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The Relationship between Lifetime Health Trajectories and Socioeconomic Attainment in Middle Age

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Abstract

A large literature demonstrates the direct and indirect influence of health on socioeconomic attainment, and reveals the ways in which health and socioeconomic background simultaneously and dynamically affect opportunities for attainment and mobility. Despite an increasing understanding of the effects of health on social processes, research to date remains limited in its conceptualization and measurement of the temporal dimensions of health, especially in the presence of socioeconomic circumstances that covary with health over time. Guided by life course theory, we use data from the British National Child Development Study, an ongoing panel study of a cohort born in 1958, to examine the association between lifetime health trajectories and socioeconomic attainment in middle age. We apply finite mixture modeling to identify distinct trajectories of health that simultaneously account for timing, duration and stability. Moreover, we employ propensity score weighting models to account for the presence of time-varying socioeconomic factors in estimating the impact of health trajectories. We find that, when poor health is limited to the childhood years, the disadvantage in socioeconomic attainment relative to being continuously healthy is either insignificant or largely explained by time-varying socioeconomic confounders. The socioeconomic impact of continuously deteriorating health over the life course is more persistent, however. Our results suggest that accounting for the timing, duration and stability of poor health throughout both childhood and adulthood is important for understanding how health works to produce social stratification. In addition, the findings highlight the importance of distinguishing between confounding and mediating effects of time-varying socioeconomic circumstances.

Keywords

Health trajectory; time-varying confounding; socioeconomic attainment; the life course

1. INTRODUCTION

A growing body of sociological research reveals a strong association between early life adversity and life course patterns of inequality (Guo 1998; Torche 2011; Warren et al. 2012). Childhood is a key period for understanding the relationship between socioeconomic disadvantage and its persistent effects over the life course, and substantial evidence demonstrates the effects of socioeconomic disadvantage on socioeconomic processes and health over the life course (Mackenbach et al. 2008; Smith 2003; Wagmiller et al. 2006). As a form of childhood adversity that is closely intertwined with both biological and social processes, recent evidence points to the role of poor health during childhood in generating social and economic inequality within and across generations (Palloni 2006). Health is a marker of population welfare that is unequally distributed at the time of birth, remains unequally distributed with age, and has important implications for social and economic patterns observed over the life course. Evidence that health plays a role in determining social position suggests a process of “health selection” into social and economic roles. Socioeconomic background and health work simultaneously and dynamically to affect socioeconomic attainment, to the extent that socioeconomic background is a determinant of both health and socioeconomic attainment (Adler et al. 2004; Smith 2003; Finch 2003; Wagmiller et al. 2006), and health at different ages has both direct and indirect effects on opportunities for socioeconomic attainment and mobility. Health selection, therefore, results from and contributes to socioeconomic disadvantage.

Research on the life course effects of socioeconomic disadvantage has expanded to incorporate duration and exposure processes into its conceptual and analytic models (e.g., Ben-Schlomo and Kuh 2002; Duncan, Ziol-Guest and Kalil 2010; Wagmiller et al. 2006). However, despite an increasing understanding of the sizeable effects of health on social processes, limited theoretical and empirical attention to the temporal dimensions of health, especially in the presence of socioeconomic circumstances that covary with health over time, precludes a comprehensive understanding of how health works to produce social stratification. While several insights from life course theory are highly relevant to the study of health and social stratification, they are often overlooked (Elder 1998; Mortimer and Shanahan 2003). First, the accumulation of inequality is sensitive to developmental processes, meaning that the timing and duration of circumstances during childhood play a key role in producing inequality in adulthood (Elder, Johnson, and Crosnoe 2003; Ferraro, Shippee, and Schafer 2009). Second, the temporal dimensions of life circumstances—timing, duration, and stability—are related to one another and should be measured simultaneously (Ben-Schlomo and Kuh 2002; Elder 1998; Mortimer and Shanahan 2003). Third, time-dependent exposures to adversity (in this case, poor health) are affected by social factors that themselves vary over time and that also influence socioeconomic attainment (Cerdá et al. 2010; Elder 1985, 1998). We incorporate these insights into a model of health and social stratification and use life course data on health, social environment and socioeconomic attainment to work toward a more complete measurement of “health selection.” In particular, we simultaneously account for the timing, duration, and stability of poor health, and we rigorously adjust for the confounding influence of time-varying socioeconomic factors at different stages of the life course.

2. BACKGROUND

Previous research offers a strong consensus that child health, most often measured by birthweight and sometimes by health during the school years, affects youths' educational achievement and attainment (Boardman et al. 2002; Cheadle and Goosby 2010; Conley, Strully, and Bennett 2003; Jackson 2010), and adults' earnings and labor force participation (Currie and Stabile 2006; Palloni 2006). A parallel body of research links health later in life, whether measured by mental health in young adulthood (e.g., Miech et al. 1999) or nutrient deficiency (e.g., Thomas and Frankenberg 2002), to economic productivity and downward social mobility. Existing evidence points to a role for health, often referred to as health selection (e.g., Warren 2009), in both limiting opportunities for the accumulation of skills and education during the early life course, and restricting entry into—and, in some cases, leading to exit from—certain socioeconomic roles in adulthood.

2.1. The Importance of Developmental Processes for Understanding Health and Social Stratification

Life course theory emphasizes the importance of developmental processes for understanding patterns observed in adulthood, placing primary importance on the connection between life stages and on the childhood circumstances that give rise to adults' well-being (Ferraro et al. 2009). Embedded in a focus across life stages is the recognition that circumstances during each life stage may have differing and combined effects on longer-term outcomes (Ben-Schlomo and Kuh 2002; Schoon et al. 2002). This perspective can be usefully applied to research on health and social stratification over the life course, which requires consideration of health during highly variable periods of sensitivity.

2.1.1. Timing—A burgeoning body of evidence demonstrates that poor health during childhood has a durable impact on socioeconomic status in adulthood because it hampers cognitive and socioemotional development during critical or sensitive periods of development (Jackson 2010; Palloni 2006; Torche 2011). The early life cycle is a highly sensitive period of brain development, with evidence that exposures in early childhood have a lasting influence on development and health (Knudsen 2004)—some research even suggests that exposures in early childhood, or in utero, can permanently “program” aspects of physical and cognitive development (e.g., Barker 1994; Gluckman and Hansen 2009). Moreover, there is further evidence of learning and attainment effects associated with school-age health after the “critical period” of early childhood (Crosnoe 2006; Thies 1999). The effects of poor health during childhood may grow with age in a process of cumulative disadvantage, whereby the short-term effects associated with health widen as youth age to manifest in a longer-term “scarring” effect of poor health earlier in the life course (Diprete and Eirich 2006; Ferraro and Shippee 2009; Goosby and Cheadle 2009; Haas, Glymour, and Berkman 2011). Because skills build on each other (Tsao, Liu, and Kuhl 2004), early differences successively affect children's ability to effectively participate in academic curricula throughout the school years and, ultimately, to attain high socioeconomic status.

Later in the life course, research on socioeconomic deprivation suggests that exposure to disadvantage that overlaps with the working career may have more negative consequences

for socioeconomic processes than exposure during childhood and adolescence. While individuals may be able to rebound from impairments in childhood health—and, subsequently, cognitive and socioemotional development—if they face better circumstances with age (e.g., Ferraro and Shippee 2009), later-life health problems may place more direct constraints on upward mobility. An alternative possibility is, therefore, that poor health in adulthood is more negatively related to socioeconomic attainment than poor childhood health. In this vein, health during adulthood, whether proxied by nutritional deficiencies (in developing settings), medical problems or self-rated health (in developed settings), is strongly related to labor market success (Chandola et al. 2002; Hallerod and Gustafsson 2011; Himmelstein et al. 2005; Thomas and Frankenberg 2002).

2.1.2. Duration and Stability—Life course theory also predicts that the degree of long-term “scarring” associated with adversity earlier in life depends on the duration and stability of that adversity (Ben-Schlomo and Kuh 2002; Ferraro and Shippee 2009; O’Rand 2009). A consideration of cumulative exposure, defined as the continued presence of a status over time, is important for understanding how inequality is generated over the life course (Diprete and Eirich 2006). To the extent that cumulative exposure to poor health over the life course persistently limits opportunities for social and economic advancement, a long duration of poor health should have a more negative association with social and economic success in midlife than more transitory episodes of illness, which may have shorter-term disruptive effects. Continuously deteriorating health throughout childhood and adulthood (the successive accumulation of health problems) or continuously poor health may lead to particularly detrimental long-term effects, as has been observed in examinations of childhood health (McLeod and Fettes 2007; Jackson 2010). Evidence for a cumulative exposure process has been observed for other forms of adversity as well. For example, having a persistently low income influences health trajectories more strongly than transient spells of low-income (Willson, Shuey, and Elder 2007) and a longer duration of obesity is more negatively related to health declines in adulthood than shorter periods of obesity (Ferraro and Kelley-Moore 2003). Health is a more complex construct than income, in the sense that measures at a given point in time reflect an underlying state that can never be fully measured. Transitory illness, therefore, may be conceptualized as the temporary outward manifestation of a more chronic underlying state of poorer health, toward the middle of an underlying continuum of “excellent” to “poor” health (rather than as a shock that involves a change from excellent to poor health).

2.2. Connections among the Temporal Dimensions of Health

As described above, time-dependent processes are increasingly being incorporated into life course models of health and social stratification, an important step toward a more comprehensive understanding of how inequality is generated. Implicit in the approach of much existing research, though, is the assumption that each temporal dimension of health operates independently of the others. In reality, health changes throughout the life course and individuals experience varying combinations of childhood and adult health. Life course theory emphasizes connections across life stages, suggesting that timing should not function independently of duration or stability (Ben-Schlomo and Kuh 2002; Elder 1998; Mortimer and Shanahan 2003). Simultaneous measurement of these temporal processes enables a

deeper understanding of the relative influence of childhood vs. adult health on socioeconomic attainment, as well as the importance of short-term adversity during specific age periods relative to cumulative processes that unfold throughout childhood and adulthood. While identifying the independent effects of each temporal dimension is quite difficult (Hallqvist et al. 2004), we offer a more complex understanding of the simultaneous operation of timing, duration and stability effects.

Differing trajectories of the timing, duration and stability of poor health should have distinct effects on socioeconomic attainment in midlife, according to the principles of life course theory. A health disadvantage that occurs early in life should be more detrimental for eventual attainment when it is followed by a long duration of poor health, or by a pattern of deteriorating health with age (Diprete and Eirich 2006; McLeod and Fettes 2007). In contrast, an isolated period of poor health during a less sensitive period of development (e.g., adolescence or early adulthood) may have short-term effects that do not persist later into adulthood. Similarly, poor health during early childhood that is not followed by a long duration should have a weaker relationship with socioeconomic attainment than the experience of early and continuously poor health.

2.3. The Role of Time-Varying Socioeconomic Factors in Affecting Exposure to Health Disadvantage

A third insight from life course theory that is relevant to the study of health and social stratification is that there is feedback between time-dependent exposures to health adversity and coexisting social factors that themselves vary over time and influence socioeconomic attainment. The presence of time-varying socioeconomic factors during childhood and adolescence poses challenges for identifying the effects of life-course health on socioeconomic attainment. An abundance of prior research establishes dynamic relationships between individuals' socioeconomic characteristics and health status. The temporal dimensions of socioeconomic status also work over the life course to influence health at each age. The strong effects of early childhood socioeconomic disadvantage on later-life disease incidence, for example, suggests that childhood is a critical period for understanding the relationship between socioeconomic status and health (Smith 2003). Similarly, evidence on the importance of poverty duration, vs. poverty exposure *per se*, highlights the importance of duration processes in understanding how socioeconomic status is related to health (Duncan, Ziol-Guest and Kalil 2010; Wagmiller et al. 2006). Given the strong socioeconomic gradient in health among both children and adults, education, income and other dimensions of socioeconomic status are therefore likely to function as confounders of health effects (Finch 2003; Link and Phelan 1995; Schnittker 2004). In addition, much of the influence of childhood health on social processes is explained by the emergence of achievement disparities early in children's schooling, suggesting that health during childhood is mediated by cognitive and academic processes that affect opportunities for educational progression and labor market prospects (Crosnoe 2006; Hall and Farkas 2011; Palloni 2006). Labor market position and its fluctuation, in turn, influence health among the same individuals as young adults (Burgard, Brand, and House 2007).

These dynamic processes clearly indicate that individuals' health status may not only affect, but also be affected by, socioeconomic correlates. However, when both health status and socioeconomic characteristics are conceptualized to vary over the life course, the possibility for reciprocal relationships between them poses a unique challenge to investigating the effects of life-course health. Figure 1 presents a stylized two-wave example to illustrate how one would address the interplay between health and time-varying covariates unfolding reciprocally over time in a conventional regression framework. This example assumes that time-varying health status is independent of the outcome of interest conditional on observed covariates, as in observational studies, but it allows for the existence of unobserved factors that affect time-varying covariates and the outcome. Formally, the model states (1) that time-varying covariates function as both confounders and mediators of time-varying health status and (2) that time-varying health status thus has both direct and indirect impacts.

Three problems can arise if a researcher analyzes this model in a conventional regression framework. A first approach would be to exclude time-varying covariates at the second wave, X_2 , treating time-dependent health status as the sole time-varying determinant of the outcome. Conditioning on X_2 may obscure the effect of life-course health, as it leads time-dependent health status and time-varying covariates to jointly determine the outcome. However, given that X_2 is a confounder of the relationship between health status at the second wave, H_2 , and the outcome, O ($X_2 \rightarrow H_2$ and $X_2 \rightarrow O$), excluding time-varying covariates can result in omitted variables bias, thereby overstating the effect of time-dependent health status.

A second approach would be to include X_2 to alleviate omitted variable bias. One problem with this approach is that conditioning on X_2 generates an indirect pathway by which health status at the first wave affects the outcome ($H_1 \rightarrow X_2 \rightarrow O$) in addition to the direct pathway ($H_1 \rightarrow O$). Because X_2 stands in the pathway from H_1 to O , conditioning on X_2 amounts to "controlling away" part of the effect of time-dependent health status, leading to understating its effect. The same approach also creates a "collider" problem (Elwert and Winship 2010; Pearl 2009). Conditioning on X_2 induces a non-causal association between its two common causes, H_1 and unobserved factors, U ($H_1 \rightarrow X_2 \leftarrow U$). As U also affects O , accounting for X_2 makes it impossible to distinguish the effect of time-dependent health status from that of unobserved factors.

Thus, conventional regression models are unlikely to sufficiently handle endogenous relationships between time-dependent health status and time-varying socioeconomic covariates. Certainly, previous research has thoroughly controlled for individuals' socioeconomic characteristics at particular points in time, convincingly suggesting that health is not simply a proxy for social and economic status. Yet, while conventional regression models can either include time-varying covariates to account for confounding or exclude them to avoid over-controlling and collider stratification, they cannot do both. We incorporate this temporal insight into our analysis by examining the *direct* impact of life-course health trajectories on midlife socioeconomic attainment when time-varying socioeconomic factors are present. In doing so, we also evaluate whether time-varying socioeconomic covariates play a particularly strong explanatory role in childhood or adulthood.

3. THE PRESENT STUDY

Existing research provides a rich understanding of the reciprocal and dynamic relationships among socioeconomic attainment, human capital development, and health. While research on the effects of social stratification on health has begun to conceptually and empirically acknowledge the importance of time-dependent processes, models of the effects of time-dependent childhood and adulthood health status on social stratification are less developed. In this article, we advance the literature on health and social stratification by simultaneously accounting for the timing, duration, and stability of health disadvantage, and by examining the sensitivity of the effect of life-course health trajectories to the presence of time-varying socioeconomic factors. Specifically, we address the following questions:

1. What health trajectories are more commonly experienced between childhood and mid-adulthood?
2. What impact do different health trajectories have on socioeconomic attainment in mid-adulthood?
3. What role do time-varying socioeconomic covariates play in linking health trajectories to mid-life socioeconomic attainment?

4. DATA AND METHODS

4.1. Data, Sample and Study Setting

This study uses data drawn from the British National Child Development Study (NCDS), an ongoing longitudinal survey that follows 17,415 children born in Great Britain (Scotland, England, and Wales) in the week of March 3, 1958 and gathers information on the same people at birth and at eight follow-up waves through age 50 (ages 7, 11, 16, 23, 33, 42, 46, and 50). The aim of the NCDS is to improve understanding of the causes and consequences of human development over the life course. The data provide rich information on parental characteristics, health, cognitive and socioemotional development, educational progress, labor market outcomes, and family relationships. Though other surveys provide excellent data on shorter periods of the early life course (early childhood, adolescence, early adulthood), the NCDS provides an unparalleled resource for the questions considered here, with its long time span, physician-reported, diagnosed health conditions, and rich measurement of the social environment. Since the data allow us to trace childhood events far into mid-adulthood, it is possible to construct all study variables prospectively (Case, Fertig, and Paxson 2005).

Mid-late twentieth century Great Britain provides a compelling site for the questions considered here, exhibiting both similarities and differences to the contemporary U.K. and to other nations. For example, the highly structured educational system during this time made learning assessments a more important gatekeeping mechanism for eventual educational attainment than is currently the case (Kerckhoff, Haney, and Glennie 2001). In addition, despite the presence of the National Health Service (beginning in 1948), socioeconomic disparities in health and health behaviors in the data are similar in size to patterns in the contemporary U.K. as well as in the United States (Marmot et al. 1978; Banks et al. 2003).

We will revisit the implications of our data for contemporary patterns, and other contexts, in the conclusions.

The analysis sample consists of 4,644 people—2,469 female and 2,175 male—who participated in all waves between 1958 and 2004—between birth and age 46.¹ Given the long time period covered in this study, some degree of sample attrition is inevitable. To the extent that there is nonrandom attrition, our analysis will produce biased results. We address this possibility by comparing the original participants with those who remain in 2004 on our key covariates.² We further adjust for sample attrition using censoring weights for time-dependent exposure to attrition—more detail on this procedure is provided in the methods section. To address wave-specific item nonresponse, we employ multiple imputation (MI) to fill in missing values, using five imputations (Little and Rubin 2002; Royston 2005).

4.2. Measures

The dependent variable of this study is occupational skill qualification at age 46, measured using the U.K. National Vocation Qualification (NVQ) scheme. NVQ levels denote the degree of competence required by an employee to perform a particular job and are an important indicator of socioeconomic status in this context (Jackson 2010; Steedman 1998). There are five NVQ levels (1–5), each including both academic and vocational qualifications. Differing NVQ levels across adulthood ages largely indicate advancements in qualifications during the working career, rather than changes in educational attainment. Higher levels indicate a more complex occupational skill set. We use the same NVQ scheme as Makepeace et al. (2003), where level 1 (reference category) includes low-scoring O-level grades and the lowest vocational certificates; level 2 includes passing O-level grades and vocational equivalents; level 3 includes at least two A-level exams and vocational equivalents; level 4 includes “sub-degree” qualifications and certificates; and level 5 includes university diplomas, teaching and nursing degrees and post-university education.

The main explanatory variable is individuals’ trajectory of exposure to poor health over the life course. As described below, we apply finite mixture modeling to identify distinct temporal patterns of health status, using a set of health status indicators from birth through age 42. Health status at birth is indicated by low birthweight status, a widely used indicator of infant health that is strongly related to both short-term skill development and longer-term socioeconomic outcomes (Boardman et al. 2002; Conley and Bennett 2001). Health during childhood (ages 7, 11, and 16) is measured by age-specific indicators of whether a physician diagnosed the child as having any physical or mental/emotional health problem that had a slight, moderate or severe impact on normal functioning.³ Health status during adulthood (ages 23, 33, and 42) is measured by self-reported general health status. At each age in adulthood, respondents were asked, “How would you describe your health generally? Would

¹Because analyses using age 50 data produce very similar results, we present results from age 46 in order to maximize sample size. Age 55 data are not yet released at the time of this analysis. We treat respondents as being lost to follow-up if they were permanently dropped out of the survey or left the survey but rejoined later. Table A1 provides further information on sample attrition patterns.

²Results shown in Table A2 suggest that respondents are more likely to remain in our analytic sample if they came from a higher social class background, were born to married parents, and had a mother who was nonsmoker. Our use of a more advantaged sample may result in an underestimation of the effects of lifetime health on socioeconomic attainment.

³The most common physical health condition at all ages is asthma, and the most common mental health condition is “emotional maladjustment.”

you say it is excellent, good, fair, or poor?” Self-reported general health status is strongly correlated with morbidity and mortality, even after accounting for physician assessed health status and health behaviors (Idler and Kasl 1995). In addition, in these data physicians’ health assessments are strongly related to parent and self-reports.⁴ To be consistent with the measures of health status at earlier ages, we measure adulthood health status dichotomously (excellent/good vs. fair/poor). Because the NCDS, like all surveys, does not permit health to be measured identically across all waves of childhood and adulthood—not a limitation, but a reflection of the varying developmental appropriateness of particular measures—we compare our predicted lifetime health trajectories to age-specific health to evaluate how well the trajectories we identify capture the specific conditions at each age. We describe this comparison below, in the results section.

NCDS data include an extensive array of covariates that are potential confounders of the association between health trajectories and socioeconomic attainment in middle age. For time-constant covariates, we measure mother’s age at birth, maternal grandfather’s social class (unskilled/semiskilled manual (reference), skilled manual, skilled nonmanual, intermediate, or professional), mother’s and father’s school-leaving age, mother’s marital status at birth (married vs. unmarried), mother’s prenatal smoking behavior after the 4th month of pregnancy (none (reference), medium, heavy, or variable), and gender. We also measure monthly family income at age 16 (the only childhood age at which income is assessed), whether the respondent was breastfed as an infant, whether both parents were present in the household from birth to age 11, the respondent’s post-school expectations at age 11 (get a job (reference), continue full-time education, or not sure), and the number of “O-level” exams (a national achievement test that partially determined educational continuation) passed by age 16.⁵ We do not control for race/ethnicity because NCDS respondents are overwhelmingly white (over 98%). Table 1 reports descriptive statistics for the outcomes and time-constant covariates.

Time-varying covariates measured during childhood include father’s social class,⁶ mother’s employment status (employed vs. unemployed), the number of children in the household, the number of residential moves, region in the U.K. (England (reference), Wales, or Scotland), parental school expectations (leave at minimum age vs. stay past minimum age), and NCDS-administered reading and math achievement test scores. Father’s social class and children’s region at birth are treated as baseline covariates, alongside the time-constant covariates. Time-varying covariates measured at each age during adulthood include the respondent’s own social class, occupational attainment, employment status, and marital status. Table 2 presents descriptive statistics for these time-varying characteristics as well as health status at selected ages. Respondents are more likely to have health limitations at ages 16 and 42 than

⁴We explore the consistency of physician and parent reports of particular conditions during childhood, and find that children whose parents report a particular condition are also less likely to be in the “no condition” category for the same condition (or family of conditions) as reported by physicians during the medical exam. These results (available upon request) suggest that physicians’ assessments are strongly related to parent and self-reports.

⁵Although monthly family income is measured at age 16, we consider it a time-constant covariate because the correlation of income across childhood years is quite high (Duncan et al. 1998). Other variables, such as breastfeeding status, parental presence, and post-school expectations, are treated as time-constant covariates only after they are measured. Including monthly family income only after age 16 produces almost identical results (results available upon request).

⁶Father’s social class is measured in the same fashion as maternal grandfather’s social class except that it further differentiates between unskilled and semiskilled manual.

at age 7. In addition, there are a range of differences in time-varying socioeconomic characteristics between individuals with and without health limitations. Compared to their counterparts, those with health limitations are more likely to have working mothers at age 7, have more siblings during childhood, have parents who expect them to leave school at the minimum age, and have lower scores on reading comprehension and math assessments. Those with health limitations are also less likely to have higher occupational attainment, be employed, and marry during adulthood.

Collectively, these measures of time-constant and time-varying characteristics allow us to simultaneously examine the timing, duration, and stability of exposures to poor health as they relate to socioeconomic attainment, and to account for the dynamic relationship between health status and socioeconomic factors.

4.3. Analytic Strategy

To address the complexity of temporal patterns of health disadvantage over the life course and the threat of confounding by time-varying socioeconomic covariates to the impact of life-course health, we adopt an analytic approach that combines finite mixture modeling with propensity score weighting. First, instead of analyzing the timing, duration, and stability of exposure to poor health separately, we apply latent class growth analysis (LCGA) to simultaneously account for each of these temporal dimensions. LCGA refers to the data as a finite mixture of unobserved groups of individuals (i.e., latent classes), allowing them to have their own growth parameters such as intercepts and slopes (Muthén 2001, 2004).⁷

LCGA identifies a latent categorical variable, C , that consists of a limited number of trajectory classes. As seen in Figure 2, each latent class is represented by the intercept, I , and slope, S . We also allow the slope to be nonlinear by including the quadratic slope parameter, Q . I , S , and Q are obtained from estimating the joint distribution of time-varying observed indicators of health status, H , using the expectation-maximization algorithm in a maximum likelihood framework. To identify the intercept, the slope parameters are fixed to zero at birth, H_1 . We use this modeling strategy to find the best-fitting number of trajectories of individuals' exposure to poor health over the life course.⁸ Because health status at each age serves as an observed time-ordered indicator, health trajectories identified in LCGA are distinct from one another in terms of the timing, duration, and stability of exposure to poor health.

To determine the best-fitting number of health trajectories, we utilize substantive knowledge from life course research on health as well as three statistical criteria: the Bayesian Information Criterion (BIC), Entropy, and the Lo-Mendell-Rubin (LMR) likelihood ratio test. We choose a model if it is deemed to be more parsimonious and accurate (lower BIC), better differentiates among trajectory classes (higher Entropy), and produces a significant

⁷In this regard, LCGA relaxes the assumptions of growth curve modeling that all individuals are drawn from a single population and that the degree of deviation from the population mean intercept and slope captures individual variation.

⁸We also considered a model where these growth parameters have their own variance and covariance estimates. This model identified a similar set of latent class trajectories but was unstable, as compared to the LCGA. We faced the problems of non-convergence and local solutions on several occasions despite our best effort to increase the number of random sets of starting values and iterations.

LMR test statistic (Celeux and Soromenho 1996; Lo, Mendell, and Rubin 2001; Raftery 1996). We also evaluate the health trajectories identified from the best-fitting model with respect to baseline characteristics.

Next, we employ propensity score weighting to properly assess the link between the trajectories of health status and socioeconomic attainment in mid-adulthood when other time-varying factors are present. The key feature of this method is the use of an inverse probability of treatment (IPT) weighting estimator, whereby individuals who experience poor health and those who do not at age k are balanced on prior health history and observed time-constant and timevarying covariates (Robins 1999; Robins, Hernán, and Brumback 2000). We calculate the conditional probability of exposure to poor health at age k as propensity score, ps , and weight individuals by the inverse of their propensity score. Individuals exposed to poor health at age k are given a weight of $1/ps$, thereby assigning those with higher propensity scores a lower weight and those with lower propensity scores a higher weight. Individuals not exposed to poor health at age k are given a weight of $1/(1 - ps)$, thereby assigning those with higher propensity scores a higher weight and those with lower propensity scores a lower weight. Intuitively, IPT weighting can be thought of as a sequential randomization of exposure to poor health by generating a pseudo-population in which exposure to poor health at any given age is independent of prior observed characteristics.

Let H_{ik} denote health status at age k and $\mathbf{X}_{i0}$ be a vector of baseline covariates. For time-varying covariates, we use overbars to denote covariate history up to age k :

$\bar{\mathbf{X}}_{ik} = \{\mathbf{X}_{i0}, \mathbf{X}_{i1}, \dots, \mathbf{X}_{ik}\}$. The IPT weights are given by

$$w_i = \prod_{k=1}^K \frac{1}{Pr(H_{ik} | \bar{H}_{ik-1}, \mathbf{X}_{i0}, \bar{\mathbf{X}}_{ik})}, \quad (1)$$

where Π is the product operator and the denominator is the probability that individual i had his/her actual health status at age k , conditional on prior health and covariate history. Logistic regression models are used to estimate the IPT weights, treating exposure to poor health at age k as a function of health status measured at age $k - 1$, baseline covariates, and time-varying covariates measured at age k . We experiment with alternative model specifications, such as interacting all explanatory variables with gender and excluding variables for achievement and expectation during childhood, and find that the results reported here are robust to these specifications (results available upon request). The IPT weights constructed above, however, tend to yield larger variance because a small number of observations with extreme weights dominate the estimation process (Hernán, Brumback, and Robins 2000). To increase efficiency, we use stabilized IPT weights:

$$sw_i = \prod_{k=1}^K \frac{Pr(H_{ik} | \bar{H}_{ik-1}, \mathbf{X}_{i0})}{Pr(H_{ik} | \bar{H}_{ik-1}, \mathbf{X}_{i0}, \bar{\mathbf{X}}_{ik})}, \quad (2)$$

where the numerator is the probability that individual i had his/her actual health status at age k , conditional on prior health status and baseline covariates (see Table A3).⁹

It is important to note that the propensity score weighting model makes the same assumption as in conventional regression models that no unobserved—time-constant and time-varying—factors affect time-varying health status and the outcome conditional on observed factors (Robins 1999). However, conventional regression models must make an additional assumption that observed time-varying covariates function as either exogenous factors or confounders of time-varying health status. Our model relaxes this assumption. Figure 3 illustrates how the IPT weighted model modifies the pathways depicted in Figure 1 that link time-varying health status and midlife socioeconomic outcomes. Since the IPT weights incorporate adjustment for time-varying socioeconomic factors as confounders into estimation, the pathways from time-varying socioeconomic covariates to health status can be removed ($X_1 \rightarrow H_1$, $X_1 \rightarrow H_2$, and $X_2 \rightarrow H_2$). As conditioning on time-varying socioeconomic covariates as mediators becomes unnecessary in estimating the effect of time-dependent exposure to poor health, the removal of the pathways involving X_2 resolves the problem of over-controlling. It also avoids collider stratification because unobserved factors (U) affecting time-varying socioeconomic covariates have no relation with time-dependent exposure to poor health. To address the issue of nonrandom sample attrition, we construct weights for time-dependent exposure to censoring (Robins, Hernán, and Brumback 2000). We calculate the conditional probability of remaining in our analytic sample at age k for individual i and weight each individual by the inverse of that probability. Let $L_{ik} = 1$ if individual i was lost to follow-up by age k and $L_{ik} = 0$ otherwise, and age $\bar{L}_{ik-1}=0$ indicate that individual i was not lost to follow-up by age $k - 1$. The stabilized censoring weights are given by

$$cw_i = \prod_{k=1}^K \frac{Pr(L_{ik}=0 | \bar{L}_{ik-1}=0, \bar{H}_{k-1}, \mathbf{X}_{i0})}{Pr(L_{ik}=0 | \bar{L}_{ik-1}=0, \bar{H}_{k-1}, \mathbf{X}_{i0}, \bar{\mathbf{X}}_{ik-1})}. \quad (3)$$

We estimate the effect of trajectories of health over the life course on socioeconomic attainment in middle age with the product of the stabilized IPT weights and the stabilized censoring weights as final weights ($fw_i = sw_i \times cw_i$). Specifically, we fit weighted ordered logit regression models that take the form:

$$\ln \left[\frac{Pr(\mathbf{O} \leq m)}{Pr(\mathbf{O} > m)} \right]_{fw} = \tau_m - [\alpha + \beta C + \mathbf{X}_0 \gamma], \quad (4)$$

where $\mathbf{O}$ denotes occupational skill qualification, m a category of the outcome, τ a threshold, and C the health trajectory from birth to age 42. We control for baseline covariates because these factors enter into both the numerator and denominator of the stabilized weights. Robust standard errors are computed to correct for within-individual correlation in the weighted sample (Robins, Hernán, and Brumback 2000).

⁹Weights are truncated at the 1st and 99th percentiles to avert disproportionate influence from outlying observations (Cole and Hernán 2008).

5. RESULTS

5.1. Lifetime Health Trajectories

To address our first research question—what health trajectories are most common between birth and mid-adulthood?—we use LCGA, which identifies four distinct trajectories.¹⁰ As shown in Figure 4, we classify these four health trajectories as follows: deteriorating then improving; continuously deteriorating; unhealthy only during adolescence; and continuously healthy.¹¹ The “deteriorating then improving” group accounts for 3.3% of the sample, with a higher likelihood of poor health during childhood than adulthood. By contrast, the “continuously deteriorating” group (10.87%) experiences a gradual increase in the risk of poor health over the life course, which leads to the highest likelihood of poor health during adulthood. About 9% of individuals have poor health only during adolescence. While it is beyond our objectives to probe why this group exists, we suspect that the onset of puberty and a sharp increase in delinquency may lead to poor health for some youth during adolescence. Finally, the majority of the sample is continuously healthy (76.77%), though this group experiences a slight decline in health during mid-adulthood.

Examining the relationship between our latent health classes and age-specific health measures reveals that those in the “deteriorating then improving” and “continuously deteriorating” groups are more likely than those in other classes to have health problems at each successive age during childhood (and in adulthood for the continuously deteriorating group); that those in the “unhealthy during adolescence” group are more likely to have health problems at age 16 vs. at childhood ages; and that those in the “continuously healthy” group are the least likely to have health problems at every age in childhood and adulthood. These descriptive results, available by request, suggest that the latent classes provide a good, efficient reflection of the age-specific combinations of health status in these data.

It is notable that we do not identify a trajectory class characterized by persistently poor health—the group that has been regarded as most vulnerable in prior research. This suggests that individuals with chronic health problems are most likely to be lost to follow-up due to their higher rates of morbidity and mortality, especially over such a long time span. Indeed, our inspection of observed indicators of age-specific health status indicates that the analytic sample contains no individual who reports poor health at all ages (results available upon request). Incorporating censoring weights into analysis certainly alleviates concerns about nonrandom sample attrition. Nonetheless, the fact that individuals with persistently poor health are difficult to follow implies that we are describing life course patterns of health and their effects for a population with relatively favorable health, and that our results for childhood health should be viewed as a lower-bound estimate.

¹⁰Goodness-of-fit indices suggest that the four class model fits the data better than other models (Table A4). Compared to the three class model, the four class model produces a lower value of BIC (a reduction by 310), a higher value of Entropy (.52 vs. .63), and a still significant value from the LMR test. The five class model improves upon the four class model in terms of BIC (a reduction by 33) but provides a worse model fit in terms of Entropy (.55) and finds one of the latent class trajectories is too small in size (less than 1% of the sample) to be used as a predictor of outcomes. We thus choose the four class model as the best representative of our data to identify health trajectories over the life course.

¹¹In Table A5, we use multinomial logistic regression to examine the relationship between these four trajectory classes and baseline covariates. We see that the “continuously deteriorating” group is least advantaged in terms of socioeconomic background. The “deteriorating then improving” group is also disadvantaged, though to a lesser degree. Meanwhile, individuals with health problems only during adolescence differ little from those who are continuously healthy.

5.2. Checking the Propensity Score Weights

Before examining the association between these health trajectories and occupational attainment in mid-adulthood, we evaluate the models that are used to construct stabilized IPT weights, censoring weights, and final weights. If our models are correctly specified, in expectation, the distribution of each of the weights should be centered around values close to 1, have small variance, and be symmetric (Hernán, Brumback, and Robins 2000). Table 3 (Panel A) suggests that all three weights meet these conditions. They have a mean close to 1, are not highly variable, and are only slightly skewed to the right.

We also examine whether incorporating our propensity score weights balances individuals with or without exposure to poor health in terms of time-varying socioeconomic characteristics. If the weights are constructed correctly, one would expect little difference in time-varying covariates between healthy and less healthy respondents at any given age. Table 3 (Panel B) shows two sets of results for each age from our logistic regression models of health status, one estimated with no stabilized IPT weights and the other with the stabilized IPT weights. We find that time-varying covariates are jointly significant in predicting age-specific health status (except for health status at birth) in the unweighted models, whereas they are jointly insignificant in the weighted models. Taken together, these results ensure that the propensity score weights are well-behaved.

5.3. Lifetime Health Trajectories and Midlife Occupational Attainment

Table 4 presents results for the impact of lifetime health trajectories on mid-adulthood occupational skill qualifications, measured by NVQ level, at age 46.¹² For the purposes of comparison, we contrast estimates from our propensity score weighting models with those from two conventional approaches—an unadjusted model that does not adjust for any covariates, and a regression-adjusted model that controls for baseline covariates. Both models are estimated with the censoring weights but without the IPT weights.

First, the unadjusted model (Model 1) shows that any cumulative exposures to poor health are associated with lower NVQ levels at age 46; however, only continuously deteriorating health is significantly associated with NVQ level, as it reduces the odds of achieving higher levels (versus lower levels) by 47% ($e^{-0.63} = 0.53$; $p < .001$). Moreover, Model 1 indicates that individuals who experience continuously deteriorating health have a lower NVQ level than both respondents who experience deteriorating then improving health and those who are unhealthy only during adolescence ($p = .082$ and $p = .003$, respectively). Second, compared to Model 1, the regression-adjusted model (Model 2) produces a smaller but still strong impact of continuously deteriorating health on NVQ level ($\beta = -0.45$; $p < .001$). Experiencing health problems only during adolescence is also associated with lower occupational skill qualification at the .10 level.

¹²We examine whether our ordered logit regression model meets the proportional odds (PO) assumption. Results from a generalized ordered logit model (available upon request) suggest that, except for gender and father's social class in 1958, all explanatory variables do not violate the PO assumption. Most importantly, the effects of health trajectories do not differ across contrasts between outcome categories.

Finally, the propensity score weighted model (Model 3) indicates that, although the impact of continuously deteriorating health on the odds of achieving higher NVQ levels is further reduced (to a 20% lower likelihood of high NVQ attainment, vs. 36% lower in Model 2), its impact remains significant and meaningful ($p < .05$). The other two health trajectories do not differ significantly from the continuously healthy group in their association with NVQ level. These findings suggest that, when poor health is limited to the childhood years, the impact of lifetime health trajectories on occupational attainment is insignificant and largely explained by time-varying socioeconomic confounders. This finding is not consistent with a “critical period” explanation, in which case we would expect to observe a persistent effect of childhood health even after accounting for duration. For those who experience continuously deteriorating health across childhood and adulthood, however, the lasting influence of health is more persistent. Adjusting for time-constant covariates reduces the impact of continuously deteriorating health by 29% ($= 100[{-0.63 - (-0.45)}]/{-0.63}$), while adjustment for time-varying covariates further reduces it by 51% ($= 100[{-0.45 - (-0.22)}]/{-0.45}$). Still, a significant and sizeable relationship remains, indicating that the association between continuously deteriorating health and lower occupational attainment is persistent, even after accounting for time-varying socioeconomic confounders.¹³

5.4. Exploring the Relative Impact of Time-Varying Socioeconomic Circumstances in Childhood and Adulthood

While the results thus far describe health over the life course, and link observed trajectories to mid-adulthood outcomes, they raise questions about *when* time-varying socioeconomic factors play a more salient role in explaining the association between health trajectories and occupational attainment—during childhood or adulthood? Given competing perspectives on the explanatory importance of childhood vs. adulthood socioeconomic circumstances, we explore this question. Results appear in Table 5. In Model 1, we replicate Model 3 in Table 4, which estimates the impact of health trajectories with propensity score weighted adjustment for time-varying covariates during both childhood and adulthood. We then estimate Model 2 with propensity score weighted adjustment only for childhood time-varying covariates, and Model 3 with propensity score weighted adjustment only for adulthood time-varying covariates.¹⁴

Compared to Model 1, Model 2 estimates that continuously deteriorating health has a slightly larger impact on mid-adulthood occupational attainment but that other health trajectories have nearly identical impacts. Model 3 shows that, although the impact of continuously deteriorating health is similar to that estimated in Model 1, the trajectory of

¹³Given differences in men’s and women’s labor market participation during this period, in Table A6 we examine heterogeneity in the impact of health trajectories by gender. Using the same analytic approach taken earlier, we identify gender-specific health trajectories and construct gender-specific propensity score weights. Although the test of coefficient equality suggests that the impact of continuously deteriorating health is not statistically distinguishable by gender, the results suggest that this health trajectory has a greater influence on men’s occupational skill qualifications ($\beta = -0.28$) than women’s ($\beta = -0.16$). This finding is not surprising, given men’s stronger attachment to the labor force during the study period. As the gap in labor force participation between men and women has narrowed for more recent cohorts, it is possible that the gender difference in the association between health trajectories and socioeconomic attainment would have become smaller.

¹⁴We note that Models 2 and 3 can only make individuals with or without poor health similar in terms of observed time-varying covariates during either childhood or adulthood, respectively. Because these models do not meet the rationale for propensity score weights to sequentially balance both groups of individuals on observed characteristics over the entire study period, the results reported here should be viewed as suggestive.

deteriorating then improving health has a larger and negative impact (though insignificant) and being unhealthy only during adolescence has a significant negative impact. Because the results in Model 2 approximate those in Model 1 more closely than those in Model 3, these findings provide suggestive evidence that time-varying socioeconomic factors during childhood play a more confounding role in linking health trajectories over the life course to occupational attainment—adjusting only for circumstances during childhood yields similar findings to models that adjust for both childhood and adulthood characteristics. These results are consistent with evidence on the substantial and durable adverse effects of childhood economic disadvantage and academic performance on socioeconomic status in adulthood (Duncan, Ziol-Guest and Kalil 2010; Hall and Farkas 2011; Jonsson 2010). In contrast, the health trajectory coefficients remain larger when adjusting only for adulthood characteristics as potential confounders, suggesting that time-varying socioeconomic circumstances during adulthood may play a more mediating role.

5.5. Additional Analyses

Lastly, we conduct two additional analyses to provide a point of comparison to our life course trajectory-based, propensity score weighting model. We first estimate a series of regression models using traditional measures of health status. Results are shown in Table 6. Each model using “snapshot” measures includes only one measure of health status—at birth, age 11, or age 33. Models using temporal measures include either timing indicators (poor health either during childhood or adulthood) or duration indicators (percent of time in poor health). For the timing measures, individuals are treated as experiencing poor health if they are in this category at least half of the period observed during childhood or adulthood. All models include controls for baseline covariates and with censoring weights.

The results from the models using a separate snapshot measure (Panel A) show that the impact of health varies in magnitude and significance by the timing of measurement. If health status were measured at either birth or age 33, one would conclude that it has a significant adverse impact on occupational skill qualifications. If health status were measured at age 11, however, one would report a statistical null finding. On the other hand, the model using the timing measures (Panel B) points to a greater influence of adulthood health than childhood health. Both single-point-in-time and timing measures, however, are problematic and incomplete because they do not appropriately capture cumulative exposure to poor health over the life course. With respect to the duration measures (Panel C), the longer the exposure to poor health, the stronger and more negative the association with NVQ level in middle age. Although consistent with our main findings, the traditional regression model of duration effects is limited in that it neither pinpoints the onset of poor health during childhood nor properly adjusts for time-varying confounders.

Next, we estimate separate health trajectories for childhood and adulthood, in order to address the possibility that the measures used during each life stage represent different underlying constructs. If low birthweight (birth), physician-diagnosed health problem (measured at all ages during childhood), and self-reported poor health (measured at all ages during adulthood) do not measure the same latent construct, our strategy may produce biased results. To address this concern, we re-estimate our models by constructing health

trajectories separately for childhood and adulthood and using corresponding propensity score weights.¹⁵ The results (not shown but available by request) indicate that deteriorating health during childhood (Model 1), and being unhealthy or having deteriorating health during adulthood (Model 2), are associated with lower NVQ levels at age 46. In Model 3, we find that the impact of deteriorating health during childhood becomes insignificant after accounting for adulthood health trajectories, suggesting a mediating role for adulthood health trajectories in explaining the impact of childhood health trajectories on mid-adulthood occupational attainment. These results are consistent with our main finding of a significant impact of continuously deteriorating health over the life course, as poor childhood health affects occupational attainment in midlife through its association with poor adulthood health.

6. DISCUSSION

An impressive body of research demonstrates that the unequal distribution of health both results from, and contributes to, socioeconomic disadvantage over the life course. We argue that our understanding of health and social stratification is improved by incorporating three theoretical insights from the life course perspective: (1) developmental processes—the timing, duration, and stability of circumstances during the life course—play an important role in generating inequality in adulthood; (2) the multiple temporal dimensions of health disadvantage—timing, duration, and stability—should be conceptualized and measured simultaneously; and (3) time-varying socioeconomic factors at different stages of the life course likely confound estimates of the direct impact of poor health and should be rigorously adjusted. Although the importance of these insights has been acknowledged on theoretical grounds, little research addresses them empirically. We use life course data to work toward a more complete measurement of “health selection” that incorporates these insights. Specifically, we identify distinct trajectories of exposure to poor health over the life course and link these trajectories to mid-adulthood outcomes while properly adjusting for time-varying socioeconomic confounders.

It is important to acknowledge the limitations of our data and approach before describing our key findings. First, perhaps because of the almost 50 year time span of the NCDS, an identical measure of health at all ages in childhood and adulthood is not available. Such a measure would not accurately reflect developmental variation in appropriate measures of health. We address this absence by using the same measures throughout all of childhood and all of adulthood, respectively; by coding the measures as closely as possible; and by examining the correlation of our health measures across all ages. All evidence suggests that the measures we employ at each age are useful, age-appropriate indicators of the underlying construct of health. While our measurement is surely imperfect, examining health across childhood, early adulthood and mid-adulthood permits us to assess the importance of cumulative exposure to poor health across the life course. Second, as with any statistical model applied to observational data, our approach does not rule out the possibility of omitted variables bias. The propensity score weighting models yield unbiased estimates only if health trajectories are independent of the outcome conditional on observed covariates. The

¹⁵We are grateful to an anonymous reviewer for suggesting this alternative analysis.

benefits of our method aside, our results should be interpreted as upper-bound estimates of the impact of poor health as they may be driven by unobserved time-constant and time-varying covariates. At the same time, however, the more socioeconomically advantaged status of our analytic sample may offset upward bias by yielding a healthier than average sample. Relatedly, the fact that sample attrition prevents us from observing anyone in “continuously poor” health suggests that we may be understating the effects of childhood health, since children in the most chronically poor health are more likely to stop participating in the survey by mid-adulthood. Third, although the health trajectory groups identified in the analysis best approximate our data, they still may fall short of capturing within-group heterogeneity (Bauer and Curran 2003; Nagin and Tremblay 2005). It is possible that even if individuals are identified to belong in the same health trajectory, their actual trajectory may exhibit variation. The trajectories we identify should be viewed as a stylized approximation that reflects the most common health trajectories individuals in our data are likely to experience over the life course.

Despite these limitations, our analysis reveals several important findings in its simultaneous consideration of multiple temporal dimensions of exposure to poor health. First, with respect to timing, we find that the impact of childhood health status on mid-adulthood outcomes is contingent on adulthood health status. Those who experience deteriorating health during childhood, but improvements in health during adulthood, fare no differently in their likelihood of high occupational attainment than those who remain continuously healthy throughout childhood and adulthood. In contrast, health trajectories have a stronger impact when we consider duration effects alongside timing. The shape of the continuously deteriorating health trajectory highlights that exposure to poor health has its origins in childhood and affects outcomes in mid-adulthood through a cumulative disadvantage process over the life cycle. Those who experience continuously deteriorating health throughout childhood and adulthood experience lower occupational attainment, on average, than their peers in more stably strong, or sporadically poor, health. It is worth noting that cumulative exposure to poor health would likely be even more strongly linked to occupational attainment in middle age if we were able to examine persistently poor health at all ages in childhood and adulthood. Because those who experience persistently poor health are the most likely to drop out of longitudinal surveys, examining this possibility remains an important task for future research.

It is important to situate our findings in the context of our data, an overwhelmingly white population who experienced a rigid educational structure in the 1950s and 1960s, as well as rapidly changing gender norms relative to more recent British cohorts. As younger and more diverse populations in the U.K. and the United States continue to be tracked as they age, it will be useful to compare the findings reported here to those among contemporary youth. For example, the much greater racial and ethnic diversity of today’s youth, combined with an increasing degree of socioeconomic inequality, could mean that the relationship between health and social processes is increasingly stratified across sociodemographic groups.

Finally, our results suggest that time-varying socioeconomic factors play an important role in linking health trajectories over the life course to midlife occupational attainment. Using a propensity score weighting approach to model the direct effects of health trajectories on

mid-adulthood outcomes indicates that improper adjustment for confounding by time-varying covariates, such as academic achievement during childhood and employment status during adulthood, leads to overstating the impact of health trajectories. This finding builds on the large body of research demonstrating the strong effects of socioeconomic disadvantage over the life course on health and social position, and recognizes that dimensions of socioeconomic status are simultaneously affecting health. In this vein, our findings have broader implications for life course models of health and social stratification. Much research regards the unequal distribution of socioeconomic resources and educational attainment as key mediators of the relationship between health and life outcomes. However, our findings call equal attention to the confounding role of such time-varying factors, as changes in the stability of health over the life cycle occur in part *because* of changing socioeconomic, familial, and educational circumstances. For example, lower attained education driven, in part, by poor childhood health may lead to poorer health among young adults. Estimating the impact of childhood health without considering these types of reciprocal relationships only partially reveals how health produces stratified outcomes in adulthood. The findings here suggest that the importance of time-varying socioeconomic factors play a particularly strong confounding role during childhood, when children experience changing family environments and take the academic learning assessments that have substantial implications for eventual educational attainment and for health in adulthood. It is important to emphasize that our approach does not preclude socioeconomic circumstances from also working as mediators in the relationship between health and socioeconomic status. Rather, by estimating the direct effect of health on SES, we work toward an estimate of how factors commonly assumed to be mediators may also be working as confounders. Moreover, examining health over the life course may provide a different estimate of confounding than would be observed by examining health during one isolated age period.

Modeling the temporal dimensions of health simultaneously with rigorous adjustment for time-varying confounding affords a more precise estimate of how health plays a role in generating inequality over the life course. By taking that approach here, we demonstrate that accounting for cumulative exposure to poor health throughout both childhood and adulthood, as well as the changing environmental circumstances that exist alongside health, is critical for understanding how health works to produce social stratification.

Appendix

Table A1

Sample Attrition Patterns

	Birth	7	11	16	23	33	42	46	<i>n</i>	%
<i>A. Not interviewed only once (N = 3,616)</i>										
1				X					1,120	30.97
2								X	821	22.70
3					X				462	12.78
4			X						433	11.97

	Birth	7	11	16	23	33	42	46	<i>n</i>	%
5						X			393	10.87
6		X							209	5.78
7							X		178	4.92
<i>B. Attritors (N = 5,422) (top 5 patterns)</i>										
1		X	X	X	X	X	X	X	1,423	26.24
2						X	X	X	833	15.36
3								X	821	15.14
4					X	X	X	X	657	12.12
5				X	X	X	X	X	599	11.05
<i>C. Rejoinders (N = 7,349) (top 5 patterns)</i>										
1				X					1,120	15.24
2					X				462	6.29
3			X						433	5.89
4						X			393	5.35
5				X		X	X	X	307	4.18

Table A2

Comparison among Different Samples

	Original sample	Study sample	Attritors	Rejoinders
Male	51.69	46.83*	54.77*	52.48
Mother's age at birth	27.46	27.63*	27.34	27.43
Maternal grandfather's social class				
Unskilled/semiskilled manual	14.15	12.73	15.13	14.34
Skilled manual	15.19	15.38	15.15	15.10
Skilled nonmanual	51.95	51.74	51.80	52.19
Intermediate	15.90	17.30	15.29	15.45
Professional	2.81	2.86	2.62	2.92
Mother's marital status at birth	95.73	97.50*	94.48*	95.54
Mother's smoking status		*		
Nonsmoker	66.35	69.56	65.56	64.91
Medium smoker	15.75	13.85	16.60	16.32
Heavy smoker	12.27	11.02	12.61	12.82
Variable smoker	5.63	5.57	5.23	5.95
Father's social class		*		
Unskilled	9.82	7.15	10.92	10.74
Semiskilled manual	12.12	12.02	11.97	12.30
Skilled manual	9.68	10.59	9.06	9.54
Skilled nonmanual	50.89	50.58	51.62	50.56
Intermediate	12.96	14.86	12.24	12.26
Professional	4.53	4.80	4.19	4.61
Region		*	*	

	Original sample	Study sample	Attritors	Rejoinders
England	83.35	82.71	82.37	84.49
Wales	5.25	6.33	4.68	4.98
Scotland	11.40	10.96	12.95	10.53
<i>N</i>	17,415	4,644	5,422	7,349

*
 $p < 0.05$ (two-tailed tests).

Table A3

Logit Models of Health Status

	Birth		Age7		Age11		Age16		Age23		Age33	
	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2
<i>Time-constant characteristics</i>												
Male	-0.40	-0.40	0.44	0.33	0.25	0.26	0.15	0.17	-0.39	-0.38	-0.07	0.06
Mother's age at birth	-0.01	-0.01	-0.01	0.00	0.00	0.01	0.01	<u>0.01</u>	0.01	0.01	0.01	-0.01
Maternal grandfather's social class												
Unskilled manual (ref.)												
Semiskilled	-0.05	-0.04	-0.08	-0.07	0.11	0.13	-0.09	-0.09	-0.12	-0.09	-0.33	-0.32
Skilled manual/nonmanual	0.00	0.01	-0.18	-0.11	-0.03	0.02	0.00	0.03	-0.13	-0.08	-0.13	-0.10
Intermediate	-0.12	-0.11	-0.02	0.10	0.01	0.07	-0.04	0.00	-0.27	-0.20	-0.28	-0.27
Professional	-0.49	-0.48	-0.29	-0.18	0.41	0.49	-0.43	-0.40	<u>0.70</u>	<u>0.71</u>	-0.18	-0.17
Age mother finished schooling	-0.03	-0.03	-0.07	-0.01	-0.05	-0.01	0.04	0.05	-0.01	0.00	-0.05	-0.06
Age father finished schooling	-0.02	-0.02	-0.03	0.04	-0.05	-0.03	0.02	0.03	-0.05	-0.03	0.01	0.02
Monthly family income	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mother's marital status at birth	-0.43	-0.42	-0.12	0.02	-0.16	-0.09	-0.13	-0.12	-0.01	-0.01	0.00	0.01
Father's social class at birth												
Unskilled manual (ref.)												
Semiskilled		-0.14	-0.14	-0.01	<u>-0.10</u>	-0.07	-0.06	-0.02	<u>-0.20</u>	-0.15	0.27	<u>0.38</u>
Skilled manual		-0.13	-0.23	0.02	<u>-0.31</u>	-0.21	-0.12	-0.03	<u>-0.29</u>	-0.21	0.11	<u>0.23</u>
Skilled nonmanual		0.01	-0.43	-0.02	-0.15	-0.02	-0.08	0.05	<u>-0.34</u>	-0.21	-0.21	<u>-0.05</u>
Intermediate		-0.16	-0.33	0.11	-0.02	0.10	-0.09	0.02	<u>-0.48</u>	-0.35	-0.14	-0.01
Professional		-0.09	-0.36	0.21	0.09	0.16	-0.30	-0.27	-0.07	0.06	-0.34	-0.20
Region at birth												
England (ref.)												
Wales		-0.03	<u>0.17</u>	0.22	-0.17	-0.37	0.08	0.03	<u>0.07</u>	0.05	0.24	0.21
Scotland		-0.08	<u>-0.29</u>	0.30	-0.08	-0.20	0.04	0.11	<u>-0.27</u>	-0.09	-0.01	0.05

	Birth		Age7		Age11		Age16		Age23		Age33		
	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1
Mother's smoking status													
Nonsmoker (ref.)													
Medium smoker	0.27	0.27	-0.03	-0.10	0.15	0.09	0.06	0.04	-0.04	-0.08	0.11	0.09	0.14
Heavy smoker	0.60	0.61	0.21	0.13	0.01	-0.05	-0.04	-0.06	0.19	0.14	0.17	0.13	0.25
Variable smoker	0.14	0.14	0.12	0.07	0.03	0.02	0.05	0.03	0.19	0.12	-0.11	-0.13	0.09
Breastfed as infant			-0.04	0.01	-0.21	-0.17	-0.09	-0.06	-0.10	-0.07	0.10	0.15	-0.27
Both parents present	-0.19	-0.09	-0.06	-0.01	-0.09	-0.06	-0.21	-0.18	-0.16	-0.13	-0.16	-0.12	-0.19
Child's post-school expectations													
Get a job (ref.)													
Continue full-time education					-0.27	0.05	-0.22	-0.11	-0.04	0.10	-0.14	-0.06	-0.09
Not sure					-0.29	-0.17	-0.21	-0.15	0.10	0.16	-0.03	0.01	-0.09
Average number of O-levels							-0.04	0.01	-0.11	-0.03	-0.10	-0.06	-0.07
<i>Time-varying characteristics</i>													
Previous health status			0.38	0.14	1.76	1.59	1.32	1.23	0.63	0.58	1.87	1.79	2.00
Father's social class													
Unskilled manual (ref.)													
Semiskilled				-0.03		0.13		0.00					
Skilled manual				-0.09		-0.03		0.00					
Skilled nonmanual				-0.14		0.11		-0.02					
Intermediate				-0.34		0.14		-0.10					
Professional				-0.42		0.40		0.09					
Mother's employment status				0.12		-0.02		-0.03					
Number of children				0.03		-0.06		0.00					
Number of moves				0.02		0.01		0.03					
Region													
England (ref.)													
Wales				-0.04		0.16		-0.01					
Scotland				-0.43		0.12		-0.04					
Parental school expectations													
Leave at minimum age (ref.)													
Stay past minimum age				-0.12		0.00		0.03					
Reading comprehension				-0.51		-0.43		-0.33					
Math				-0.21		-0.07		0.04					
Social class													
Unskilled manual (ref.)													

	Birth		Age7		Age11		Age16		Age23		Age33		M1
	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	M1	M2	
Semiskilled													−0.11
Skilled manual										−0.35			<u>−0.16</u>
Skilled nonmanual										<u>−0.36</u>			<u>−0.39</u>
Intermediate										<u>−0.75</u>			<u>−0.36</u>
Professional										−0.38			<u>−0.79</u>
NVQ level													
Level 1 (ref.)													
Level 2										<u>−0.39</u>			<u>−0.42</u>
Level 3										<u>−0.74</u>			<u>−0.22</u>
Level 4										<u>−0.71</u>			<u>−0.30</u>
Level 5										<u>−1.15</u>			<u>−0.16</u>
Employment status										<u>−0.36</u>			<u>−0.59</u>
Marital status										−0.18			−0.17

Note: M1 and M2 are used for computing the numerators and denominators of the stabilized IPT weights, respectively. Shaded cells indicate statistical significance at the .05 level.

Table A4

Model Selection for Trajectories of Health Status

Number of latent classes	BIC	Entropy	Lo-Mendell-Rubin
2	23330.79	0.64	0.00
3	23098.25	0.52	0.00
4	22787.79	0.63	0.00
5	22754.62	0.55	0.00

Table A5

Multinomial Logit Model of Trajectories of Health Status

	DI vs. CH	CD vs. CH	UA vs. CH
Male	0.21	−0.05	0.11
Mother's age at birth	0.01	0.01	0.00
Maternal grandfather's social class			
Unskilled manual (ref.)			
Semiskilled	−0.12	<u>−0.41</u>	0.16
Skilled manual/nonmanual	0.05	−0.23	0.16
Intermediate	0.11	−0.33	0.06
Professional	−0.32	0.19	−0.26
Age mother finished schooling	0.05	−0.03	0.03
Age father finished schooling	0.05	0.00	−0.02
Monthly family income	0.00	0.00	0.00

	DI vs. CH	CD vs. CH	UA vs. CH
Father's social class at birth			
Unskilled manual (ref.)			
Semiskilled	-0.12	0.05	0.14
Skilled manual	-0.34	-0.33	-0.01
Skilled nonmanual	0.01	-0.76	0.23
Intermediate	-0.47	-0.43	0.15
Professional	-0.96	-0.45	0.14
Region at birth			
England (ref.)			
Wales	-0.78	0.05	0.08
Scotland	-0.49	-0.20	0.13
Mother's marital status at birth	-0.36	-0.21	-0.21
Mother's smoking status			
Nonsmoker (ref.)			
Medium smoker	0.20	0.11	0.00
Heavy smoker	0.26	0.28	-0.21
Variable smoker	0.07	0.13	-0.28
Breastfed as infant	-0.51	-0.06	-0.06
Both parents present	0.11	-0.16	0.09
Child's post-school expectations			
Get a job (ref.)			
Continue full-time education	0.01	-0.18	-0.14
Not sure	0.02	-0.09	-0.14
Average number of O-levels	-0.13	-0.13	-0.01

Note: DI is deteriorating then improving, CD continuously deteriorating, UA unhealthy only during adolescence, and CH continuously healthy. Shaded cells indicate statistical significance at the .05 level.

Table A6

Ordered Logit Regressions of NVQ Level on Health Trajectories, by Gender

	NVQ level	
	Female	Male
Deteriorating then improving	0.07 (0.30)	0.14 (0.18)
Continuously deteriorating	-0.16 (0.14)	-0.28 [†] (0.16)
Unhealthy only during adolescence	-0.11 (0.18)	-0.28 (0.17)
Continuously healthy (reference)	—	—

Note: Robust standard errors in parentheses. All models are estimated with propensity score weights.

[†] $p < 0.10$;

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$ (two-tailed tests).

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Fig. 1.
Conventional Pathways Linking Health Status to Socioeconomic Attainment
Note: H = health status, X = time-varying covariates, O = outcomes, and U = unobserved factors.

Fig. 2.

Latent Class Growth Model

Note: H = health status, I = intercept, S = slope, Q = quadratic slope, and C = latent class.

Fig. 3.
Propensity Score Weighted Pathways Linking Health Status to Socioeconomic Attainment
Note: H = health status, X = time-varying covariates, O = outcomes, and U = unobserved factors.

Fig. 4.
Trajectories of Health Status over the Life Course

Table 1

Descriptive Statistics for Time-Constant Characteristics

Variable	
<i>Outcome</i>	
NVQ level, %	
Level 1	13.93
Level 2	31.02
Level 3	19.34
Level 4	32.10
Level 5	3.61
<i>Time-constant characteristics</i>	
Male	46.83
Mother's age at birth	27.63
Maternal grandfather's social class	Skilled manual/nonmanual
Age mother finished schooling	15–16 years old
Age father finished schooling	15–16 years old
Monthly Family income	184.41
Mother's marital status at birth	97.50
Mother's smoking status	
Nonsmoker	69.52
Medium smoker	13.89
Heavy smoker	11.03
Variable smoker	5.56
Breastfed as infant ^a	71.00
Both parents present ^a	86.78
Child's post-school expectations, % ^b	
Get a job	18.17
Continue full-time education	30.02
Not sure	51.81
Average number of O-levels ^c	2.12
<i>N</i>	4,644

^a is considered as a time-constant covariate after birth.

^b is considered as a time-constant covariate after age 7.

^c is considered as a time-constant covariate after age 11.

Table 2

Descriptive Statistics for Time-Varying Characteristics

Variable	Age 7		Age 16		Ages 42	
Poor Health, %	Yes	No	Yes	No	Yes	No
	[5.01]	[94.99]	[14.70]	[85.30]	[15.08]	[84.92]
<i>Childhood characteristics</i>						
Father's social class	SM	SM	SM	SNM		
Mother's employment status, %	48.24	42.11	67.83	69.10		
Number of children	1.81	1.71	1.71	1.68		
Number of moves	1.07	1.06	1.56	1.59		
Region, %						
England	86.50	82.92	82.45	84.22		
Wales	6.71	6.33	6.71	5.73		
Scotland	6.79	10.75	10.84	10.05		
Parental school expectations, %						
Leave at minimum age	16.07	14.83	56.06	51.58		
Stay past minimum age	83.93	85.17	43.94	48.42		
Reading comprehension	-0.28	0.21	0.05	0.25		
Math	-0.27	0.14	0.12	0.23		
<i>Adulthood characteristics</i>						
Social class					SNM	SNM
NVQ level					2.50	2.85
Employment status, %					72.84	90.70
Marital status, %					69.85	74.44
N			4,644			

Note: Percent distributions of health limitation at each age are in brackets. SM is skilled manual and SNM skilled nonmanual.

Table 3

Weight Construction

A. Descriptive statistics for weights													
Weight	Mean	S.D.	Percentile				Age 7	Age 11	Age 16	Age 23	Age 33	Age 42	
			1st	25th	Median	75th							99th
Stabilized IPT weight (<i>sw</i>)	1.00	0.33	0.31	0.87	0.96	1.09	2.38						
Stabilized censoring weight (<i>cw</i>)	0.99	0.15	0.78	0.90	0.96	1.04	1.56						
Final stabilized weight (<i>sw</i> × <i>cw</i>)	0.99	0.36	0.32	0.79	0.93	1.12	2.31						

B. Balance check for time-varying covariates

	Birth	Age 7	Age 11	Age 16	Age 23	Age 33	Age 42							
<i>F</i>	0.28	0.06	16.19	0.60	8.48	0.46	5.03	0.05	5.84	0.12	7.15	0.06	14.99	0.14
<i>df</i>	7	7	14	14	14	14	14	14	11	11	11	11	11	11
<i>P</i> -value	0.96	1.00	0.00	0.87	0.00	0.94	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00
Stabilized IPT weight	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Table 4

Ordered Logit Regression of NVQ Level on Health Trajectories

	Model 1 Unadjusted	Model 2 Regression- adjusted	Model 3 Propensity score weighted
(1) Deteriorating then improving	−0.27 (0.18)	−0.22 (0.18)	0.09 (0.19)
(2) Continuously deteriorating	−0.63*** (0.11)	−0.45*** (0.11)	−0.22* (0.11)
(3) Unhealthy only during adolescence	−0.17 (0.11)	−0.21 [†] (0.11)	−0.19 (0.12)
(4) Continuously healthy (reference)	–	–	–
Test of equality in Model 3			
(1) vs. (2)	$p = 0.082$	$p = 0.273$	$p = 0.160$
(1) vs. (3)	$p = 0.624$	$p = 0.928$	$p = 0.199$
(2) vs. (3)	$p = 0.003$	$p = 0.096$	$p = 0.837$

Note: Robust standard errors in parentheses. All models are estimated with censoring weights.

[†]
 $p < 0.10$

*
 $p < 0.05$

**
 $p < 0.01$

 $p < 0.001$ (two-tailed tests).

Table 5

Ordered Logit Regressions of NVQ Level, by Alternative Propensity Score Weights

	Model 1 Both childhood and adulthood TVCs	Model 2 Childhood TVCs only	Model 3 Adulthood TVCs only
Deteriorating then improving	0.09 (0.19)	0.10 (0.20)	−0.22 (0.19)
Continuously deteriorating	−0.22* (0.11)	−0.25* (0.12)	−0.26* (0.11)
Unhealthy only during adolescence	−0.19 (0.12)	−0.16 (0.11)	−0.24* (0.11)
Continuously healthy (reference)	—	—	—

Note: Robust standard errors in parentheses. TVCs are time-varying covariates.

[†]
 $p < 0.10$

*
 $p < 0.05$

**
 $p < 0.01$

 $p < 0.001$ (two-tailed tests).

Table 6

Ordered Logit Regressions of NVQ Level on Conventional Health Measures

	NVQ level
<i>A. Snapshot measures of poor health</i>	
Birth	−0.34* (0.16)
Age 11	−0.05 (0.14)
Age 33	−0.37*** (0.10)
<i>B. Timing of poor health</i>	
Childhood	−0.32† (0.16)
Adulthood	−0.50*** (0.12)
<i>C. Duration of poor health</i>	
Never (reference)	—
1–25 percent of time	−0.23* (0.09)
26–50 percent of time	−0.45*** (0.10)
51–100 percent of time	−1.11*** (0.30)

Note: Robust standard errors in parentheses. All models control for baseline covariates (not shown) and are estimated with censoring weights. For timing, individuals are treated as experiencing poor health if they are in this category at least half the time either during childhood or adulthood.

†
 $p < 0.1$

*
 $p < 0.05$

**
 $p < 0.01$

 $p < 0.001$ (two-tailed tests).