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Body mass index trajectories from adolescence to midlife: differential effects of parental and respondent education by race/ethnicity and gender

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Abstract

Objectives—Race/ethnicity and education are among the strongest social determinants of body mass index (BMI) throughout the life course, yet we know relatively little about how these social factors both independently and interactively contribute to the rate at which BMI changes from adolescence to midlife. The purpose of this study is to (1) examine variation in trajectories of BMI from adolescence to midlife by mothers' and respondents' education and (2) determine if the effects of mothers' and respondents' education on BMI trajectories differ by race/ethnicity and gender.

Design—We used nationally representative data from the National Longitudinal Survey of Youth. Our sample included White (*n*=4433), Black (*n*=2420), and Hispanic (*n*=1501) respondents. Self-reported height and weight were collected on 16 occasions from 1981 to 2008. We employed two-level linear growth models to specify BMI trajectories.

Results—Mothers' education was inversely associated with BMI and BMI change among women. Among men, mothers' education was inversely associated with BMI; these educational disparities persisted for Whites, diminished for Blacks, and widened for Hispanics. Respondents' education was inversely associated with BMI among women, but was positively associated with the rate of BMI change among Black women. Respondents' education was inversely associated with BMI among White and Hispanic men, and positively associated with BMI among Black men. These educational disparities widened for White and Black men, but narrowed for Hispanic men.

Conclutions—Our results suggest that by simultaneously considering multiple sources of stratification, we can more fully understand how the unequal distribution of advantages or disadvantages across social groups affects BMI across the life course.

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Disclosure

The authors have no conflict of interest to report.

Keywords

obesity; longitudinal; disparities; socioeconomic status; cumulative inequality

Introduction

Obese persons are at increased risk of cardiovascular disease, hypertension, stroke, diabetes, disability, and premature mortality (Thorpe and Ferraro 2004, Wannamethee *et al.* 2005, Alley and Chang 2007), with the strongest associations between obesity and mortality often found in midlife. Race/ethnicity and education are two of the strongest social factors associated with obesity risk; Blacks, Hispanics, and persons with low-socioeconomic status (SES) in adulthood generally have higher body mass index (BMI) than Whites and persons with high SES in adulthood (Burke *et al.* 1996, McTigue *et al.* 2002, Chang and Lauderdale 2005, Li *et al.* 2007, Clarke *et al.* 2009, Flegal *et al.* 2010). Moreover, childhood and adolescence appear to be critical periods in the timing and risk of obesity onset (Guo *et al.* 1994, Gordon-Larsen *et al.* 2004, Rzehak and Heinrich 2006); thus, economic and social disadvantage experienced in childhood and adolescence may also play a role in obesity risk in adulthood. We know little, however, about how race/ethnicity and life course SES affect changes in BMI across multiple developmental stages. The purpose of this study is to examine whether racial/ethnic and educational inequalities in BMI widen, diminish, or persist from late adolescence to midlife.

Theoretical framework

We employ a life course approach in our study of BMI trajectories and posit that divergence in BMI trajectories between groups results from multiple and intersecting systems of social stratification (Elder *et al.* 2003, Ferraro and Shippee 2009). These systems of social stratification – SES, race/ethnicity, and gender–produce an unequal distribution of economic and social advantages or disadvantages that can impact health across the life course. A particularly useful theory for understanding the development of health disparities that has emerged from the life course approach is the theory of cumulative inequality proposed by Ferraro and Shippee (2009). According to the theory of cumulative inequality, advantage established in early life, such as being White or growing up in a wealthy family, results in greater accumulation of opportunities and resources that put already advantaged individuals in a better position to delay the onset of illness. In comparison, disadvantage established in early life, such as being a racial/ethnic minority or growing up in a poor family, is more likely to result in greater accumulation of disadvantages over the life course that accelerate the aging process and disease onset (Ferraro and Shippee 2009). As a result, cumulative inequality theory suggests that health disparities between advantaged and disadvantaged groups will widen as individuals age.

Prior studies have examined processes of cumulative inequality across a range of health outcomes and have documented widening health disparities by education or race/ethnicity, at least through midlife (Kahn and Williamson 1991, Burke *et al.* 1996, Willson *et al.* 2007, Walsemann *et al.* 2008, Clarke *et al.* 2009, Walsemann *et al.* 2009). Yet, few of these studies have focused on BMI. Of those that have, the results generally find widening disparities through midlife. For example, Burke *et al.* (1996) found that among young adults, Black women weighed more at baseline and gained more weight than White women. Clarke *et al.* (2009) reported that among individuals transitioning to midlife, BMI increased at a faster rate among the less educated, Blacks, and Hispanics. As a result, the largest BMI disparities by race/ethnicity and education occurred at midlife. In comparison, although Kahn and Williamson (1991) reported greater increases in BMI over a 10-year period among Black women as compared to White women, and lower educated women as compared to highly educated women, they found no such effect among men.

The extent to which these social factors affect the rate at which BMI increases or decreases over the life course remains unclear for three reasons. First, prior studies often rely on cross-sectional data that confound period, cohort, and age effects, or on longitudinal data that utilize only two observations, and hence cannot disentangle random fluctuations from true change (Kahn and Williamson 1991, Burke *et al.* 1996, Gordon-Larsen *et al.* 2004). Second, most studies that assess intraindividual change utilize community samples that may not be generalizable to the US population (Baltrus *et al.* 2005, Freedman *et al.* 2005, Lewis *et al.* 2005, Mujahid *et al.* 2005), or have only focused on one or two developmental periods (e.g., adolescence, young adulthood) (Kimm *et al.* 2005, Rzehak and Heinrich 2006, Li *et al.* 2007), thereby limiting our understanding of how these social factors impact BMI across the life course. Third, Hispanics have often been omitted from studies of how BMI changes across the life course (Kahn and Williamson 1991, Burke *et al.* 1996, Baltrus *et al.* 2005, Freedman *et al.* 2005, Lewis *et al.* 2005, Mujahid *et al.* 2005), even though cross-sectional studies continue to document higher levels of BMI among Hispanic women and men (Flegal *et al.* 2010). Given these limitations, we know little about how race/ethnicity and education shape BMI trajectories from adolescence to midlife, a period of the life course in which obesity is most strongly linked to morbidity and premature mortality.

The theory of cumulative inequality also posits that health disparities documented in adulthood often have their origins in early life. According to cumulative inequality, family lineage can affect adult health through genetic transmission and shared environments (Ferraro and Shippee 2009). Moreover, early life conditions pattern exposure to health-related risk factors, some of which may be overcome, others of which may continue to resonate into adulthood. Thus, childhood and adolescent disadvantage likely affects the rate at which BMI changes over the life course above and beyond individuals' own adult disadvantage. For example, Clarke *et al.* (2009) found that parents' education was associated with BMI trajectories in early adulthood and midlife even after adjustment for respondents' education; respondents whose parents' attained less than a college degree reported higher BMI at age 18 and a faster rate of increase in BMI which leveled off at midlife. In comparison, respondent's education was unrelated to BMI at age 18, but was inversely associated with the rate of BMI change. This suggests that early life disadvantage may play a more prominent role in *establishing* disparities in BMI trajectories in early adulthood than adult educational attainment.

Although inequality develops across multiple systems of stratification (Ferraro and Shippee 2009), most studies examining BMI disparities treat education, race/ ethnicity, and gender as independent social characteristics that contribute additively to these disparities. By considering only the independent effects of these social characteristics, traditional approaches to studying disparities in BMI trajectories risk misestimating or misunderstanding the effects of race/ethnicity, education, and gender. For example, examining racial/ethnic differences in BMI trajectories without considering the additional component of gender variation would result in the mistaken conclusion that Blacks, in general, gain weight faster than Whites, when in fact this effect exists primarily among women (Kahn and Williamson 1991, McTigue *et al.* 2002, Gordon-Larsen *et al.* 2004, Freedman *et al.* 2005). Moreover, assessing the independent effects of race/ethnicity, education, and gender is also potentially problematic because it ignores the extent to which people simultaneously experience their race/ethnicity, educational status, and gender (Weber 2010). Different combinations of these social characteristics will yield unique lived experiences that shape an individual's health and aging process (Krieger *et al.* 1993, Williams and Collins 1995). The purpose of our study is to investigate whether racial/ethnic and educational inequalities in BMI widen, diminish, or persist using a nationally representative sample of the US population who were followed from late adolescence to midlife. We add to the literature by also ascertaining if the relationship between education (parental and respondent) and BMI differs by race/ethnicity and gender. We hypothesize that (1) Black and Hispanic respondents will have higher BMI than Whites, and these disparities will widen with age; (2) parental and respondent education will be independently and inversely associated with BMI trajectories, such that trajectories will be steeper among individuals with low parental and respondent education, resulting in widening BMI disparities by midlife; and (3) the extent to which parental and respondent education affects BMI trajectories will differ by race/ ethnicity and gender.

Methods

Sample

The National Longitudinal Survey of Youth 1979 Cohort (NLSY79) is a nationally representative sample of men and women born in the years 1957–1964 who were living in the USA in 1979. Respondents were interviewed annually from 1979 to 1994, and interviewed biennially after 1994, with data collection ongoing. Respondents were 14–21 years old in 1979 and were 43–52 years old in 2008, the most recent year data was available. The retention rate in 2008 was 78% (Bureau of Labor Statistics 2008).

Our sample includes noninstitutionalized, civilian respondents self-reporting as White, Black, or Hispanic, and who reported their weight and height at least once during the survey interval. Observations on weight were exclude for pregnant women. Less than 1% of respondents (N=59) were lost to mortality prior to the first assessment of height and weight in 1981. We also excluded respondents with missing data on covariates resulting in a loss of approximately 8% of eligible respondents (n=724). Respondents with missing data were more likely to be Black, Hispanic, and male. After exclusions and attrition, our sample consisted of 8354 respondents (4433 non-Hispanic Whites, 2420 non-Hispanic Blacks, and 1501 Hispanics).

Respondents provided 1–16 observations of BMI. About 70% of the sample provided at least 11 observations; 4.1% of respondents (N=342) died by 2008. Sensitivity analyses suggested that mortality did not bias our results. That is, results from a restricted sample of respondents who had not died during the survey interval did not differ substantively from results that included respondents who died during the survey interval. Thus, we present data from the full sample only.

Measures

Our dependent variable was BMI [(weight (kg))/(height in meters)^2]. Respondents' self-reported their height and weight in 1981, 1982, and 1985. Self-reports of weight were also collected in 1986, 1988, 1990, 1992, 1993, and biennially from 1994 to 2008.

We focused on four social indicators, race/ethnicity, mothers' education, respondents' education, and gender. We classified *race/ethnicity* as non-Hispanic White, non-Hispanic Black, and Hispanic. *Mothers' education* was measured at baseline as the number of years of schooling respondents' mothers completed. We used mothers' education for two reasons. First, mothers' education had less missing data (~6%) than fathers' education (~15%). Second, mothers' education may be more important for BMI than fathers' education because mothers are more likely to be responsible for their children's eating (Savage *et al.* 2007) and physical activity behaviors (Gordon-Larsen *et al.* 2000). *Respondents' education* was a time-varying measure of the number of years of schooling respondents had completed at the time of the interview.

We included covariates that may be associated with BMI or the social-indicator variables. In 1979, respondents reported the following about their household when they were age 14: *family structure* (nuclear, step-family, female-headed, and other), *area of residence* (South, non-South, outside of the USA), and the *community* (rural, non-rural) where respondents lived. We categorized respondents' *nativity* as US-born versus foreign-born and the *nativity of respondents' parents* as both or known parent(s) US-born, one of two parents foreign-born, or both or known parent(s) foreign-born. If the respondent indicated never knowing one of his or her parents, the nativity of the known parent was used to categorize parents' nativity (i.e., if known parent was US born, we categorized as 'both or known parents US-born'). We included time-varying measures of respondents' *occupational status* (professional/ managerial, labor/farm, sales/service/clerical, not working), *marital status* (married, divorced/separated/widowed, never married), and *community* (rural, non-rural; not classified) where respondents lived at the time of each interview. We also included *birth cohort* (1957–1960–1961–1964) and *mortality status* (died during survey interval, did not die).

Statistical analyses

Given expected differential effects of race/ethnicity and education on BMI for males and females (Baltrus *et al.* 2005; Chang and Lauderdale 2005; Flegal *et al.* 2010), all analyses were stratified by gender. First, we examined the distribution of sample characteristics. Next, we estimated two-level linear growth models to investigate the extent to which race/ethnicity, mothers' education, and respondents' education were associated with BMI over time, independently and conditionally. In our models, age represents time. Two-level linear growth models account for the nested structure of the data (i.e., observations nested within individuals) and the unbalanced nature of the data (i.e., varying numbers of observations per person) (Singer and Willet 2003). To facilitate interpretation of the model's intercept, we centered age at 32, the mean age of our sample across the survey interval. We found nonlinearity in BMI change; therefore, we included a quadratic age variable in all models.

Interactions between race/ethnicity and mothers' education, and between race/ ethnicity and respondents' education assessed the differential effects of each education measure on BMI by race/ethnicity. These variables were interacted with age and age-squared to adjust for each variable's influence on the rate of BMI change. Additionally, we interacted mortality with age and age-squared to adjust for potential differences in the rate of BMI change experienced by individuals who died versus those who had not died by 2008. We also interacted birth cohort with age and age-squared to adjust for potential cohort differences in the rate of BMI change.

We employed the following two-level linear growth model:

$$Y_{it} = \lambda_{00} + \sum \lambda_{it} X_{it} + \sum \alpha_{it} Z_{it} + \zeta_{0i} + \zeta_{1i} + \zeta_{2i} + \varepsilon_{it} \quad (1)$$

where Y_{it} is BMI for respondent i at time t and Y_{it} to Y_{nt} are independent; $i = 1, \ldots, n$ respondents across $t = 1, \ldots, T$ waves; λ_{00} is the average BMI at age 32, $\Sigma \lambda_{it} X_{it}$ is the sum of time-invariant covariates (e.g., race/ethnicity, mother's education, family structure at 14, area of residence at 14, community at 14, nativity of respondent and respondent's parents, birth cohort, mortality); $\Sigma \alpha_{it} Z_{it}$ is the sum of time-varying covariates and cross-level interactions (e.g., respondent's education, occupational status, marital status, community, age, age-squared, age×race/ethnicity, age-squared×race/ethnicity, age×mother's education, age-squared×mother's education, age×mother's education×race/ethnicity, age-squared×mother's education×race/ethnicity, age×respondent's education, age-squared×respondent's education, age×respondent's education×race/ethnicity, age-squared×respondent's education×race/ethnicity, age×birth cohort, age-squared×birth cohort, age×mortality, and age-squared×mortality); ζ_{0i}, ζ_{1i}, and ζ_{2i}, are random effects that represent unobserved heterogeneity for respondent i, and are assumed to be normally distributed with mean 0; and ε_{it} is the random within-person error of prediction for respondent i at time t. We assume that the random effects ζ_{0i}, ζ_{1i}, and ζ_{2i} are independent of ε_{it}, and that all random components are independent of all covariates (Singer and Willet 2003).

Two-level linear growth models were estimated with maximum likelihood using *xtmixed* in Stata v11 (Stata Corp. 2009). Model fit was determined based on the change in −2 log-likelihood, which is distributed χ^2 with degrees of freedom determined by the number of covariates added to the model. We did not use sampling weights because the NLSY79 does not provide appropriate weights to use in longitudinal analyses; however, previous studies demonstrate that unbiased coefficients are produced in unweighted analysis if one includes the variables that were used to sample respondents (Winship and Radbill 1994).

Using a model-building approach to test our hypotheses, a total of six models were examined. Model 1 tested the main effect of race/ethnicity on BMI trajectories, adjusting for respondents' and parents' nativity, birth cohort, birth cohort×age, birth cohort×age-squared, mortality, mortality×age, and mortality×age-squared. Model 2 added the main effect for mothers' education and Model 3 tested the interaction between mothers' education and race/ethnicity. Model 4 tested the main effect of respondents' education on BMI trajectories and Model 5 examined the interaction between respondents' education and race/ethnicity. Lastly, Model 6 combined Models 3 and 5 to test the main and interactive effects of race/ethnicity and mothers' education *and* the main and interactive effects of race/ethnicity and respondents' education on BMI trajectories. Models 2–6 adjusted for the covariates in Model 1 as well as for community, family structure, and region (all at age 14). In addition, Models 4–6 also adjusted for time-varying measures of occupational status, community, and marital status.

Our model-building approach allowed us to investigate models similar to those that others have studied as well as models that are unique to our study. More specifically, Model 1 serves as the simplest model that only captures racial/ethnic differences in BMI–this model serves as our baseline model. Next, Models 2 and 4 represent models analogous to those that others have investigated (i.e., the main effect of mothers' education and respondents' education on BMI trajectories, respectively). Models 3, 5, and 6 represent models that are unique to our study. Model 3 examines the interactive relationship between race/ethnicity and mothers' education. Model 5 examines the interactive relationship between race/ethnicity and respondents' education. Model 6 examines both sets of interactive relationships (race/ethnicity and mothers' education as well as race/ethnicity and respondents' education). Thus, although we present results for all six models, Models 3, 5, and 6 are the main aspects of our study, with most of our emphasis placed on Model 6.

Sensitivity analysis

We examined the extent of bias resulting from missing data by utilizing a sequential regression imputation method to impute data for *independent* variables with item nonresponse (Raghunathan *et al.* 2002). We did not impute data for the dependent variable. We produced five multiply imputed data sets; even with a rate of 50% missing information, estimates based on five imputed data sets have standard deviations negligibly larger than estimates based on infinite data sets. We replicated analyses across the five data sets and combined the results to produce final estimates using methods detailed elsewhere (Schafer 1999). Estimates from the multiply imputed data were similar to those from data using list-wise deletion (results available from the corresponding author). Given that our findings did not change in any meaningful way, we present results based on data that used list-wise deletion.

We ran supplementary analyses that adjusted for time-varying indicators of daily smoking, given its association with education and BMI. These results mirror those obtained in analyses unadjusted for smoking. Because the smoking indicators likely have substantial measurement error–they were not collected yearly and the questions used to measure smoking changed across waves–and because including smoking in the models resulted in a loss of 1353 respondents, we report results from analyses unadjusted for smoking.

Results

Descriptive statistics

The sample consisted of 8354 respondents; 4318 women and 4036 men (Table 1). Respondents were primarily female (52%), White (53%), lived in nuclear families at age 14 (69%), and lived in the US nonSouth at age 14 (63%). The mean BMI across the survey interval was 26.05. On average, respondents' mothers completed 10.81 years of schooling and respondents completed 12.90 years of schooling. Few respondents were foreign-born (7%) or had parents who were foreign-born (12%). In adulthood, the modal occupational status of respondents' was sales/service/clerical industry (36%); 45% were married and 76% lived in nonrural areas. The distribution of sample characteristics was similar for women and men, except for BMI and occupational status.

Two-level linear growth models

Model 1, in Table 2, shows that BMI at age 32 was significantly higher for Black (b=3.411) and Hispanic (b=2.231) women compared to White women, and over time, Black and Hispanic women experienced significantly faster linear growth (b=0.121 and b=0.065, respectively) but slower rates of acceleration (b=−0.0046 and b=−0.0021, respectively) in BMI relative to White women. Coefficient estimates from Model 1 are plotted in Figure 1. The predicted BMI trajectories show that, net of nativity, birth cohort, and mortality, racial/ethnic disparities among women widened from late adolescence to mid-adulthood.

Model 2 additionally included mothers' education and shows that mothers' education was inversely associated with BMI at age 32 (b=−0.204), as well as with BMI linear growth (b= −0.003), but was positively associated with acceleration in BMI (b=0.0003); these associations did not appear to vary by race/ethnicity (Model 3). Model 4 shows that respondents' education was also inversely associated with BMI at age 32 but that, unlike mothers' education, respondents' education was not significantly associated with the rate of linear growth or acceleration in BMI. However, among Black women, respondents' education was associated with a faster rate of linear growth in BMI relative to White women (Model 5).

Both mothers' education and respondents' education were included in Model 6 along with all possible interactions between education and race/ethnicity. Mothers' education continued to have a significant inverse association with BMI at age 32 and the rate of linear growth in BMI, and these associations did not differ by race/ ethnicity (Figure 2).

In Model 6, respondents' education continued to have an inverse association with BMI at age 32 regardless of race/ethnicity. Among White women, BMI differences between less and more educated women remained relatively constant across adulthood (Figure 3). By contrast, compared to White women, the rate of linear BMI change appeared faster among Black women with more versus less education (b=0.009), but over time, the rate of BMI change slightly decelerated among Black women with more versus less education (b=−0.0005). As a result, educational disparities between Black women with more versus less education diminished in the 30s, but began to increase slightly as they entered midlife (Figure 3). No statistical significant racial/ethnic differences between respondents' education and BMI change were found for Hispanic women as compared to White women.

It is also important to note that regardless of mothers' or respondents' education, the racial/ethnic differences in BMI trajectories evident in Model 1 remain in Model 6. For example, as shown in Figure 3, the disparity between Black and White women with 16 years of schooling increases from 1.54 BMI units at age 24 to 4.18 BMI units at age 44, whereas the disparity between Hispanic and White women with 16 years of schooling increases from 1.05 BMI units at age 24 to 2.13 BMI units at age 44.

For men, predicted BMI trajectories by race/ethnicity showed that racial/ethnic disparities were significant, but smaller than women's (Figure 4). Specifically, results from Model 1 in Table 3 show that the observed racial/ethnic differences in Figure 4 are indeed statistically significant; BMI at age 32 was significantly higher among Black (b=0.534) and Hispanic (b=1.702) men compared to White men, and over time, Black and Hispanic men experienced significantly faster linear growth (b=0.052 and b=0.037, respectively) but slower rates of acceleration (b=−0.0016 and b=−0.0030, respectively) in BMI relative to White men. Thus, as shown in Figure 4, the direction and size of disparities among men changed from late adolescence through midlife; at age 16, BMI was significantly lower among Black men as compared to White men, but by age 32, the opposite was true. Conversely, at age 16, BMI was slightly higher among Hispanic men compared to White men, and by age 32 this gap had widened considerably.

Next, as shown in Model 2 (Table 3), similar to the relationship between mothers' education and BMI trajectories for women, for men, mothers' education was inversely associated with BMI at age 32 (b=−0.099) as well as with the linear growth (b=−0.002), but was positively associated with acceleration in BMI (b=0.0003). Likewise, these relationships did not vary by race/ethnicity.[1] Model 4 shows that respondents' education was also inversely associated with BMI at age 32 (b=−0.102) as well as with linear growth (b=−0.003), but was positively associated with acceleration in BMI (b=0.0005). However, unlike mothers' education, the relationship between respondents' education and BMI varied by race/ethnicity (Model 5). Among White men, respondents' education was inversely associated with BMI and this inverse association widened over time. In comparison to White men, the association between respondents' education and BMI differed for Black men at age 32 (b=0.163) as well as in the rate of linear growth (b=0.013), and acceleration (b=−0.0006). Among Hispanic men, the only racial/ethnic differences noted were in linear growth of BMI trajectories (b=0.006).

Estimates from Model 6 (Table 3) reveal that after controlling for respondents' education, mothers' education remained a statistically significant predictor of males' BMI at 32 (b= −0.101). Although there were no observed racial/ethnic differences in the effect of mothers' education on BMI at 32, there were racial/ethnic differences in the effect of mothers'

[1]Although the mothers' education×Black coefficient in Model 3 is statistically significant, overall, based on changes in the −2LL, Model 3 is not a better model than Model 2, therefore, we refrain from interpreting results from Model 3.

education on the rate of acceleration between Black and White men. As shown in Figure 5, the rate of acceleration in BMI between Black men whose mothers completed less versus more education (b=0.0005) was significantly different from the rate of BMI acceleration between White men whose mothers completed less versus more education (b=0.0000). White men whose mothers completed 10 years of schooling appear to have the same acceleration in their BMI trajectories as those whose mother completed 16 years of schooling. Among Black men, however, acceleration in BMI trajectories did differ between mothers' education levels; BMI trajectories of those whose mothers completed less education were slightly faster than those whose mothers completed more education. Additionally, as shown in Figure 5, the rate of linear change between Hispanic men whose mothers completed less versus more education (b=−0.005) was significantly different from the rate of linear change between White men whose mothers completed less versus more education (b=0.001). As a result, the gap between Hispanic men whose mothers completed less versus more education widened with age.

Finally, among men, statistically significant racial/ethnic differences were noted for the association between respondents' education, BMI at age 32, linear growth, and acceleration in BMI, after controlling for mothers' education (Model 6). First, opposite patterns were observed for White and Black men in terms of the overall relationship between respondents' education and race/ethnicity (Figure 6); compared to White men for whom those with more education experienced lower BMI across the life course, Black men with more education experienced higher BMI at 32 than their less educated counterparts. Second, specific aspects of the change in predicted BMI trajectories for Hispanic and Black men were statistically different than the increasing gap between less and more educated White men. The rate of linear BMI change appeared faster among Black men with more versus less education (b=0.013), but over time, the rate of BMI change slightly decelerated among Black men with more versus less education (b=−0.0007). Thus, as Black men aged, the more educated generally experienced increasingly higher levels of BMI compared to the less educated (Figure 6). An opposite pattern was observed for Hispanic men; Hispanic men with more versus less education experienced lower BMI across early adulthood, but this difference diminished by midlife such that the BMI at age 44 of Hispanic men with 16 years of schooling was roughly equivalent to Hispanic men with 10 years of schooling (b=−0.10; estimate based on predicted trajectories).

It is also important to note that regardless of mothers' or respondents' education, the racial/ethnic differences in BMI trajectories evident in Model 1 remain in Model 6. For example, in Figure 6 the disparity between Black and White men with 16 years of schooling increases from 0.08 BMI units at age 24 to 1.60 BMI units at age 44.

Discussion

Race/ethnicity, education, and gender are three dimensions of social stratification that have been consistently and strongly associated with BMI. Yet, few studies have examined how these three dimensions of social stratification independently and interactively contribute to BMI disparities across the life course. Moreover, few studies have explored the long-term effect of parental education on life course BMI, even though parental education may be important for establishing weight gain. The purpose of our study was to examine the extent to which racial/ethnic and educational inequalities in BMI widen, diminish, or persist from late adolescence to midlife. We hypothesized that (1) Black and Hispanic respondents would have higher BMI than Whites, and these disparities would widen with age; (2) parental and respondent education would be independently and inversely associated with BMI trajectories; and (3) the effects of parental and respondent education on BMI trajectories would vary by race/ethnicity and gender.

The results generally supported our first hypothesis. Black and Hispanic respondents reported higher BMI at age 32 than Whites, but the disparity was greater for women than men. Among women and men, Black-White and Hispanic-White BMI disparities widened as respondents entered midlife. These results are somewhat consistent with prior studies. For example, Clarke *et al.* (2009) reported higher baseline BMI and faster rates of BMI change among Blacks and Hispanics compared to Whites. Other studies have also found that Black women report higher BMI and faster rates of BMI change through midlife than White women (Kahn and Williamson 1991, Burke *et al.* 1996, Baltrus *et al.* 2005), but the extent to which they find Black-White differences in BMI and BMI change among men varies. It is possible that differences in sample representativeness, length of follow-up, and number of observations assessed in these studies contribute to the inconsistency of results for Black men.

We also found that mothers' education was independently and inversely associated with BMI trajectories. BMI was higher among White, Black, and Hispanic men whose mothers completed fewer years of schooling; however, the gap persisted for White men, diminished for Black men, and widened for Hispanic men. Conversely, BMI trajectories were steeper among women whose mothers completed fewer years of schooling, regardless of race/ethnicity. This finding held after adjustment for respondents' education, suggesting that mother's education has long-term effects on weight gain for women, independent of their own educational attainment. Moreover, the association between mothers' education and BMI trajectories appears stronger for women than men. Childhood socioeconomic conditions may have more lasting effects on women because women experience less social mobility over the life course than men. For example, in a study of social mobility across three generations, Biblarz *et al.* (1996) found that granddaughters were just as likely to be segregated into female dominated occupations as their grandmothers. Similarly, Warren *et al.* (2002) found that across the life course, women, on average, had occupational earnings that were lower than their fathers, their brothers, and their male peers. Thus, childhood SES appears to be more strongly linked to adult SES among women than men. It is possible that the effect of childhood SES on BMI trajectories becomes relatively less important for men because of their greater SES attainment in adulthood. Conversely, for women, much of the effect of SES on BMI trajectories may be captured with information on childhood SES because, among women, childhood SES, and adult SES are more strongly correlated.

As hypothesized, the association between respondents' education and BMI trajectories differed by race/ethnicity and gender. White and Hispanic women with more education had lower BMI than those with less education; this gap did not change as respondents' aged. The disparity between Black women with more versus less education, however, diminished in their 30s, but began to widen slightly as they entered midlife. Educated women tend to delay childbearing; age-at-first birth peaks for this group around age 30 compared to age 21 for less educated women (Sullivan 2005). Moreover, Black women with normal weight prepregnancy are more likely to retain 6 kg or more of their pregnancy weight 10–18 months postpartum compared to their White counterparts, regardless of pregnancy weight gain (Abrams *et al.* 2000). Taken together, these findings suggest that one possible explanation for the smaller education gap found among Black women in their 30s relates to delayed childbearing among educated Black women coupled with postpartum weight retention.

Education was *inversely* associated with BMI among White men, and education disparities widened with age. In comparison, education was *positively* associated with BMI among Black men, and education disparities widened with age. Prior studies have also reported higher BMI among educated Black men as compared to less educated Black men (Mujahid *et al.* 2005). Although education was *inversely* associated with BMI among Hispanic men, education disparities diminished with age. Educated men are more likely to be in occupations that require minimal to no physical activity. This is true in our sample as well (results not shown). Although education is associated with higher income and wealth, this association is stronger among White men than among Black or Hispanic men (Williams 1999, Shapiro 2004). Thus, educated Black and Hispanic men are not only more likely than their less educated counterparts to hold jobs that require little physical activity, but also they are also less likely to have access to the same amount of disposable income (i.e., wealth) as similarly situated White men. Consequently, educated White men may have greater means to seek other opportunities for physical activity than similarly educated Black or Hispanic men. Indeed, research finds that at similar levels of education, occupation, and income, Black and Hispanic men are, in general, more likely to be physically inactive than White men (Crespo *et al.* 2000). Although we adjusted for occupational status, we did not have consistent measures of wealth or physical activity to test this possibility. Further investigations into how education translates into resources and behaviors that buffer against weight gain (e.g., time, physical environment, and disposable income available for physical activity) may help to elucidate the seemingly counterintuitive association between education and BMI trajectories among Black and Hispanic men.

Overall, our findings lend support to two propositions from the theory of cumulative inequality. First, our results provide evidence that childhood conditions are important for understanding adult health and that early adversity is associated with health differentiation over time. Moreover, we find that childhood disadvantage is not merely a proxy for adult disadvantage; they are each independently associated with BMI. Second, our findings support the proposition that inequality develops across multiple systems of stratification and that it is the combination of these social characteristics that shape individuals' BMI trajectories across the life course.

Limitations

We utilized self-reported height and weight, which likely underestimated the true weight of respondents, particularly at the right tail of the weight distribution. However, because we compared individuals with themselves over time, effects of underreporting weight were minimized (Bowman and DeLucia 1992). Considerable ethnic heterogeneity exists within the Hispanic population; however, sample limitations prevented formal subgroup analyses. An important extension of the current study would be to further consider how childhood and adult SES affects the BMI trajectories of Hispanic subgroups (e.g., Puerto Ricans, Cubans) or if other sociocultural differences between Hispanic subgroups contributes to differences in BMI trajectories. Lastly, our results were based on respondents born between 1957 and 1964 and living in the USA in 1979, and can only be generalized to this population. Among more recent cohorts, educational disparities in BMI may be diminishing (Zhang and Wang 2004); although we are unaware of any evidence that suggests that the effect of childhood disadvantage on BMI trajectories differs across cohorts. Other longitudinal studies with multiple birth cohorts and observations are needed to more fully understand the effects of age and cohort on BMI trajectories across developmental periods.

Conclusions

Our study can be situated within the larger body of work that has examined how health disparities widen, persist, or diminish across the life course. We extend this body of research by demonstrating that trajectories of BMI depend not only on differences between social groups, but also on differences within social groups. We find that mothers' and respondents' education impact BMI trajectories from late adolescence through midlife, but their impact differs by race/ethnicity and gender. Our results suggest that by simultaneously considering multiple sources of stratification, we can more fully understand how the unequal distribution of advantages or disadvantages across social groups affects BMI across the life course.

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Key messages

1. Mothers' education was inversely associated with BMI among both women and men, but disparities widened for all women and Hispanic men, persisted for White men, and diminished for Black men.
2. Disparities between Black women with more versus less education diminished in the mid-30s, whereas educational disparities persisted for White and Hispanic women.
3. Education was positively associated with BMI for Black men and inversely associated with BMI for White men. These disparities widened with age for both groups.
4. Simultaneously considering multiple sources of stratification is important for understanding how disadvantage affects BMI across the life course.

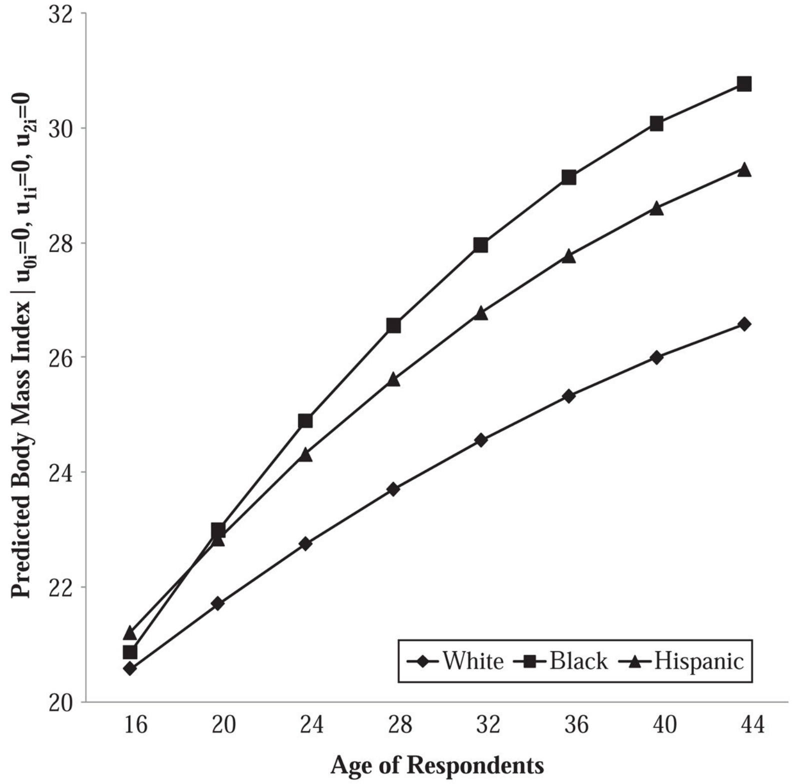

Figure 1.

Predicted average BMI trajectories for females by race/ethnicity, National Longitudinal Survey of Youth (NLSY79).

Note: Predicted trajectories based on Model 1 estimates, and represents average predicted trajectories for respondents in the 1961–1964 birth cohort who did not die during survey interval.

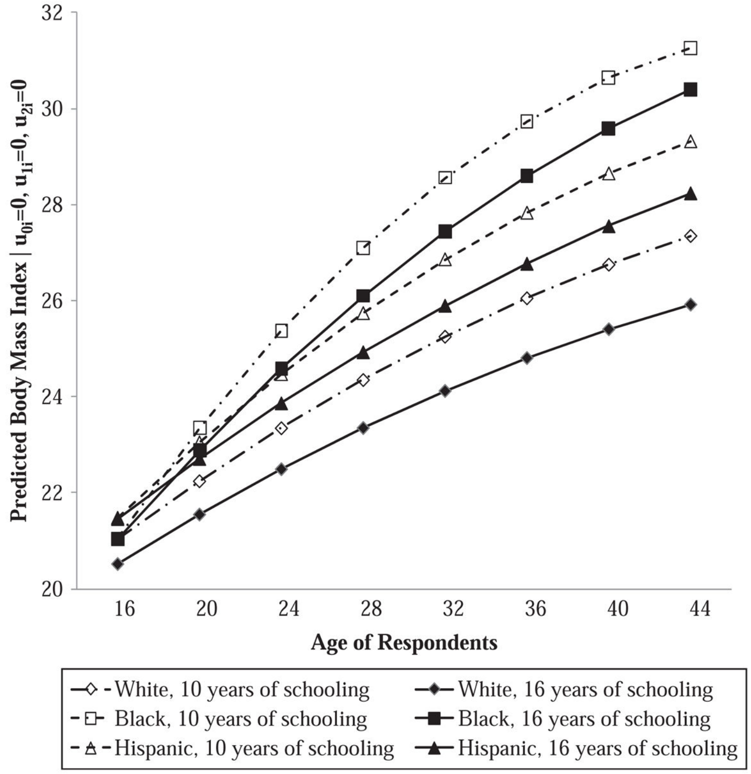

Figure 2.

Predicted average BMI trajectories for females by mothers' education and race/ ethnicity, National Longitudinal Survey of Youth (NLSY79)

Note: Predicted trajectories based on Model 6 estimates. Respondents' education held constant at 12 years of schooling; remaining covariates held constant at their grand mean. Predicted trajectories represent respondents in the 1961–1964 birth cohort who did not die during survey interval.

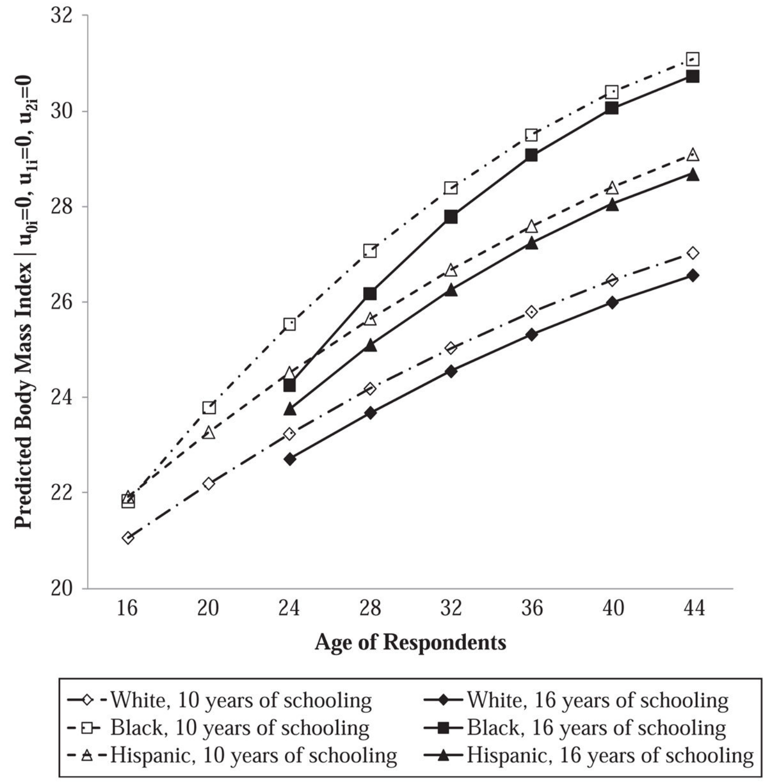

Figure 3.

Predicted average BMI trajectories for females by respondents' education and race/ethnicity, National Longitudinal Survey of Youth (NLSY79).

Note: Predicted trajectories based on Model 6 estimates. Mother's education held constant at 12 years of schooling; remaining covariates held constant at their grand mean. Predicted trajectories represent respondents in the 1961–1964 birth cohort who did not die during survey interval.

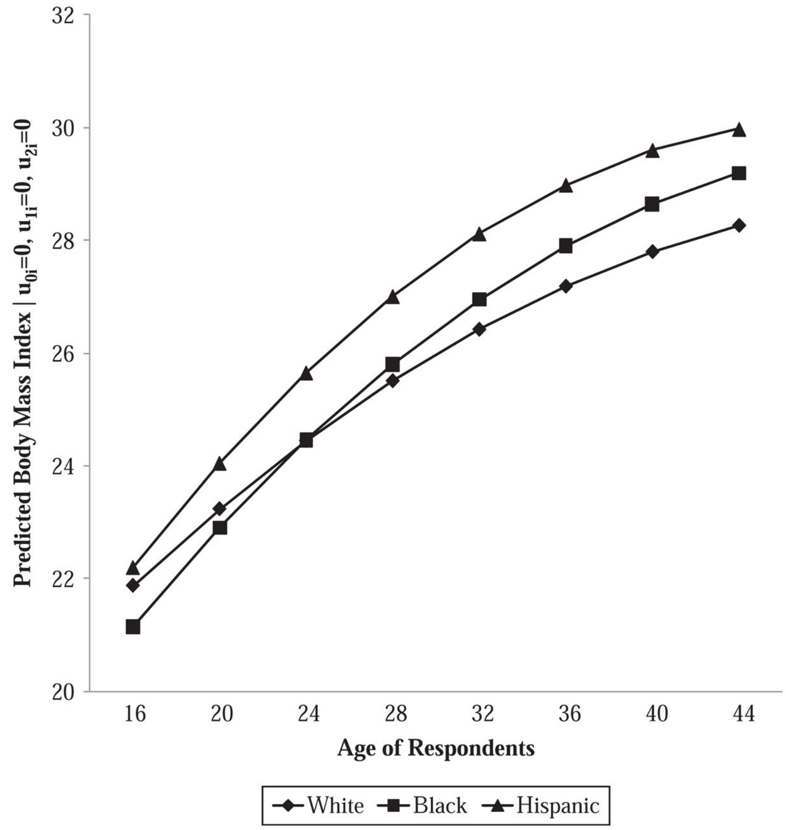

Figure 4.

Predicted average BMI trajectories for males by race/ethnicity, National Longitudinal Survey of Youth (NLSY79).

Note: Predicted trajectories based on Model 1 estimates, and represents average predicted trajectories for respondents in the 1961–1964 birth cohort who did not die during survey interval.

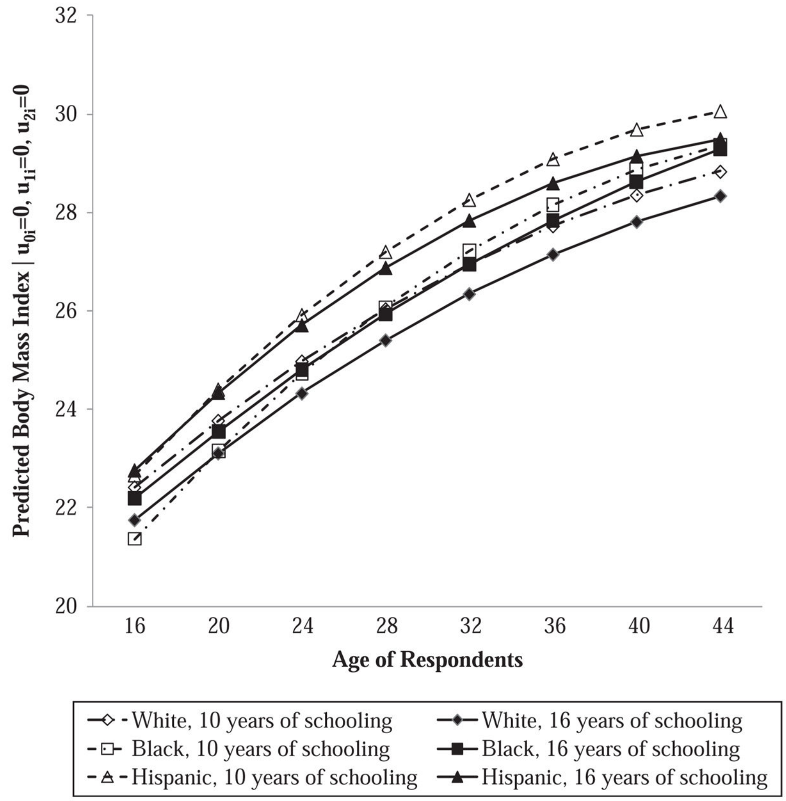

Figure 5.

Predicted average BMI trajectories for males by mothers' education and race/ ethnicity, National Longitudinal Survey of Youth (NLSY79).

Note: Predicted trajectories based on Model 6 estimates. Respondents' education held constant at 12 years of schooling; remaining covariates held constant at their grand mean. Predicted trajectories represent respondents in the 1961–1964 birth cohort who did not die during survey interval.

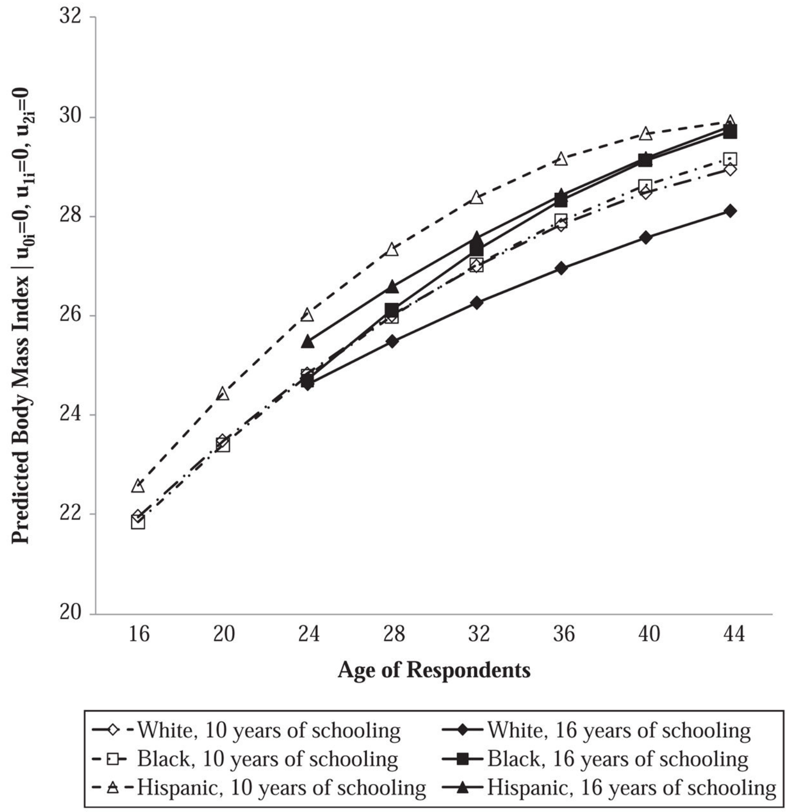

Figure 6.
Predicted average BMI trajectories for males by respondents' education and race/ ethnicity, National Longitudinal Survey of Youth (NLSY79).
Note: Predicted trajectories based on Model 6 estimates. Mother's education held constant at 12 years of schooling; remaining covariates held constant at their grand mean. Predicted trajectories represent respondents in the 1961–1964 birth cohort who did not die during survey interval.

Table 1

Descriptive statistics of study sample by gender, National Longitudinal Survey of Youth (1979)[a].

	Full sample, *n*=8354	Female, *n*=4318	Male, *n*=4036
Body mass index[b,c]	26.05	25.68	26.41
Race/ethnicity			
White	0.53	0.53	0.53
Black	0.29	0.29	0.29
Hispanic	0.18	0.18	0.18
Female	0.52		
Mothers' education[b]	10.81	10.76	10.86
Respondents' education[b,c]	12.90	13.01	12.79
Birth cohort			
1957–1960	0.48	0.50	0.46
1961–1964	0.52	0.50	0.54
Respondents' nativity			
Respondent foreign-born	0.07	0.06	0.07
Parents' nativity			
Both or known parent US-born	0.88	0.88	0.88
One parent foreign-born	0.05	0.05	0.04
Both or known parent foreign- born	0.07	0.07	0.08
Family Structure at 14			
Nuclear	0.69	0.69	0.69
Step-family	0.07	0.07	0.07
Female-headed	0.19	0.19	0.19
Other	0.05	0.05	0.05
Community at 14			
Rural	0.20	0.20	0.20
Non-rural	0.80	0.80	0.80
Area of residence at 14			
US South	0.35	0.35	0.34
US Non-South	0.63	0.63	0.64
Outside US	0.02	0.02	0.02
Occupational status[c]			
Professional/managerial	0.22	0.24	0.21
Labor	0.26	0.10	0.42
Sales/service/clerical	0.36	0.47	0.25
Not working	0.16	0.19	0.12
Marital status[c]			
Married	0.45	0.47	0.44
Divorced/separated/widowed	0.16	0.19	0.13
Never married	0.39	0.34	0.43

	Full sample, *n*=8354	**Female, *n*=4318**	**Male, *n*=4036**
Community[c]			
Rural	0.20	0.20	0.19
Non-rural	0.76	0.77	0.76
Not classified	0.04	0.03	0.05
Died in survey interval	0.04	0.02	0.05

[a]Estimates are proportions unless otherwise noted, may not add to 1 due to rounding error.

[b]Continuous variable, mean presented.

[c]Time-varying measure, estimates presented are over survey interval.

Table 2

Estimates from two-level linear growth models for BMI, female respondents (*n*=4318), National Longitudinal Survey of Youth (NLSY79).

	Model 1[f] b(SE)	Model 2[f,g] b(SE)	Model 3[f,g] b(SE)	Model 4[f,g,h] b(SE)	Model 5 [f,g,h] b(SE)	Model 6[f,g,h] b(SE)
Status at age 32 Intercept	24.552* (0.139)	24.511* (0.143)	24.513* (0.140)	24.979* (0.146)	24.977* (0.147)	24.874* (0.150)
Black[a]	3.411* (0.182)	3.106* (0.200)	3.096* (0.209)	3.434* (0.200)	3.486* (0.206)	3.311* (0.220)
Hispanic[a]	2.231* (0.247)	1.539* (0.267)	1.646* (0.305)	2.200* (0.248)	2.205* (0.251)	1.664* (0.311)
Mothers' education[b]		−0.204* (0.028)	−0.223* (0.045)			−0.189* (0.047)
Mothers' education×Black			0.008 (0.070)			0.001 (0.072)
Mothers' education×Hispanic			0.046 (0.065)			0.028 (0.066)
Respondents' education[b]				−0.121* (0.018)	−0.118* (0.026)	−0.082* (0.027)
Respondents' education×Black					−0.027 (0.044)	−0.019 (0.046)
Respondents' education×Hispanic					0.018 (0.046)	0.012 (0.048)
Rate of change[c]						
Age	0.203* (0.006)	0.203* (0.006)	0.203* (0.006)	0.203* (0.006)	0.206* (0.007)	0.202* (0.007)
Age^2	−0.0029* (0.0004)	−0.0029* (0.0004)	−0.0029* (0.0004)	−0.0032* (0.0005)	−0.0030* (0.0005)	−0.0030* (0.0004)
Age×Black	0.121* (0.008)	0.117* (0.008)	0.120* (0.008)	0.128* (0.008)	0.123* (0.009)	0.122* (0.010)
Age^2×Black	−0.0046* (0.0006)	−0.0043* (0.0006)	−0.0040* (0.0006)	−0.0049* (0.0006)	−0.0055* (0.0007)	−0.0047* (0.0007)
Age×Hispanic	0.065* (0.010)	0.051* (0.010)	0.046* (0.012)	0.072* (0.009)	0.068* (0.010)	0.049* (0.013)
Age^2×Hispanic	−0.0021* (0.0007)	−0.0010 (0.0008)	−0.0012 (0.0009)	−0.0021* (0.0007)	−0.0023* (0.0007)	−0.0011 (0.0010)
Age×Mothers' education		−0.003* (0.001)	−0.005* (0.002)			−0.005* (0.002)
Age^2×Mothers' education		0.0003* (0.0001)	0.0001 (0.0002)			0.0001 (0.0002)
Age×Mothers' education×Black			0.004 (0.003)			0.002 (0.003)
Age^2×Mothers' education×Black			0.0004 (0.0002)			0.0005 (0.0002)
Age×Mothers' education×Hispanic			0.000 (0.003)			0.000 (0.003)
Age^2×Mothers' education×Hispanic			0.0002 (0.0002)			0.0002 (0.0002)
Age×Respondents' education				0.002 (0.001)	−0.001 (0.002)	0.001 (0.002)
Age^2×Respondents' education				−0.0001 (0.0001)	0.0000 (0.0001)	−0.0000 (0.0001)
Age×Respondents' education×Black					0.011* (0.003)	0.009* (0.003)

	Model 1[f] b(SE)	Model 2[f,g] b(SE)	Model 3[f,g] b(SE)	Model 4[f,g,h] b(SE)	Model 5[f,g,h] b(SE)	Model 6[f,g,h] b(SE)
Age^2×Respondents' education×Black					−0.0003 (0.0002)	−0.0005* (0.0002)
Age×Respondents' education×Hispanic					0.004 (0.003)	0.004 (0.003)
Age^2×Respondents' education×Hispanic					−0.0003 (0.0002)	−0.0003 (0.0002)
Random effects[d]						
u_{0i}	5.042	5.000	5.000	5.010	5.010	4.995
u_{1i}	0.189	0.189	0.189	0.189	0.189	0.189
u_{2i}	0.013	0.013	0.013	0.013	0.013	0.013
Goodness of fit						
Δ −2 log likelihood[e]	−4548.2*	−83.6*	−6.0	−418.4*	−22.5*	−410.7*, −59.4*

* $p<0.05$ two-tailed test.

[a] Reference group is White.

[b] Mother's and respondent's education are continuous and centered at 12.

[c] Age is centered at 32.

[d] Unconditional model variance estimates: u_{0i}=5.361, u_{1i} =0.325, u_{2i}=0.014.

[e] Change in the −2LL contrasts Model 1 to the unconditional model (not shown); Model 2 to Model 1; and Model 3 to Model 2; Model 4 to Model 1; Model 5 to Model 4; Model 6 to Model 3 (top estimate); and Model 6 to Model 5 (bottom estimate).

[f] Adjusting for nativity of respondent and respondents' mother and father; birth cohort; birth cohort×age; birth cohort×age-squared; mortality; mortality×age; and mortality×age-squared.

[g] Adjusting for community at age 14, family structure at age 14, and area of residence at age 14.

[h] Adjusting for time-varying measures of occupational status, community, and marital status.

Table 3

Estimates from two-level linear growth models for BMI, male respondents (n=4036), National Longitudinal Survey of Youth (NLSY79).

	Model 1[f] b(SE)	Model 2[f,g] b(SE)	Model 3[f,g] b(SE)	Model 4[f,g,h] b(SE)	Model 5[f,g,h] b(SE)	Model 6[f,g,h] b(SE)
Status at age 32 Intercept	26.417* (0.107)	26.400* (0.111)	26.387* (0.109)	26.745* (0.115)	26.784* (0.117)	26.751* (0.117)
Black[a]	0.534* (0.144)	0.415* (0.160)	0.491* (0.165)	0.541* (0.159)	0.425* (0.161)	0.375* (0.169)
Hispanic[a]	1.702* (0.200)	1.354* (0.216)	1.393* (0.243)	1.626* (0.202)	1.593* (0.203)	1.361* (0.247)
Mothers' education[b]		−0.099* (0.022)	−0.148* (0.035)			−0.101* (0.036)
Mothers' education×Black			0.118* (0.057)			0.055 (0.058)
Mothers' education×Hispanic			0.054 (0.049)			0.031 (0.050)
Respondents' education[b]				−0.102* (0.014)	−0.135* (0.019)	−0.124* (0.020)
Respondents' education×Black					0.163* (0.035)	0.175* (0.036)
Respondents' education×Hispanic					−0.021 (0.037)	−0.011 (0.039)
Rate of change[c]						
Age	0.210* (0.005)	0.210* (0.005)	0.210* (0.005)	0.207* (0.005)	0.213* (0.005)	0.213* (0.005)
Age^2	−0.0047* (0.0003)	−0.0047* (0.0003)	−0.0047* (0.0003)	−0.0041* (0.0003)	−0.0045* (0.0004)	−0.0045* (0.0004)
Age×Black	0.052* (0.006)	0.050* (0.006)	0.050* (0.007)	0.054* (0.006)	0.043* (0.007)	0.039* (0.007)
Age^2×Black	−0.0016* (0.0005)	−0.0013* (0.0005)	−0.0011* (0.0005)	−0.0015* (0.0005)	−0.0017* (0.0005)	−0.0012* (0.0005)
Age×Hispanic	0.037* (0.007)	0.027* (0.008)	0.023* (0.010)	0.037* (0.007)	0.031* (0.008)	0.015 (0.010)
Age^2×Hispanic	−0.0030* (0.0005)	−0.0017* (0.0006)	−0.0019* (0.0007)	−0.0025* (0.0005)	−0.0028* (0.0006)	−0.0024* (0.0008)
Age×Mothers' education		−0.002* (0.001)	−0.001 (0.002)			0.001 (0.002)
Age^2×Mothers' education		0.0003* (0.0001)	0.0002 (0.0001)			0.0000 (0.0001)
Age×Mothers' education×Black			−0.000 (0.003)			−0.005* (0.003)
Age^2×Mothers' education×Black			0.0003 (0.0002)			0.0005* (0.0002)
Age×Mothers' education×Hispanic			−0.002 (0.002)			−0.005* (0.002)
Age^2×Mothers' education×Hispanic			0.0001 (0.0002)			−0.0001 (0.0002)
Age×Respondents' education				−0.003* (0.001)	−0.007* (0.001)	−0.007* (0.001)
Age^2×Respondents' education				0.0005* (0.0001)	0.0005* (0.0001)	0.0005* (0.0001)

	Model 1[f] b(SE)	Model 2[f,g] b(SE)	Model 3[f,g] b(SE)	Model 4[f,g,h] b(SE)	Model 5[f,g,h] b(SE)	Model 6[f,g,h] b(SE)
Age×Respondents' education×Black					0.013* (0.002)	0.013* (0.002)
Age^2×Respondents' education×Black					−0.0006* (0.0002)	−0.0007* (0.0002)
Age×Respondents' education×Hispanic					0.006* (0.002)	0.008* (0.003)
Age^2×respondents' education×Hispanic					0.0003 (0.0002)	0.0003 (0.0002)
Random effects[d]						
u_{0i}	3.852	3.839	3.836	3.832	3.820	3.816
u_{1i}	0.148	0.148	0.148	0.148	0.147	0.147
u_{2i}	0.010	0.010	0.010	0.010	0.010	0.010
Goodness of fit						
$_{\Delta}$−2 log likelihood[e]	−4815.7*	−49.6*	−8.2	−303.7*	−59.5*	−339.8*, −34.4*

*p<0.05 two-tailed test.

[a]Reference group is White.

[b]Mother's and respondent's education are continuous and centered at 12.

[c]Age is centered at 32.

[d]Unconditional model variance estimates: u_{0i} =3.968, u_{1i}=0.273, u_{2i}=0.011.

[e]Change in the −2LL contrasts Model 1 to the unconditional model (not shown); Model 2 to Model 1; and Model 3 to Model 2; Model 4 to Model 1; Model 5 to Model 4; Model 6 to Model 3 (top estimate); and Model 6 to Model 5 (bottom estimate).

[f]Adjusting for nativity of respondent and respondents' mother and father; birth cohort; birth cohort×age; birth cohort×age-squared; mortality; mortality×age; and mortality×age-squared.

[g]Adjusting for community at age 14, family structure at age 14, and area of residence at age 14.

[h]Adjusting for time-varying measures of occupational status, community, and marital status.