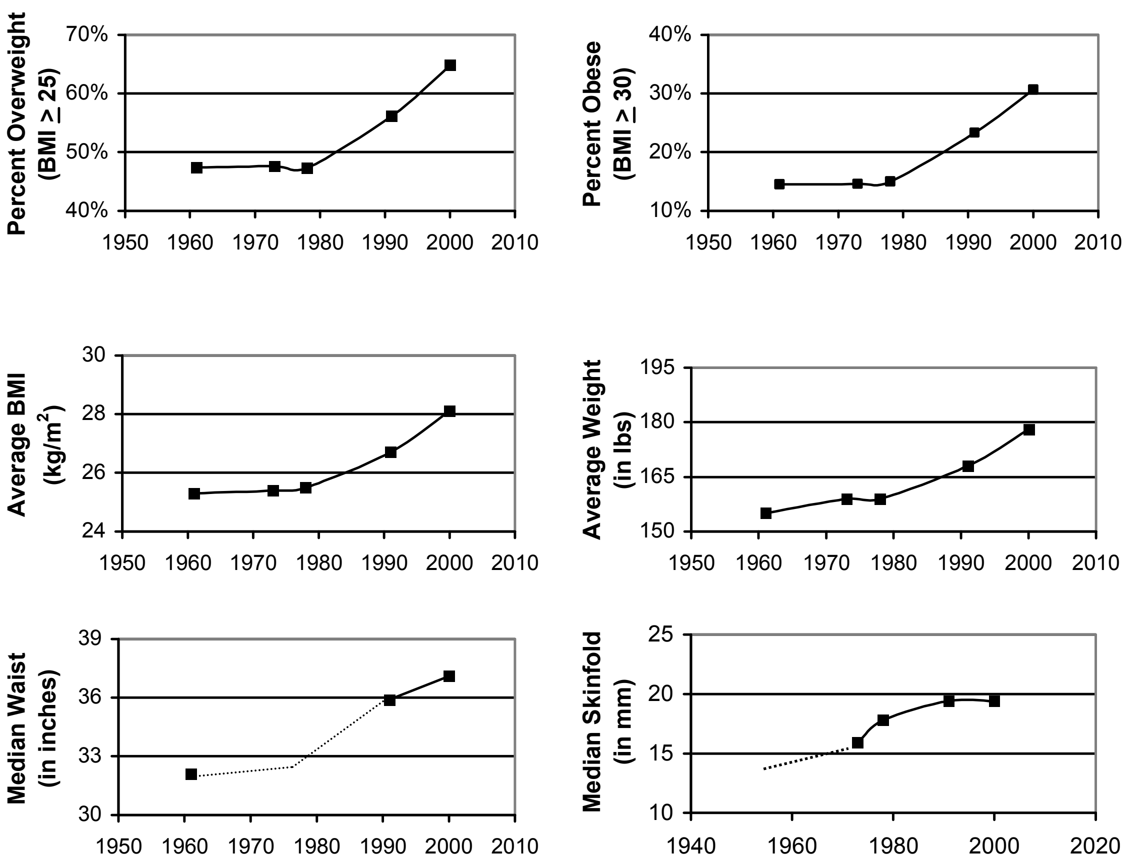
These analyses rely primarily on a graphical approach to estimate the age, period, and cohort-based trends in adult body weight. Although the adopted graphical approach limits my ability to make claims about statistical inference, the unadjusted prevalence rates have provided results that are, in my opinion, conceptually more valid and methodological more reliable than the A-P-C modeling approaches, given their misspecification and identification problems. Furthermore, the cohort-stratified prevalence data is informative and useful in its own right, regardless of whether a statistical model verifies the existence of a cohort effect over and above a period or age effect.

Although the majority of this analysis relies on graphical approaches, I also provide a regression-based model in which I simultaneously estimate the effects of age, period, and cohort on American body weight trends. Once I completed the graphical analyses of the data, I had enough information to reliably estimate an A-P-C model. The graphical approaches provided a blueprint for which parameters should be constrained in the model.

Obesity Trends: Period Trends

The time-trends presented previously in Chapter 4 documented the secular trends associated with the Obesity Epidemic. Summarized here in Figure 5.2, the data show that American body weight has increased dramatically throughout the most recent decades of history, with the most significant changes occurring in the 1980s and 1990s.

Figure 5.2 The Obesity Epidemic 1959-2002: Evidence of a Period-Level Trend. Data come from the NHANES data collection: 1959-1962, 1971-1975, 1976-1980, 1988-1994, 1999-2002. The nodes (■) represent the midpoint of each data collection period. The dashed lines (----) estimate the trend where data were not available for a particular wave. Sample is restricted to non-pregnant adults age 20-74. All estimates have been weighted to control for unequal probabilities of selection and nonresponse and have been standardized to the 2000 Standard Population.



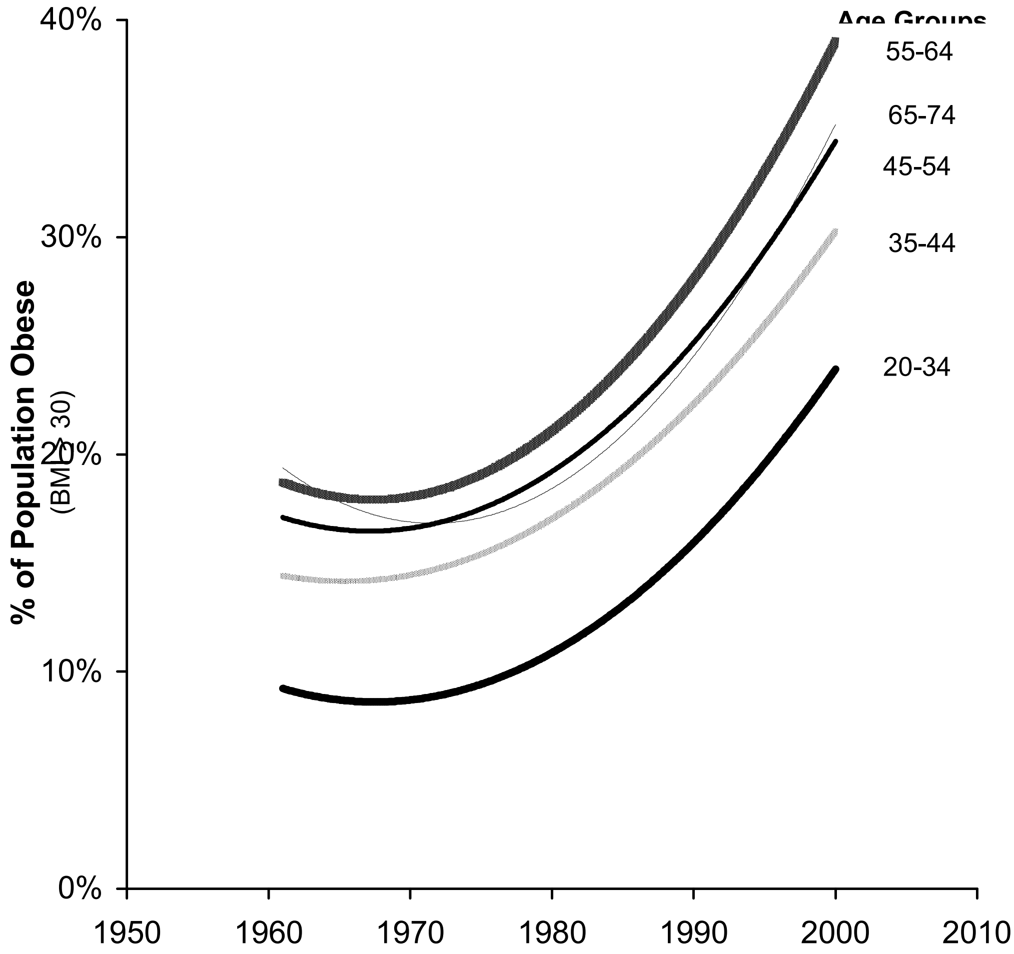
Chapter 4 ruled out the possibility that this secular trend was an artifact of changing measurement standards; however, it is still unclear whether the Obesity Epidemic should be considered a true period-level effect. A trend is only considered a period-level trend when it is shared equally across the entire population. This means that all persons in the population, regardless of age or other demographic differences, would have experienced the Obesity Epidemic similarly. Putting demographic differences aside (that will be the focus of Chapter 6), Figure 5.3 explores whether all age groups have been affected by the secular increases in obesity similarly.

When the prevalence rates were stratified by age and then plotted against historical time, the resulting age-specific trends all resemble a similar quadratic form, indicating that the Obesity Epidemic has had a greater impact during the 1980s and 1990s, than during the 1960s and 1970s. The age-specific trend-lines were fitted to a second-order polynomial regression equation:

$$Y = B_0 + B_1 \text{ (age)} + B_2 \text{ (age}^2\text{)} + e$$

This quadratic form fits the NHANES data points very well, $R^2_{\text{age 20-34}} = 0.99$, $R^2_{\text{age 35-44}} = 0.995$, $R^2_{\text{age 45-54}} = 0.999$, $R^2_{\text{age 55-64}} = 0.98$, and $R^2_{\text{age 65-74}} = 0.999$.

Figure 5.3 Period-Level Changes in Obesity Prevalence by Select Age Groups, 1959-2002. Data come from the NHANES data collection. Sample is restricted to non-pregnant adults age 20-74. All estimates have bee weighted to control for unequal probabilities of selection and nonresponse and have been standardized to the 2000 Standard Population. Trend lines were smoothed by fitting the five data points to a second-order polynomial regression equation where O*besity Prevalence* = $B_0 + B_1$ (age) + B_2 (age^2) + *e.*

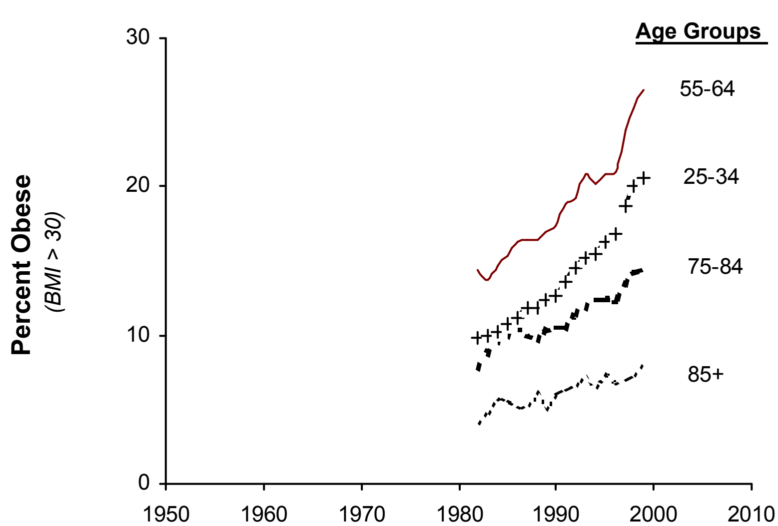


Although each of the trend lines follows a similar upward sloping curve, a few notable differences emerged when the data were presented in this way. First, the *magnitude* of obesity differs across the various age groups. The youngest age group

(20-34) had the lowest rates of obesity during every moment in history, whereas the middle-aged group (55-64) exhibited the highest prevalence rates. The absolute difference between these two age groups was at least 8.5 percentage points across each of the five waves of NHANES data. This finding is tantamount to estimating the age effect, while controlling for differences that are due to secular increases.

The second finding concerns the *pace* at which the Obesity Epidemic has increased throughout the past forty years. Comparing the shape of each age-stratified trend line shows that the 55-64 age group had the most rapid increase during the 1980s and 1990s. Although not entirely visible from the trends plotted in Figure 5.3, comparison of the estimated regression equations corroborate this finding. Figure 5.4, which is based on annual prevalence data from the National Health Interview Survey (NHIS), more clearly illustrates this finding.

Figure 5.4 Period-Level Rates of Obesity by Select Age Groups (25-85+), 1982-1999.
Data come from the National Health Interview Survey (NHIS). Although the overall prevalence rate is lower than that estimated with NHANES data (see Chapter 4 for explanation), the form is the same. Actual prevalence rates are plotted.



For Figure 5.4, I plotted the annual time trend from1982-1999 for select age groups. So as to not clutter the graph with too many data points, I chose to only plot the age group which had the highest prevalence rate (age 55-64) and the age group which had the lowest prevalence rates (age 25-34) according to the NHANES data presented in Figure 5.3. I also plotted two additional age groups (age 75-84, age 85+) that were not consistently available from the NHANES to provide a wider range of ages than is consistently available from the NHANES. The time trends are expressed in statistical notation, with x being calendar year, and Y being the percentage of the population with a BMI $\geq$ 30:

$$\boldsymbol{Y_{\text{age 25-34}} = 0.63\,x - 1233}$$

$$\boldsymbol{Y_{\text{age 55-64}} = 0.68\,x - 1336}$$

$$\boldsymbol{Y_{\text{age 75-84}} = 0.33\,x - 647}$$

$$\boldsymbol{Y_{\text{age 85+}} = 0.18\,x - 344}$$

It should be noted that a linear time trend is the best fitting line, since the NHIS data (1982-1999) only captures the time period after the inflection occurred. A quadratic equation, such as those used to estimate the NHANES-derived time trend, is only necessary when the data span the decades of little change (1960s, 1970s) as well as the decades of more rapid change (1980s, 1990s).

Comparing the value of the slopes in the estimated trend lines supports the findings that the increase was more rapid for some groups than others, whereas comparing the value of the constant indicates that some age groups are more likely to be obese than others. The younger and middle-aged segments of the adult population (age 25-34, 55-64) exhibited significantly steeper rates of change, compared to the elderly segments of the population (age 75-84 and 85+) who had much flatter rates of increase during the decades when the Obesity Epidemic was in full swing. The middle-aged group (age 55-64) had significantly higher rates of obesity, compared to both the young adults (age 25-34) and the elderly (age 75+).

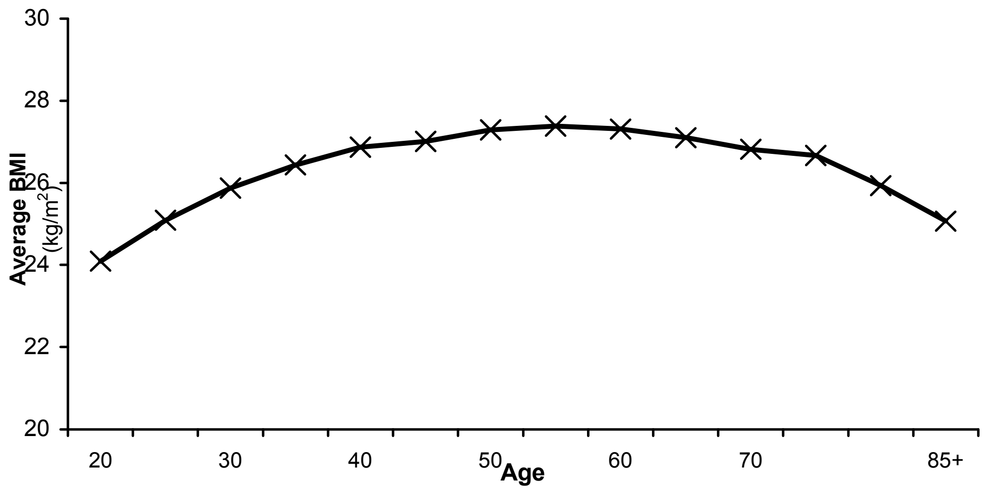
Obesity Trends: Age Differences

Given the differences that emerged when the time-trends were stratified by age, I reorganized the data in yet another way to more fully understand how this second notion of time (*life course time*) may impact the prevalence of obesity across the adult population. It is important to keep in mind that the NHANES is a repeated cross-sectional survey and not a repeated-measures longitudinal study. Thus, the age-trends discussed in this project refer to the prevalence of obesity at various life stages, rather than longitudinal changes that occur across an individual life course.[1]

Bearing this caveat in mind, the next set of estimates document the age-differences associated with adult body weight trends. Figure 5.5 plots the average prevalence of obesity and the average levels of BMI across five-year age groups. Figure 5.6 presents the same data, but stratified by period (i.e., the year the data were collected) to illustrate potential interactions between *life course time* and *historical time*.

[1] Refer to recent work by sociologist Ken Ferraro, which adopts the latter approach to documenting the age-trends (Ferraro & Kelley-Moore, 2003)

Figure 5.5 Average Body Mass Index and Prevalence of Obesity and Overweight Throughout the Life Course. Data come from the combined NHANES data collection. Sample represents the American adult population age 20-74+ in the years 1959-2002. Estimates exclude pregnant women and have been standardized to the 2000 Standard Population. All estimates are weighted to control for unequal probabilities of selection and nonresponse. The top panel measures mean levels of BMI (kg/m^2). The bottom panel measures prevalence of obesity (BMI $\geq$ 30) and overweight (BMI $\geq$ 25). The plotted data points were calculated by taking a weighted average of the age-adjusted means from each of the five individual NHANES, with the weights being the number of valid cases available for each wave of the survey.



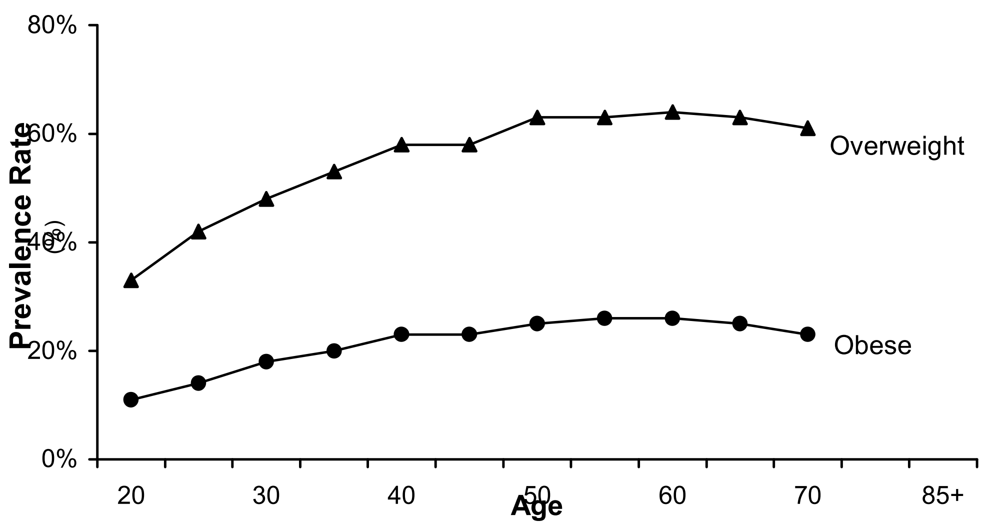
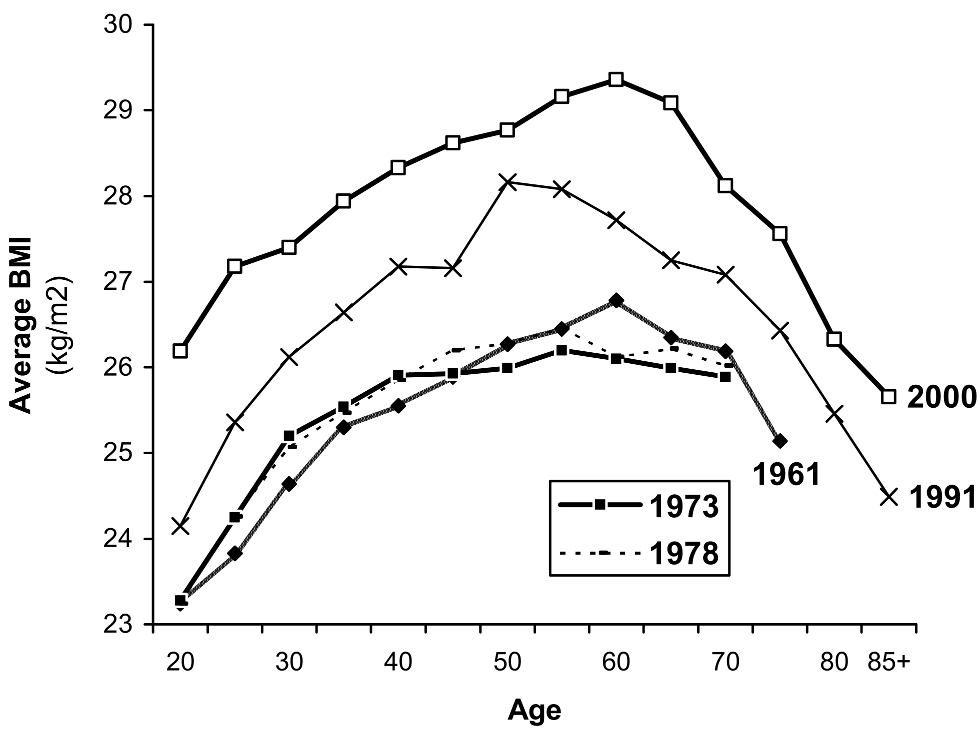


Figure 5.6 Average Body Mass Index Across the Life Course by Survey Wave. Data come from the NHANES data collection. The sample represents the adult population age 20-74+ at three different time points in history: 1973 (NHES 1971-1975), 1991 (NHANES III 1988-1994), and 2000 (NHANES IV 1999-2002). The plots for 1961 (NHES 1959-1962) and 1978 (NHANES II 1976-1980) have been excluded to simplify the presentation. Estimates exclude pregnant women and have been standardized to the 2000 Standard Population. All estimates are weighted to control for unequal probabilities of selection and nonresponse.



Both Figure 5.5 and Figure 5.6 suggest that persons in midlife have higher levels of BMI and are more likely to be obese than persons in the earlier or later stages of adulthood**.** Although there is a large body of research that also reports this curvilinear or concave pattern across the life course (Ferraro & Booth, 1999; Flegal et al., 2002; Gallagher et al., 1996; Launer et al., 1994; Stevens et al., 1998; Taylor & Ostbye, 2001), further analysis is needed before I am willing to call this pattern an age-effect. First and foremost, documenting this trend using a repeated measures longitudinal data source is necessary to clarify whether this trend is an age-difference or an age-effect.

The period-stratified data are best fit to series of quadratic equations, in which the first-order age-term is positive and the second-order term is negative.

$$\boldsymbol{BMI_{1961} = 18.5 + 0.26\,(age) - 0.002\,(age^2)}$$

$$\boldsymbol{BMI_{1973} = 18.5 + 0.28\,(age) - 0.003\,(age^2)}$$

$$\boldsymbol{BMI_{1978} = 18.2 + 0.29\,(age) - 0.003\,(age^2)}$$

$$\boldsymbol{BMI_{1991} = 18.0 + 0.35\,(age) - 0.003\,(age^2)}$$

$$\boldsymbol{BMI_{2000} = 22.0 + 0.24\,(age) - 0.002\,(age^2)}$$

First, notice how the constant or "starting point" of the trend-line shifted upwards at the latest time period. This indicates that a period-level effect is in operation. Next, notice how the coefficient associated with the first-order age-term has also shifted upwards until the latest wave of data, at which time the relative difference between the younger age groups does not appear to be as great as it had been in earlier decades. Had the slopes been identical across the five sets of plotted points, a simple period-level explanation would have explained the upward shift in the constant of the equations. Not to mention, the existence of an age-effect would also have received greater support.

It is possible that the downward trend at the later stages of the adult life course is a reflection of selective survival. For example, if persons with the highest BMIs are more likely to die prematurely and if a significant portion of those premature deaths occur during midlife when the BMI levels are the highest, then the declines that are evident in the latter half of the adult life course may simply reflect a shift in the populations being compared. That is, the persons surviving past age 60 may have always had lower rates of obesity and less body fat than those who died prematurely, thus bringing down the prevalence rates for the oldest age groups. This hypothesis has not been tested here, nor can it be tested with the repeated cross-sectional data of NHANES. However, previous research has provided compelling evidence that persons with the highest BMI have a significantly higher risk for death during midlife (Allison, Fontaine, Manson, Stevens, & Vanltallie, 1999; Allison, Gallagher, Heo, PiSunyer, & Heymsfield, 1997; Allison, Zhu, Plankey, Faith, & Heo, 2002; HHS, 2001; McGinnis & Foege, 1993; NIH & NHLBI, 1998). A majority of the years-of-life-lost that are associated with obesity are attributable to deaths occurring at midlife (Fontaine, Redden, Wang, Westfall, & Allison, 2003)

It is also possible that the downward portion of the age curve may reveal a cohort effect, instead of an age effect. The remainder of this chapter will explore this hypothesis in much greater detail, but to offer a quick explanation, one must keep in mind that the oldest persons in the sample are also the ones who were born during periods of American history when obesity was not nearly as common as it is today. Given that these persons were not exposed to the obesogenic decades of American culture until after the had lived a large proportion of their adult lives, they may exhibit lower levels of BMI throughout all of life, thus bringing down the estimates associated with the latest stages of the life course.

Obesity Trends: Cohort Differences

In order to estimate cohort trends, I had to reorganize the data yet again. This time, I pooled all five NHANES samples to produce one data set with approximately 62,000 cases. Although the NHANES data only span forty years of history (1959-2002), this approach has given me up to fifty years of life course data for ten different ten-year birth cohorts, spanning the years 1886-1995. As shown in Table 5.2, the pooled data represent nearly the entire adult life course (age 20-74) for the cohort born between 1926 and 1935, often called the Greatest Generation (Frey, Abresch, & Yeasting, 2001). These data also capture various stages of adult life for the Lucky Generation, born between 1936 and 1945 (Frey et al., 2001) and Generation X, born between 1966 and 1975. Both the early and late Baby Boomers, born 1946-1955 and 1956 to 1965 respectively (Macunovich, 2002), are also represented in these data. Unfortunately, the full adult age range (age 20-74) is not available for every birth cohort, since the study period only spanned the years 1959 to 2002.

Table 5.2 Age Ranges Provided by the NHANES Data Collection by Cohort

Birth Cohorts	total age range	NHES I *(1959-1962)*	NHANES I *(1971-1975)*	NHANES II *(1976-1980)*	NHANES III *(1988-1994)*	NHANES IV *(1999-2002)*
1886-1895	65-74	65-74				
1896-1905	55-74	55-66	66-74	71-74		
1906-1915	45-74	45-56	56-69	61-74	73-74	
1916-1925	35-74	35-46	46-59	51-64	63-74	
1926-1935	25-74	25-36	36-49	41-54	53-68	65-74
1936-1945	20-64	20-26	26-39	31-44	43-58	55-64
1946-1955	20-54		20-29	21-34	33-48	45-54
1956-1965	20-44			20-24	23-38	35-44
1966-1975	20-34				20-28	25-34
1976-1985	24					24

By calculating the mean body fat at each age for each birth cohort, these data provide a pseudo-longitudinal perspective to these otherwise cross-sectional data because each of the five waves has provided a repeated measure of body weight or body fat for each cohort group. This approach to organizing the data provides one way to further explore the age-effect without needing repeated-measures longitudinal data. This approach is also a simple way to consider all three aspects of time (age, period, cohort) within a single analysis.

Tables 5.3 through 5.5 present the prevalence data using this cohort-based approach. Table 5.3 presents changes in average BMI levels, while Tables 5.4, 5.5, and 5.6 document how the prevalence of overweight, obesity, and morbid obesity changed across the life course for each of the ten birth cohorts. Each table cell presents an estimate of body fat that has been stratified by both age and cohort status. When the age range for a particular cohort was available from only one wave of data, the simple mean is presented in the cell. However, when an age range for a particular cohort was available from more than one wave of data, a weighted average between the two waves was taken. To derive the weighted average, I multiplied the age-stratified estimate from each available wave by the number of cohort members from that wave. The products were then summed and divided by the total number of cases contributing to that particular estimate. Refer to Appendix C for more information on how these table estimates were produced.

Table 5.3 Average BMI Throughout the Life Course by Cohort

		Five-Year Age Groups										
Age in 1980	*Birth Cohorts*	20	25	30	35	40	45	50	55	60	65	70
85-94	1886-1895										26.1	26.2
75-84	1896-1905								26.50	26.78	26.2	25.9
65-74	1906-1915						25.87	26.27	25.99	26.09	26.2	26.2
55-64	1916-1925				25.28	25.55	26.01	26.05	26.52	26.18	27.3	27.1
45-54	1926-1935		23.9	24.64	25.69	25.92	25.98	26.47	28.11	27.72	28.7	28.1
35-44	1936-1945		24.3	25.16	25.30	25.73	27.22	28.16	28.97	29.36		
25-34	1946-1955	23.4	24.2	25.10	26.74	27.18	28.39	28.77				
15-24	1956-1965	22.9	25.3	26.12	27.67	28.33						
5-14	1966-1975	24.2	26.9	27.40								
0- 4	1976-1985	26.2										

Table 5.4 Prevalence of Overweight Throughout the Life Course by Cohort

Age in 1980	*Birth Cohorts*	*Five-Year Age Groups*										
		20	25	30	35	40	45	50	55	60	65	70
85-94	1886-1895										56%	56%
75-84	1896-1905								57%	61%	54%	55%
65-74	1906-1915						51%	58%	54%	55%	58%	53%
55-64	1916-1925				45%	50%	55%	54%	58%	57%	66%	62%
45-54	1926-1935		35%	40%	50%	53%	51%	57%	69%	68%	73%	71%
35-44	1936-1945		35%	43%	46%	48%	60%	68%	71%	77%		
25-34	1946-1955	27%	35%	42%	56%	59%	62%	72%				
15-24	1956-1965	22%	43%	50%	61%	68%						
5-14	1966-1975	35%	51%	58%								
0- 4	1976-1985	47%										

Table 5.5 Prevalence of Obesity Throughout the Life Course by Cohort

Age in 1980	*Birth Cohorts*	*Five-Year Age Groups*										
		20	25	30	35	40	45	50	55	60	65	70
85-94	1886-1895										18%	21%
75-84	1896-1905								18%	20%	16%	16%
65-74	1906-1915						16%	19%	17%	18%	18%	18%
55-64	1916-1925				14%	15%	16%	17%	20%	17%	27%	24%
45-54	1926-1935		9%	11%	14%	16%	16%	19%	33%	28%	36%	32%
35-44	1936-1945		11%	14%	15%	16%	24%	31%	36%	41%		
25-34	1946-1955	7%	10%	14%	23%	25%	31%	33%				
15-24	1956-1965	5%	14%	21%	27%	32%						
5-14	1966-1975	12%	21%	26%								
0- 4	1976-1985	21%										

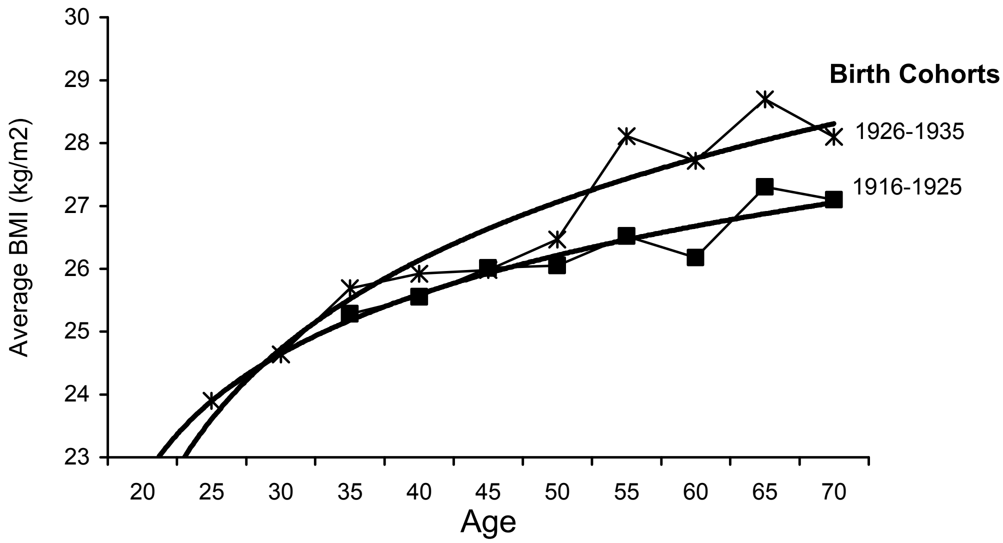
Table 5.6 Prevalence of Morbid Obesity Throughout the Life Course by Cohort

Age in 1980	*Birth Cohorts*	*Five-Year Age Groups*										
		20	25	30	35	40	45	50	55	60	65	70
85-94	1886-1895										0.3%	0.0%
75-84	1896-1905								1.9%	2.1%	0.7%	0.8%
65-74	1906-1915						1.7%	0.8%	2.2%	1.0%	1.3%	1.9%
55-64	1916-1925				1.6%	1.2%	1.2%	1.4%	2.1%	1.0%	2.5%	3.0%
45-54	1926-1935		0.8%	0.6%	2.0%	1.5%	2.4%	0.9%	3.4%	2.5%	5.5%	2.8%
35-44	1936-1945		1.2%	1.6%	0.9%	2.1%	4.1%	4.7%	5.8%	5.6%		
25-34	1946-1955	0.6%	0.7%	1.4%	4.6%	3.2%	5.1%	5.0%				
15-24	1956-1965	0.6%	1.5%	2.7%	5.2%	5.3%						
5-14	1966-1975	1.1%	3.6%	4.0%								
0- 4	1976-1985	4.3%										

Interpreting these data tables takes a bit of practice. Viewing the data from left to right shows how body weight and body fat changed across the life course for each of the ten birth cohorts (age-effect). Viewing the data from top to bottom reveals how body weight or the presence of body fat at a particular stage in the life course increased with each successive cohort (period effect). Viewing the table all together shows how each cohort has been affected by living a certain stage of life within a particular moment in history when the Obesity Epidemic was or was not in full swing. To help locate these trends within both continuums of time, a column has been added to each table to show how old the cohort was in 1980, the approximate year when the Obesity Epidemic is thought to have started.

When viewing the cohort data tables horizontally, the most interesting pattern to note is the absence of a downward trend at the later stages of the adult life course. Instead, I found a fairly constant trajectory, whereby cohorts appear to become gradually fatter throughout all of adulthood (age 20-74). Although the rate of increase does appear to slow down after the earliest stages of adulthood, the plotted age trajectories did not reverse themselves to produce the concave pattern of age differences which earlier suggested that body weight declines after about age 60. It should be noted that the declines in body weight that occur at the very end of life, due to serious illness and/or its treatment (Launer et al., 1994), are not necessarily captured by these data because the sample is truncated at age 74. Overall, the select trajectories shown in Figure 5.7 suggest that the curvilinear age-effect that is commonly reported in the literature may overstate the declines at the end of the life course because they fail to consider age differences that are due to each cohort's differential exposure to secular trends (Alwin & McCammon, 2001)

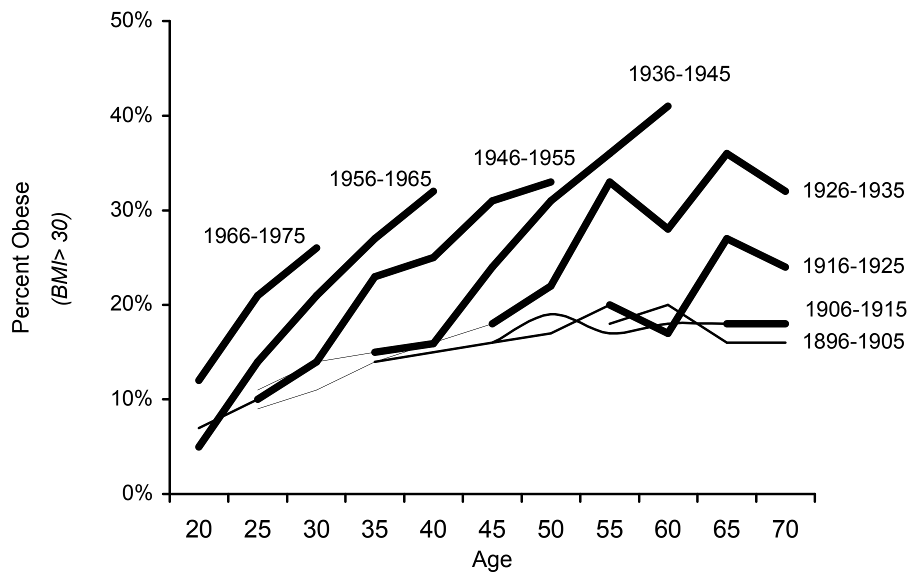
Figure 5.7 Average BMI Across the Life Course for Select Cohorts. Data come from the NHANES data collection. Both unadjusted means and the best-fitting trend line are presented. These two cohorts are presented because they provided the most complete set of life course data. Refer to Appendix C for the life course trends associated with other birth cohorts.



When viewing the data in Tables 5.3 through 5.6 vertically, the trends offer more support for a secular trend. Regardless of life stage and regardless of how obesity is measured, each successive cohort has a higher levels of body fat than previously born cohorts. For example, at age 20, the early baby boomers (1946-1955) had an average BMI of 23.37; however, later born cohorts, such as Gen-X (1966-1975), had significantly higher BMI levels at the same age (24.15). At age 50, the average BMI of the early baby boomers was 28.77 and approximately 33% of them were obese. The cohort born a half a decade before them (1906-1915) had an obesity prevalence rate of only 19% and an average BMI of 26.27 at age 50. At age 70, relatively few persons born in 1886-1905 were morbidly obese, but approximately 3% of the 1926-1935 cohort was morbidly obese at the latest stages of the adults life course.

Because each cohort was at a different stage in the life course when the Obesity Epidemic emerged, I hypothesized that some cohorts would be more affected by the secular trends than others. Figure 5.8 delineates which portion of the cohort's life course occurred pre-1980 and which occurred post-1980. (According to these and other analyses, the Obesity Epidemic is thought to have emerged sometime during the late 1970s or early 1980s). All but the earliest born cohorts sustained a sharp increase in obesity prevalence after 1980. The unaffected cohorts, those born prior to 1915, were over the age of 65 when the Obesity Epidemic presumably emerged during the late 1970s or early 1980s. Perhaps these cohorts had established some sort of health regimen earlier in the life course that minimized the effect of the secular trends that caused the rest of the population to gain weight.

Figure 5.8 Prevalence of Obesity by Birth Cohort: Pre- and Post-1980. Data come from the NHANES data collection. The dark/thick portion of the trend line is based on data collected after 1980. The thin/light portion of the trend represents data pre-1980. The 1976-1985 cohort and the 1886-1895 cohort have been excluded because they had too few data points to draw a trend line.



On average, the youngest members of the adult population, or those who were born most recently, have significantly higher levels of body fat than earlier-born cohorts *ever* had during their life course. For example, nearly 60 percent of Gen-xers (born 1966-1975) and three-quarters (72%) of Baby Boomers (born 1946-1955) were overweight in 2000. The average BMI for the Gen-Xers at age 30 exceeded that of any cohorts born prior to 1925, at any stage in the life course. More than one in five persons (21%) born between 1976-1985 were already obese by the time they reached 25 years of age; and one in 25 (4.3%) were morbidly obese at these young ages.

Each cohort that was born after 1915 tends to follow that characteristic check-mark pattern, where obesity prevalence remained unchanged prior to 1980, but increased rapidly during the 1980s and 1990s. In this regard, the cohort-stratified data lends even greater support for the presence of a period-level effect. However, the data plotted in Figure 5.8 also suggest that birth year may be a strong predictor in how likely one is to become obese at various stages of the life course. Clearly, those persons born later have had a far greater probability of being obese at any age than those born earlier in the twentieth century.

Obesity Trends: A Modeling Approach

Throughout this chapter, I have graphically displayed American body weight data across three conceptually distinct dimensions of time: age, period, and cohort. This approach has provided a unique perspective on the nature of the obesity epidemic that has occurred in recent American history. In terms of the first dimension of time, *period*, the data clearly suggest that the obesity epidemic is a secular phenomenon of the 1980s and 1990s, but not of the 1960s and 1970s. In regards to *age*, the data show that obesity prevalence increases across increasing age-groups of the population, but that the decline commonly hypothesized to occur during the later stages of the adult life course is not as pronounced as originally documented in the research. Instead, I have suggested that there may be a leveling off instead of a decline and that the hypothesized decline at later ages is more an artifact of measurement than a real phenomenon. Finally, *cohort*-stratified data suggest that the prevalence of obesity has increased with each successively-born cohort born after 1915.

Armed with these empirically-derived "facts," I had enough information to effectively model American body weight trends using an A-P-C modeling approach. In order to eliminate the multicollinearity problems associated with such models, I constrained the time-based predictors in the following ways:

- Age is presumed to follow a quadratic function, where the increase is greatest in earlier ages and then slows down at the later stages of the adult life course.
- Period is presumed to follow the characteristic check-mark pattern that has been discussed previously. That is, the prevalence of obesity remained relatively unchanged during the 1960s and 1970s, but increased dramatically during the 1980s and 1990s.
- Later-born cohorts are successively more obese, than earlier-born cohorts. Furthermore, those cohorts born prior to 1916 appear to be less affected by the obesity epidemic than all the other cohorts born after 1915.

Using these parameters, I estimated a regression-based model to predict the relative influence of age, period, and cohort on average BMI and obesity prevalence in a single multivariate regression model.

The most striking feature of Table 5.7 is the fact that all three time-based predictors (age, period, and cohort) remain significant, when estimated in a single model. This multivariate approaches serves primarily as a way to substantiate the previous findings from the graphical approaches: The age-effect does follow a quadratic function, with a leveling off at later ages of the adult life course. The period-effect does follow a check-mark type of pattern. And, the cohort-effect is increasingly stronger with every ten-year cohort.

Table 5.7 Age-Period-Cohort Effects on Obesity Trends

	BMI	**Obese**
	B	*Exp (B)*
Age		
Age	0.39 ***	1.12 ***
Age-Squared	-0.003 ***	0.999 ***
Period		
Pre 1980	*Reference*	*Reference*
1988-1994	1.70 ***	1.81 ***
1999-2002	2.49 ***	2.08 ***
Cohort		
Prior to 1916	*Reference*	*Reference*
1916-1925	-0.11	0.97
1926-1935	0.10	1.10
1936-1945	0.37 *	1.23 **
1946-1955	0.56 **	1.30 **
1956-1965	0.66 **	1.38 **
1966-1975	0.74 **	1.54 **
1976-1985	1.23 **	2.20 ***
Constant	16.54	0.01
Adjusted R^2	0.08	
-2 Log Likelihood		54924.06
X^2 (df)		2301 (11)

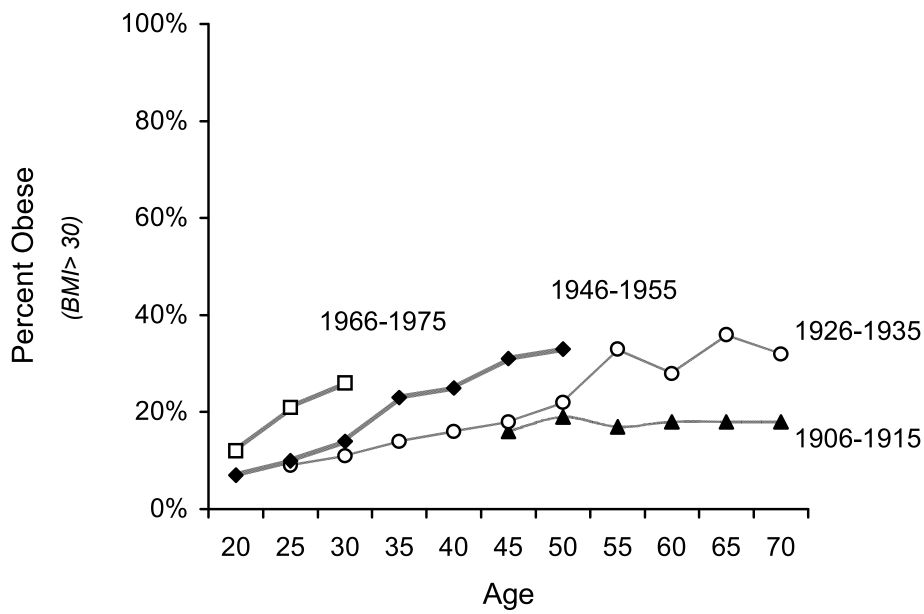
Notes : **BMI** is measured as weight in kilograms divided by height in meters-squared. **Obese** refers to having a BMI ≥ 30. **Obese III** refers to having a BMI ≥ 40. The model predicting BMI was estimated using OLS regression. The models predicting Obese and Obese III were estimated using binary logistic regression. * p ≤ .05, ** p ≤ .01, p ≤ .001

Obesity Trends: Projections About the Future

The nature of these trends when broken down by the three time-based predictors provides new and important information about the reality and the consequences of the Obesity Epidemic in America. Viewing these data, it is particularly troubling to think about how the higher "starting points" of the later born cohorts will be compounded across the life course.   Furthermore, it is almost incomprehensible to think about how cohorts born after the 1980s will look when they reach adulthood.

From a strictly planning perspective, these data, particularly the cohort-stratified data, are invaluable because they provide considerable insight about which cohorts and at which ages intervention or prevention efforts should be targeted to control the spread of the Obesity Epidemic in America. Furthermore, these cohort-specific data can be used to make more informed projections about the consequences of the Obesity Epidemic.

Figure 5.9 Prevalence of Obesity for Select Cohorts: Raw Data.   Data come from the NHANES data collection.

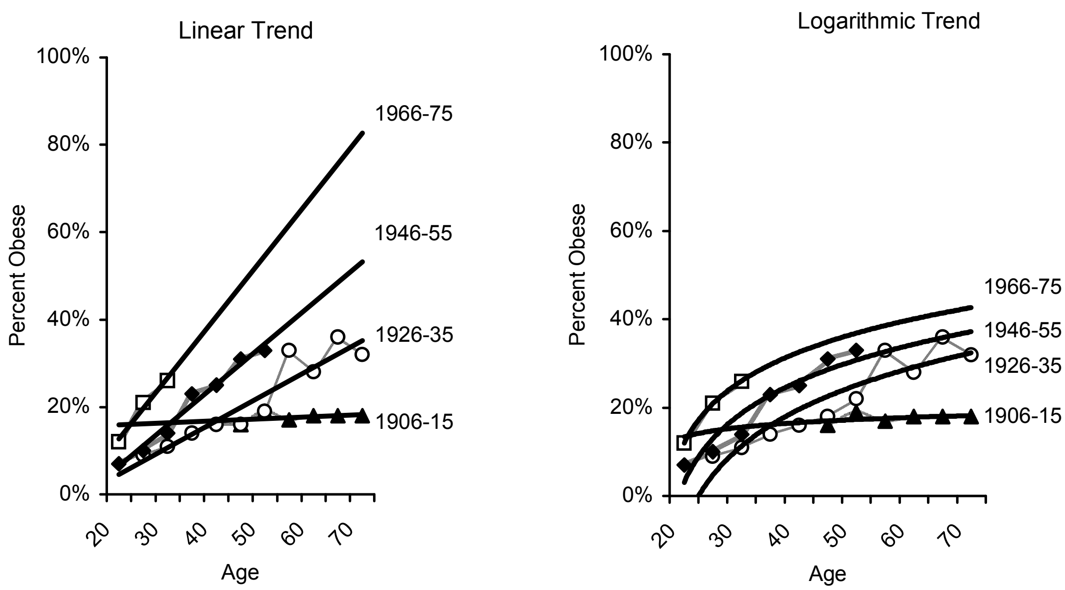


For example, using the cohort-stratified data presented in Figure 5.9 above, I offer preliminary projections estimating the potential consequences of the Obesity Epidemic. Because it is unclear whether obesity trends will continue at their current rate, whether they will accelerate to an even greater pace, or whether they will level off or decline in coming years, the exact form of the projection line must be based on reasonable assumptions provided by the analyst.

For illustration purposes, Figure 5.10 presents both a linear and a logarithmic trend-line to estimate the future prevalence of obesity for the four separate cohort trends that are plotted in Figure 5.9. If we assume that the Obesity Epidemic continues at its current pace and assume that the age-trend is linear throughout the adult life course (age 20-74), more than 80 percent of the Gen-X cohort (born 1966-1975) will be obese by age 70. About half of the early baby boomers (born 1946-1955) will be obese by age 70. Using a logarithmic approach, the projections are a bit more conservation, but nevertheless still troubling. At every stage of the life course, the later born cohorts have significantly higher rates of obesity than their predecessors. Substantively, the differences found across cohorts paint a very gloomy picture about the future health and well-being of cohorts who are still in the younger stages of the adult life course. Assuming that being obese implies the need for greater health care, the financial and practical implications of these projected trends are great.

Figure 5.10 Obesity Prevalence for Select Cohorts: Linear and Logarithmic Trends.

Data come from the NHANES data collection. The linear trend was estimated using the form Y = a + b (t). The logarithmic trend was estimates using the form Y = log a + log b (t), where Y is the proportion of the population with a BMI greater than 30, a is a constant, b is the slope associated with the time-trend, and t is age in years.



Summary

This chapter's conceptual attention to "time" has offered a new approach to documenting the Obesity Epidemic in America from 1960-2000. First, I plotted standard prevalence data over historical time to document a secular trend of increasing body weight. Next, I plotted body weight over various stages of the adult life course to illustrate age difference in the prevalence of obesity. Then, by carefully considering and interacting these two dimensions of time through a series of graphical and estimation procedures, I was able to consider whether being born at different moments in history have affected one's chances of becoming obese or maintaining a healthful level of body fat. Both graphical approaches and estimation techniques suggest that American body weight has shifted radically by each of these dimensions of time.

Drawing on the assumptions of a cumulative-risk framework, these data suggest that latest born cohorts have faced and will face considerably more consequences associated with the Obesity Epidemic than the earlier born cohorts. This is presumably because they have spent greater proportions of their life course exposed to the secular trends that have produced a culture of inactivity and obesity (Brown, 1991; Brown & Krick, 2001). When the effect of one's historical location is compounded across the life course, as was done here, it appears as if the severity of the Obesity Epidemic has been underestimated for the youngest cohorts of American culture and overestimated for the cohorts born earlier in twentieth century.

References

Allison, D., Fontaine, K. R., Manson, J. E., Stevens, J., & Vanltallie, T. B. (1999). Annual deaths attributable to obesity in the united states. *Journal of the American Medical Association, 22*(16), 1530-1538.

Allison, D. B., Gallagher, D., Heo, M., PiSunyer, F. X., & Heymsfield, S. B. (1997). Body mass index and all-cause mortality among people age 70 or over: The longitudinal study of aging. *International Journal of Obesity, 21*(6), 424-431.

Allison, D. B., Zhu, S. K., Plankey, M., Faith, M. S., & Heo, M. (2002). Differential associations of body mass index and adiposity with all-cause mortality among men inthe first and second national health and nutrition examinations surveys (nhnaes i and nhanes ii) followup studies. *International Journal of Obesity and Related Metabolic Disorders, 26*(3), 410-416.

Alwin, D. F., & McCammon, R. J. (2001). Aging, cohorts, and verbal ability. *Journal of Gerontology: Social Science, 56B*(3), S151-S161.

Arbyn, M., VanOyen, H., Tibaldi, F. S., & Molenberghs, G. (2002). Description of the influence of age, period and cohort effects on cervical cancer mortality by loglinear poisson models (belgium 1955-1994). *Archives of Public Health, 60*(2), 73-100.

Avila, M. H., & Walker, A. M. (1987). Age dependence of cohort phenomena in breast cancer mortality in the united states. *American Journal of Epidemiology, 126*(3).

Beller, A. S. (1977). *Fat and thin: A natural history of obesity*. New York: Farrar, Straus, and Giroux.

Berger, A. A. (2000). *Ads, fads, and consumer culture: Advertising's impact on american character and society*. Lanham, MD: Rowan & Littlefield Publishers.

Brown, P. J. (1991). Culture and the evolution of obesity. *Human Nature, 2*(1), 31-57.

Brown, P. J., & Krick, S. V. (2001). *Culture and economy in the etiology of obesity: Diet, television, and the illusions of personal choice*.Unpublished manuscript, Emory University.

Bumpass, L. L. (1990). What's happening to the family? Interactions between demographic and institutional change. *Demography, 27*(4), 483-498.

Crystal, S., & Shea, D. (1990). Cumulative advantage, cumulative disadvantage,and inequality among elderly people. *The Gerontologist, 30*(4), 437-443.

Easterlin, R. A., Schaeffer, C. M., & Macunovich, D. J. (1992). Will the baby boomers be less well off than their parents? Income, wealth, and family circumstances over the life cycle in the united states. *Population and Development Review, 19*(3), 497-522.

Ferraro, K. F., & Booth, T. L. (1999). Age, body mass index, and functional illness. *Journal of Gerontology: Social Science, 54B*(6), S339-S348.

Ferraro, K. F., & Kelley-Moore, J. A. (2003). Cummulative disadvantage and health: Long-term consequences of obesity? *American Sociological Review, 68*, 707-729.

Fienberg, S. E., & Mason, W. M. (1979). Identification and estimation of age-period-cohort models in analysis of discrete archival data. *Sociological Methodology, 10*, 1-67.

Fishwick, M. W. (2002). *Popular culture in a new age*. New York: Hawthorn Press.

Flegal, K., Caroll, M., Ogden, C., & Johnson, C. (2002). Prevalence and trends in obesity among us adults. *Journal of the American Medical Association, 288*, 1723-1727.
Fontaine, K. R., Redden, D. T., Wang, C., Westfall, A. O., & Allison, D. B. (2003). Years of life lost due to obesity. *Journal of the American Medical Association, 289*(2), 187-193.
Frey, W. H., Abresch, B., & Yeasting, J. (2001). *America by the numbers*. New York: The New Press.
Fu, W., & Rohan, T. E. (2001). *Age-period-cohort analysis ii: Intrinsic estimator and effective trend*.Unpublished manuscript.
Gallagher, D., Visser, M., Sepulveda, D., Pierson, R. N., Harris, T., & Heymsfield, S. B. (1996). How useful is body mass index for comparison of body fatness across age, sex, and ethnic groups? *American Journal of Epidemiology, 143*, 228-239.
Glenn, N. D. (1976). Cohort analysts' futile quest: Statistical attempts to separate age, period, and cohort effects. *American Sociological Review, 41*, 900-904.
Heckman, J., & Robb, R. (1985). Using longitudinal data to estimate age, period, cohort effects in earning equation. In W. M. Mason & S. E. Fienberg (Eds.), *Cohort analysis in social research*. New York: Springer-Verlag.
Hedley, A. A., Ogden, C. L., Johnson, C. L., Carroll, M. D., Curtin, L., & Flegal, K. (2004). Prevalence of overweight and obesity among us children, adolescents, and adults, 1999-2002. *Journal of the American Medical Association, 291*, 2847-2850.
HHS. (2001). *The surgeon general's call to action to prevent and decrease overweight and obesity*. Rockville, MD.
Hobcraft, J., Menken, J., & Preston, S. (1982). Age, period, and cohort effects in demography: A review. *Population Index, 48*, 4-43.
Jolliffe, D. (2004). Continuous and robust measures of the overweight epidemic: 1971-2000. *Demography, 41*(2), 303-314.
Klein, R. J., & Schoenborn, C. (2001). Age adjustment using the 2000 projected us population. *Healthy People 2010 Statistical Notes, 20*(Jan 2001).
Launer, L. J., Harris, T., Rumpel, C., & Madans, J. (1994). Body mass index, weight change, and risk of mobility disability in middle-aged and older women: The epidemiologic follow-up study of nhanes i. *Journal of the American Medical Association, 271*, 1093-1098.
Macunovich, D. J. (2002). The baby boomers. In D. Ekerdt (Ed.), *Macmillan encyclopedia of aging*. New York: Macmillan.
Mannheim, K. (1952). Sociological problems of generations, *Essays on the sociology of knowledge* (pp. 286-322). New York: Oxford University Press.
Mason, K. O., Mason, W. M., Winsborough, H. H., & Poole, W. K. (1973). Some methodological issues in cohort analysis of archival data. *American Sociological Review, 38*(2), 242-258.
Mason, W. H., & Fienberg, S. E. (1985). *Cohort analysis in social research: Beyond the identification problem*. New York: Springer.
Mason, W. M., & Wolfinger, N. H. (2002). Cohort analysis, *International encyclopedia of the social and behavioral sciences* (pp. 2189-2194). Nrkew Yo: Elsevier.
McGinnis, J. M., & Foege, W. H. (1993). Actual causes of deaht in the united states. *Journal of the American Medical Association, 270*(18), 2207-2212.

McKay, B. (2002, July 23). Government's standard lumps hunks, athletes with truly obese. *Wall Street Journal,* pp. B1.

Mills, C. W. (1952). *Sociological imagination*. New York: Oxford University Press.

Mokdad, A. H., Ford, E. S., Bowman, B. A., Dietz, W. H., Vinicor, F., Bales, V. S., & Marks, J. S. (2003). Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *Journal of the American Medical Association, 289*(1), 76-79.

NIH, & NHLBI. (1998). *Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults* (NIH Publication 98-4083): United States Department of Health and Human Services, Public Health Services.

O'Brien, P. M. (2000). Age period cohort characteristic models. *Social Science Research, 29*, 123-129.

O'Malley, P., Bachman, J. G., & Johnson, L. D. (1988). *Differentiation of period, age, and cohort effects on drug use*.Unpublished manuscript, Ann Arbor, MI.

Owram, D. (1997). *Born at the right time: A history of the baby boom generation*. Toronto: University of Toronto Press.

Palmore, E. (1978). When can age, period, and cohort be separated? *Social Forces, 57*(1), 282-295.

Portrait, F., Alessie, R., & Deeg, D. (2002). *Disentangling the age, period, cohort effects using a modeling approach*.Unpublished manuscript, Amsterdam, The Netherlands.

Reynolds, S. L., Crimmins, E. M., & Saito, Y. (1998). Cohort differences in disability and disease presence. *The Gerontologist, 38*(5), 578-590.

Ryder, N. B. (1965). The cohort as a concept in the study of social change. *American Sociological Review, 30*, 843-861.

Shell, E. R. (2002). *The hungry gene: The science of fat and the future of thin*. New York: Atlantic Monthly Press.

Stevens, J., Cai, J., Pamuk, E. R., Williamson, D. F., Thun, M. J., & Wood, J. L. (1998). The effect of age on the association between body mass index and mortality. *The New England Journal of Medicine, 338*(1), 1-7.

Taylor, D. H., & Ostbye, T. (2001). The effect of middle and old-age body mass index on short-term mortality in older people. *Journal of the American Geriatric Society, 49*(10), 1319-1326.

Thornton, A. (1989). Changing attitudes toward family issues in the united states. *Journal of Marriage and the Family, 51*, 873-893.

Vinh-Hung, V., & Storme, G. Visual display of epidemiological time series (age, period, cohort data).

Vita, A. J., Terry, R. B., Hubert, H. B., & Fries, J. F. (1998). Aging, health risks, and cumulative disability. *The New England Journal of Medicine, 338*(1035-1041).

Williamson, D. F. (1995). Prevalence and demographics of obesity. In K. D. Brownell & C. G. Fairburn (Eds.), *Eating disorders and obesity: A comprehensive handbook*. New York: Guilford.

Wilmoth, J. W. (1990). Variation in vital rates by age, period, and cohort. *Sociological Methodology, 20*, 295-335.

Wyke, A. (1997). *21st century miracle medicine: Robosurgery, wonder cures, and the quest for immortality*. New York: Plenum Press.

Yang, Y., Fu, W., & Land, K. (2003). A methodological comparison of age-period-cohort models: Fu's intrinsic estimator and conventional generalized linear models.