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The Simultaneous Effects of Socioeconomic Disadvantage and Child Health on Children's Cognitive Development

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Abstract

Family socioeconomic status (SES) and child health are so strongly related that scholars have speculated child health to be an important pathway through which a "cycle of poverty" is reproduced across generations. Despite increasing recognition that SES and health work reciprocally and dynamically over the life course to produce inequality, however, existing research has yet to address how these two pathways simultaneously shape children's development. Using longitudinal data from the Fragile Families and Child Wellbeing Study and marginal structural models, we ask three questions: 1) how does the reciprocal relationship between socioeconomic disadvantage and child health affect estimates of each circumstance on children's cognitive development?; 2) how do their respective effects vary with age?; and 3) do family SES and child health have differential effects on cognitive development across population subgroups? The results show that the negative effects of socioeconomic disadvantage and poor health are insensitive to their reciprocal relationships over time. We find divergent effects of socioeconomic disadvantage and poor health on children's cognitive trajectories, with a widening pattern for family SES effects and a leveling-off pattern for child health effects. Finally, the effects of socioeconomic disadvantage are similar across all racial/ethnic groups, while the effects of child health are largely driven by white children. We discuss theoretical and policy implications of these findings for future research.

Keywords

Socioeconomic disadvantage; Child health; Reciprocity; Cognitive Development

INTRODUCTION

Childhood is a key period of development when the skills that track into adulthood are most sensitive to social and biological environments (Ferraro, Shippee, and Schafer 2009). Robust literatures document that children's cognitive development, a marker of child well-being that is strongly correlated with social and economic processes within and across generations, is strongly affected by family socioeconomic status (SES) and health (Duncan et al. 1998;

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Palloni 2006). At the same time, there is a growing understanding that SES and health have a reciprocal relationship, whereby these circumstances work simultaneously and dynamically to produce inequality over the life course. The socioeconomic "gradient" in health is a nearly universal feature of industrialized societies, as SES—most commonly measured by education and income—consistently predicts health behavior, physical and mental health, and mortality in a process of "social causation" (Adler et al. 1994; Currie 2009; Link and Phelan 1995; Masters, Hummer, and Powers 2012). And a burgeoning body of research links children's "noncognitive" or "soft" characteristics, including health, temperament, and behavior, to stratification processes over the life course, including family structure, children's academic achievement, and eventual labor market outcomes (Bowles and Gintis 1976; Diprete and Jennings 2011; Hall and Farkas 2011; Jackson 2010; Palloni 2006; Reichman, Corman, and Noonan 2004).

Existing evidence suggests that hypotheses about the effects of family socioeconomic background on children's development, and about the process of "health selection" into skill development (and eventual social and economic roles), are not mutually exclusive. In fact, family SES and child health are so strongly related that scholars have speculated child health to be an important pathway through which a "cycle of poverty" is reproduced across generations, via the effects of health on family processes, human capital acquisition, and eventual socioeconomic resources (Aizer and Currie 2014; Case, Fertig, and Paxson 2005; Currie 2009; Haas 2006; Palloni 2006; Palloni et al. 2009). However, despite implicit recognition of the bidirectional relationship between SES and health, "social causation" and "health selection" are often empirically treated as competing processes in estimating their respective effects, in part because of the difficulty of accounting for reciprocal relationships (e.g., Conley and Bennett 2000; Link and Phelan 1995; McLeod and Shanahan 1993). Existing approaches may therefore either over- or under-estimate the effects of socioeconomic (dis)advantage and/or child health on the outcomes of interest, especially when both factors vary with age. Using longitudinal data and focusing on a multidimensional measure of health that includes both physical conditions and behavior, we acknowledge—both conceptually and empirically—that social causation and health selection are complementary, rather than competing, processes that shape inequality over the life course.

Furthermore, research to date pays little attention to heterogeneity in the effects of socioeconomic disadvantage and health. Existing tests of the "social causation vs. health selection" debate often identify average effects from samples that, despite their richness, lack substantial variation over the life course and/or ethnoracial diversity (e.g., Haas 2006; Jackson 2010; Palloni 2006; Warren 2009). The lack of research on heterogeneous effects may result in inconsistent findings, limiting the breadth of our understanding about the production of inequality in children's development. Given that the prevalence, severity, and experience of socioeconomic disadvantage and health limitations vary by age and across racial/ethnic groups, it is crucial to investigate the extent to which these circumstances have differential effects (Kroger, Pakpahan, and Hoffmann 2015; Lichter, Parisi, and Taquino 2012; Williams et al. 2010).

In this paper, we use longitudinal data from the Fragile Families and Child Wellbeing Study (FFCWS) to address three separate, but related, questions. First, how does the reciprocal relationship between family socioeconomic disadvantage and child health affect estimates of each circumstance on children's cognitive development? Second, how do the respective effects of socioeconomic disadvantage and poor health vary with age? Drawing from life course theory, we consider whether the time-varying effects of each circumstance are stable, increasing, or decreasing after thoroughly adjusting for the effects of children's other characteristics. Third, do family SES and child health have differential effects across racial/ethnic subgroups? By considering the ways in which SES and health simultaneously work to shape children's cognitive development, the results will help to advance our understanding of the strong intergenerational relationships among childhood socioeconomic position, children's health, and academic development.

SOCIOECONOMIC DISADVANTAGE, CHILD HEALTH, AND COGNITIVE DEVELOPMENT

Socioeconomic inequalities in children's learning are present well before children enter school, a troubling fact given strong correlations among achievement, completed schooling, and economic status, and the powerful degree to which early-life development and achievement track over the life course and are rewarded in the labor market (Duncan et al. 1998; Duncan, Ziol-Guest, and Kalil 2010; Farkas 2003; Wagmiller et al. 2006). Simultaneously, children's health and behavior problems strongly predict skill development and academic achievement, as well as socioeconomic status later in life (Bowles and Gintis 1976; Conley and Bennett 2000; Diprete and Jennings 2011; Palloni 2006). SES and health thus both result from and contribute to each other at all stages of the life course (Adler et al. 1994; Conley and Bennett 2000; Finch 2003; Jackson 2010; Wagmiller et al. 2006). While it is clear that both socioeconomic and health conditions shape children's developmental trajectories and have lasting, cumulative impacts over the life course (Elder 1998; Heckman 2007; Shonkoff and Phillips 2000), it is less clear how the reciprocal relationship between SES and health governs their respective effects on children's cognitive development.

A large literature documents the effects of socioeconomic (dis)advantage on health, with social conditions acting as a "fundamental cause" of wellbeing in that they determine access to the resources, institutions, and networks necessary for healthy development and a productive life (Link and Phelan 1995; Masters et al. 2012; Miech et al. 2011). While much research on socioeconomic gradients in health and on the hypothesis of "social causation" has focused on adults, growing evidence also reveals strong gradients among children. Children in highly educated and higher-income families have better health than those with fewer resources to draw from (Case, Lubotsky, and Paxson 2002; Finch 2003). Recent research suggests that child health may be an important pathway through which family SES affects children's development, and more generally produces a "cycle of poverty" through its effects on family processes and resources, human capital acquisition, and eventual socioeconomic resources (Aizer and Currie 2014; Case et al. 2005; Haas 2006; Palloni 2006; Palloni et al. 2009).

At the same time, there is ample evidence that health, broadly defined to include illness, temperament, and behavior, has strong direct and indirect effects on opportunities for socioeconomic attainment and mobility. This hypothesis has raised the possibility of “health selection,” whereby the causal ordering leads from health to socioeconomic status through both biological and social pathways (Bartley and Plewis 1997; Boardman et al. 2002; Cheadle and Goosby 2010; Conley and Bennett 2000; Currie 2009; Miech et al. 1999). While most research on health selection considers the effects of health on individual-level socioeconomic processes, there is also strong evidence that children’s health affects family circumstances both directly (via monetary costs and effects on parental employment) and implicitly (via effects on parental relationship quality and caregiving time and stress). Poor child health is associated with parental relationship instability, poor parental health, and a lower probability of both maternal and paternal labor force participation (Garbarski 2014; Noonan, Reichman and Corman 2005; Powers 2001; Powers 2003; Reichman et al. 2004). Parents of children with poor health, defined by behavioral problems, low birthweight, or general health problems, spend less time in paid work settings in order to manage caregiving responsibilities (Powers 2001). Some research suggests that children’s mental health problems (defined by internalizing and externalizing behaviors) and general physical health have direct family monetary costs on the order of several thousand dollars per year, as well as induce even larger annual monetary costs via declines in hours worked, labor force participation, future earnings, and family health and well-being (e.g., Busch and Barry 2007; Stabile and Allin 2012).

Child health also induces socioeconomic differences in parents’ time use with children, with highly educated parents spending more time on compensatory activities than their lower-educated peers (e.g., Hsin 2012). Moreover, the financial and time-related burdens associated with caring for a child with impaired health—whether measured by severe illness, general health limitations, or behavior problems—are a source of stress in the family that can affect the quality of parents’ relationships, and parents’ caregiving stress, in part due to the strain on economic resources (Donenberg and Baker 1993; Hogan et al. 2012; Reichman et al. 2004; Vaughn et al. 2013). These findings, which are robust to techniques that account for endogeneity from simultaneity and omitted variables bias, suggest not only that child health affects family economic resources and behaviors, but also that both individual and family-level processes may explain the effects of child health on individual-level SES later in the life course.

Compelling evidence to date, from largely separate bodies of research, documents strong associations between family SES and child health and strong effects of both family SES and child health on cognitive development, suggesting that child health may partially explain the intergenerational transmission of SES. These findings motivate consideration of how the reciprocal relationship between family SES and child health influences the independent effects of each circumstance on children’s development. Our approach rigorously and comprehensively tests several plausible possibilities: that child health is a pathway leading from family SES to child development, that the effects of family SES and/or child health are driven by the other factor and/or are spurious, or that each circumstance has strong direct effects on child development that are not explained by other factors. Understanding these relationships during childhood offers important insights into the production of socioeconomic inequality in well-being over the life cycle, given increasing recognition that the reproduction of intergenerational inequality begins at a very young age (Jonsson 2010).

Moving beyond a Unidirectional Examination of the Relationship between Socioeconomic Disadvantage and Health

Despite the conceptual acknowledgement of the bidirectional relationships between SES and health, studies to date almost always consist of unidirectional examination of the effects of socioeconomic or health conditions, but not both (e.g., Jackson 2010; Lynch 2006). Relying on an *a priori* definition of the direction of causality contradicts the recognition that social causation and health selection processes co-evolve across life stages. That is, unidirectional approaches make it difficult to gauge effects of one circumstance in the presence of simultaneously operating effects of the other. Recent studies have adopted a dynamic perspective to examine the time-varying interplay between the two circumstances, estimating models (e.g., cross-lag models) in which SES (health) at one life stage influence health (SES) at the next life stage (Chandola et al. 2003; Hass 2006; Mulatu and Schooler 2002; Warren 2009). This approach is informative but not fully adequate for addressing how the reciprocal relationship between socioeconomic disadvantage and health shapes children's cognitive development. As we describe below, key shortcomings of existing approaches are that they treat each circumstance as the sole time-varying factors, thereby overlooking the role of other time-varying covariates; and that they do not facilitate estimating the total effects of socioeconomic disadvantage and health on child outcomes when both are reciprocally related to each other.

Figure 1 illustrates the complications that arise in examining the effects of socioeconomic disadvantage and child health on cognitive development. Figure 1A formally presents the idea that (1) time-varying exposure to socioeconomic disadvantage (D) and time-varying child health (H) function both as a confounder and as a mediator of one another in affecting children's cognitive achievement (O) and that (2) time-varying exposures to socioeconomic disadvantage and poor health thus have both direct and indirect effects. For ease of exposition, we focus on socioeconomic disadvantage as a time-varying treatment and consider child health—and other time-varying factors—as time-varying covariates, but the same principles apply when changing the treatment-covariate relationship. As in other observational studies, this example assumes that conditional on observed factors, unobserved factors do not bias the effects of time-varying treatments on the outcome. Obviously, conditional independence is a strong assumption. For example, the association between socioeconomic disadvantage and health may be spurious, to the extent that both are jointly determined by some lurking factors (the "indirect selection" hypothesis). SES variation in health may reflect under- or over-reporting among some groups (Kadushin 1964), or the effects of childhood health on SES may simply reflect the tendency of unhealthy children to become unhealthy adults. It is worth noting, however, that the weight of evidence suggests that such unobserved heterogeneity reduces, but does not eliminate, the independent effects of SES or health (e.g., Thomas and Frankenberg 2002).

The reciprocal relationship between socioeconomic disadvantage and child health over time may create additional sources of bias in estimating their effects even under the assumption of no unobserved heterogeneity. Two approaches can be employed to estimate the effects of time-varying exposure to socioeconomic disadvantage. One approach (Figure 1B) is to treat socioeconomic disadvantage as a sole time-varying determinant of the child outcome while ignoring time-varying health status. Consider, for example, a model that estimates the effect of socioeconomic disadvantage at time 2 (D_2) on the outcome at time 2 (O_2) while excluding health status at time 1 (H_1). Figure 1B shows that excluding H_1 can produce an omitted variable bias because H_1 operates as a confounder of the association between D_2 and O_2. This approach may overestimate the effects of time-varying exposure to socioeconomic disadvantage.

To address this concern, an alternative approach (Figure 1C) is to include H_1 in the model. However, conditioning on H_1 induces over-controlling in estimating the total effect of socioeconomic disadvantage on the outcome. In addition to the usual pathway ($D_0 \rightarrow D_1 \rightarrow D_2 \rightarrow O_2$), part of the effect of socioeconomic disadvantage is attributed to the effect of child health, as adjusting for H_1 as a mediator of D_0 controls away the effect of D_0 on O_2 ($D_0 \rightarrow H_1 \rightarrow O_2$). This over-controlling problem may result in an underestimation of the effects of time-varying exposure to socioeconomic disadvantage.[1]

In sum, both approaches insufficiently handle the bidirectional, time-varying relationship between SES and child health. Existing panel models can either include time-varying child health—and other time-varying covariates—to account for their confounding with time-varying exposure to socioeconomic disadvantage, or exclude them to avoid over-controlling, but cannot do both simultaneously. In this vein, making assertions about the effects of socioeconomic and child health conditions is difficult unless their bidirectional, time-varying confounding is properly accounted for.

HETEROGENEITY IN SOCIOECONOMIC DISADVANTAGE AND CHILD HEALTH EFFECTS

Age-Specific Patterns

Averaging the respective effects of SES and health across childhood can establish useful estimates and, indeed, studies often implicitly assume that the effects of children's environments do not vary with age. This approach has produced evidence that achievement gaps observed early in life remain stable in size over time (Magnuson, Waldfogel, and Washbrook 2012). However, this approach may not detect meaningful non-linear patterns as children age, masking heterogeneity in the time-varying effects of socioeconomic standing and child health.

Cumulative inequality theory offers strong evidence in support of a second possibility: that the effects of SES and poor health on achievement may become more negative as children

[1]Researchers also identify collider stratification bias that can arise in this approach (Morgan and Winship 2007; Pearl 2009). Suppose that unobserved factors influence time-varying child health and the outcome but not the treatment, i.e., time-varying exposure to socioeconomic disadvantage. Conditioning on child health generates an unnecessary correlation between its common causes, i.e., socioeconomic disadvantage and unobserved factors, even under the assumption of no unobserved heterogeneity of the treatment effect. Because unobserved factors also affect the outcome, conditioning on child health makes it impossible to distinguish the effects of socioeconomic disadvantage from those of unobserved factors.

age because of developmental processes (Ferraro and Shippee 2009; Ferraro et al. 2009). Because the early life cycle, particularly the prenatal period through age three, is a highly sensitive period of brain development, baseline inequalities in achievement may compound as children enter and progress through the school years. There is also evidence that longer-term exposure to socioeconomic disadvantage during childhood has strong negative effects on achievement and attainment (Duncan et al. 2010; Lee 2014), and that poor health during infancy has early and increasing effects on children's academic achievement, especially when it influences later health conditions (Jackson 2015). The weight of evidence suggests that the impacts of socioeconomic and health disadvantages are likely stronger and more durable as children age, not only because they hamper children's development during critical and sensitive periods of development, but because they are more likely to accumulate into chronic disadvantages that successively limit opportunities for human capital development, and social and economic advancement (Jackson 2015; McLeod and Shanahan 1996; Torche 2011; Wagmiller et al. 2006).

Finally, it is possible that children's achievement is particularly affected by their socioeconomic and health conditions at critical turning points, such as the age of entry into formal schooling, when children must adjust to a transition in their roles and responsibilities. A life course perspective suggests that the effects of children's environments are "socially timed," whereby there is age variation in the norms and consequences associated with particular roles (Elder 1994). Children's entry into schooling may result in a deflection in their achievement beyond the predicted effect of their circumstances before that point, due to both the effects of their new environments and children's adjustment to the requirements of their more complex roles (Kerckhoff, Haney, and Glennie 2001). On the one hand, because the transition to school represents an expansion of children's roles beyond the family, achievement gaps may be most pronounced around this age. On the other hand, after this transition, age-specific socioeconomic or health disadvantage may have short-term disruptive effects from which children can rebound. A leveling-off pattern can arise to the extent that schooling functions as a countervailing mechanism that alters the early effects of socioeconomic disadvantage and poor health (Ferraro and Kelly-Moore 2003; Jackson 2010).

A robust literature documents the effects of timing and cumulative exposures to socioeconomic disadvantage and poor health on outcomes at one point in time (e.g., Duncan et al. 2010; Jackson 2010; Lee 2014). Empirical investigations that measure effects at multiple childhood ages are scarce, however, making it difficult to formulate specific hypotheses about the relative importance of duration and timing effects when both the treatments and outcomes vary with age. Attending to age stratification processes, we explicitly examine whether the effects of SES and poor health on cognitive development are stable, cumulative, or leveling-off during early and middle childhood.

Racial/Ethnic Heterogeneity

Finally, ethnoracial differences are an important dimension of heterogeneity in the effects of socioeconomic and health disadvantage. Children who experience both racial/ethnic minority status and socioeconomic hardship face a "double jeopardy" of multiple marginalized statuses (Ferraro and Farmer 1996). Ethnoracial minority children are disproportionately likely to experience both short and long-term poverty, to experience acute and chronic health problems, to live in disadvantaged neighborhoods, and to attend under-resourced schools (Currie 2005; Iceland 2013; Lichter et al. 2012). The stress associated with financial hardship, poor health, discrimination, and crime makes it more difficult for children to thrive developmentally from an early age, and may be particularly detrimental for children who experience several stressors simultaneously (Duncan et al. 1998). In this case, the effects of socioeconomic disadvantage or poor health on cognitive development may be more pronounced among racial/ethnic minority children. The status advantages associated with being white may diminish the potentially negative consequences of family economic hardship and child health, such that these effects are stronger and more negative among black and Hispanic children.

Alternatively, ethnoracial minority children may be more resilient in the face of multiple forms of disadvantage, despite a higher prevalence and severity of disadvantage. Given the higher likelihood of concentrated poverty and poor health among black and Hispanic children, stronger support systems (e.g., extended kinship networks) may provide a beneficial coping resource (McLoyd et al. 2000). As a result, children may be more resilient during and after a negative economic or health event, whereas groups among which these events are less common may be more vulnerable to the negative effects of a hardship. Although a greater number of hardships may cumulatively result in a lower level of cognitive achievement, the marginal contribution of each disadvantage among those children may be small. Previous studies, for example, demonstrate a weaker negative association between family disruption and children's educational achievement among African-American children than among whites in the U.S. (Amato and Kieth 1991; Smith 1997), and a stronger negative effect of poor health on non-Hispanic white adolescents' educational attainment (Jackson 2009). We test these two hypotheses—greater effects of socioeconomic and health disadvantage for racial/ethnic minority or for white children—by considering reciprocal relationships between the two circumstances and their age-varying effects.

DATA AND METHODS

Data

The Fragile Families and Child Wellbeing Study (FFCWS) is a longitudinal birth cohort study of 4,898 children born between 1998 and 2000 in 20 U.S. cities with populations greater than 200,000 (Reichman et al. 2001). Given its research design requiring an oversample of births to unmarried parents, the FFCWS consists of 1,186 children born to married parents and 3,712 children born to unmarried parents. Baseline interviews were conducted shortly after the birth, with mothers interviewed in the hospital and fathers interviewed either in the hospital or by phone as soon as they could be located. Follow-up surveys were conducted when the focal child was 1, 3, 5, and 9 years of age. We obtain information on maternal, paternal, and child characteristics at the focal child's birth from the baseline survey, and on subsequent family and child characteristics from the follow-up surveys. Response rates for the baseline survey were 82% for married mothers, 87% for unmarried mothers, 89% for married fathers, and 75% for unmarried fathers. Response rates for the Years 1, 3, 5, and 9 surveys were 91%, 88%, 87%, and 76%, respectively, for mothers who completed the baseline interview.

The FFCWS is well-suited for the objective of this study, given growing public and policy concerns about increasing rates of socioeconomic and health disadvantage in childhood, and their implications for development. These concerns are particularly directed at socioeconomically disadvantaged populations, among whom the FFCWS affords close examination. The FFCWS is also among only a few national longitudinal household surveys in the U.S. that permit prospective observations of children, and is the only birth cohort study that permits continuous observation from birth into the school years.[2] The data contain repeated measures of family socioeconomic conditions, child health, and child cognitive achievement during early to middle childhood, alongside a rich array of time-constant and time-varying covariates.

Our study sample consists of 2,952 mother-child pairs. We exclude 1,791 observations that are lost to follow-up and 155 observations in which mothers live less than half time with their focal child.[3] Analysis of these observations (results available upon request) suggests that the study sample is slightly socioeconomically advantaged compared to the baseline sample: mothers in the study sample are more likely to be white, native-born, more educated, non-poor, employed, and have a higher level of cognitive ability than those in the baseline sample. However, these differences are minor: the difference in the proportion of families in poverty at birth between the baseline and study samples is 1.36 percentage points (35.24 percent vs. 33.88 percent). Our study sample is therefore still based on a socioeconomically disadvantaged population, while partly missing children who are more advantaged and/or healthier. As these children are more likely to be in the control groups, this pattern of missingness could bias the results downward. For missing observations on study variables due to item-nonresponse, we create 20 multiply imputed (MI) data sets using chained equations (Royston 2004). As the study variables are related not only to our study objectives but also to the likelihood of having a missing value, we account for all variables in our MI procedure (Allison 2002). Following von Hippel (2007) and Young and Johnson (2015), we then exclude any missing observations on the outcome variable in the analysis. For our panel analysis, we convert our study sample to person-year data, which yields 6,525 person-years.[4]

Measures

Outcome Variable—Children's cognitive achievement is measured by the Peabody Picture Vocabulary Test-Revise (PPVT-R), assessed at ages 3, 5, and 9. The PPVT-R is designed to evaluate children's verbal skills, lexical knowledge, and receptive language skills. The analysis standardizes the test scores to have a mean of 0 and a standard deviation

[2]For example, the Early Childhood Longitudinal Study-Birth Cohort tracks children from birth only through kindergarten entry. The National Longitudinal Survey of Youth 1979 (NLSY79)-Children and Young Adults collects information on children born only to NLSY79 mothers.

[3]Given our analytic strategy described below, we exclude mother-child pairs that were lost to follow-up from the analysis. They consist of those who permanently dropped out of the survey and those who left the survey but rejoined later. To address this issue of whole-wave missingness, we incorporate censoring weights in our marginal structural models.

[4]The analysis examines only children whose cognitive achievement test is conducted in English because of its incompatibility with that in Spanish (Dunn and Dunn 1997). For this reason, the respondents contribute 2.3 person-years, on average, to our panel data.

of 1, such that the effects of socioeconomic disadvantage and child health are expressed in standard deviation units. A higher score represents a better outcome.

Socioeconomic Disadvantage and Child Health—We measure these two factors as two time-varying treatment variables that predict children's trajectories of cognitive achievement. First, family socioeconomic disadvantage in each wave is determined using a ratio of annual family income to estimated income needs, set by the U.S. Census Bureau. Both family income and needs are adjusted for family size and updated for inflation using the Consumer Price Index. The income-to-needs ratio serves as a reliable proxy for family socioeconomic standing because it also relates to parental occupation and employment status. In the analysis, we use a quartile measure of the income-to-needs ratio to be comparable to our measurement of child health.

Second, child health is measured by mother-rated global health status and mental health. At ages 1, 3, 5, and 9, mothers were asked to report whether their child's general health is "poor," "fair," "good," "very good," or "excellent." Because relatively few children were in poor or fair health across waves, we collapse these categories such that the resulting measure of child health has four categories (from "poor/fair" to "excellent"). General health status is highly correlated with physician-assessed health status and health behaviors, and is a strong predictor of morbidity and mortality (Idler and Kasl 1995). In addition, at ages 3, 5, and 9, mothers responded to a series of 3-point Likert scale items on their child's externalizing and internalizing behavior problems ("not true (0)," "sometimes or somewhat true (1)," or "often or very true (2)"). Derived from the Child Behavior Checklist (Achenbach and Rescorla 2000), these items have been extensively used to measure children's mental health, and are strongly related to family processes (Currie 2009; McLeod and Fettes 2007).[5] Externalizing problem behavior is measured by the sum of the aggressive and rule-breaking behavior subscales ($\alpha \approx .88$ across waves), while internalizing problem behavior is measured by the sum of the anxious/depressive and withdrawn behavior subscales ($\alpha \approx .82$ across waves). To be consistent with our measure of child general health status, we compute a summed score of these two sets of problem behaviors and categorize children's total problem behaviors into quartiles. Then we sum these two four-category scale measures—one for general health status and the other for mental health—and construct a final quartile score of child health.

We code the measures of socioeconomic disadvantage and child health such that higher values indicate being disadvantaged and in poor health, respectively.[6] These measures allow us to examine the effects of both circumstances more comprehensively and estimate them more efficiently. Nonetheless, uncertainty in measurement may make the results less reliable. To check the robustness of our operationalization, we re-estimate our models using alternative measures. We examine binary measures of socioeconomic disadvantage (1 if below the official poverty threshold; 0 if otherwise) and child health. For the binary measures of child health, children are coded as being in poor health if they are either "poor/

[5]For the Year 1 measure of child mental health, we use the Emotionality, Activity, and Sociability Temperament Survey for children as the CBCL scales are available from Year 3 on (Mathieson and Tambs 1999).

[6]We specify our models such that the quartile measures of socioeconomic disadvantage and child health are linearly linked to children's cognitive development. In a supplementary analysis (results available upon request), we test if the associations should be specified to be nonlinear by introducing quadratic terms in the models, and reject the nonlinear specification.

fair" on general health, or above the borderline clinical cut point of 60 (conservative) or the 90th percentile cut point (liberal) on total problem behaviors. We also examine binary and ordinal measures of child health focusing only on mother-reported general health. We discuss results based on these alternative measures in the Results section.

Covariates—Our analysis includes an extensive set of covariates that are correlated with family SES, child health, and cognitive achievement, and that have been often "unobservable" in previous research. Time-constant covariates include maternal, paternal, and child characteristics, measured at baseline. For maternal characteristics, we measure age, race/ethnicity (black, Hispanic, white, or other), immigration status (1 if immigrant; 0 if otherwise), educational attainment (less than high school, high school (or GED), some college, or college degree or more), age at first birth, cognitive ability (a subtest score of Wechsler's (1981) Adult Intelligence Scale-Revised), impulsivity (an abbreviated form of Dickman's (1990) dysfunctional impulsivity scale), and whether she lived with both parents at age 15 (1 if yes; 0 if no). For biological fathers' characteristics, we measure age, mixed-race couple, immigration status, educational attainment, employment status (not employed, working part-time, or working full-time), and incarceration status (1 if ever incarcerated; 0 if otherwise). Child characteristics consists of gender (1 if male; 0 if female), first-born status (1 if yes; 0 if no), and low birth weight status (1 if below 2,500 grams; 0 if otherwise).

In addition, we construct an array of time-varying characteristics that covary with time-varying exposures to socioeconomic disadvantage and poor health. These mother-reported time-varying covariates include family structure (married to biological father, married to social father, cohabiting with biological father, cohabiting with social father, or single),[7] employment status, living with parent (i.e., child's grandparent) (1 if yes; 0 if no), number of children, depression status (1 if yes; 0 if no), alcohol/drug problems (1 if any; 0 if otherwise), and general health status (poor/fair, good, very good, or excellent). Depression status is based on the Composite International Diagnostic Interview-Short Form (Kesseler et al. 1998). We treat time-varying covariates measured at birth as baseline covariates. We also measure children's age (in months) as a time-varying covariate to account for variation in the time of assessment of child cognitive achievement at each age. Table 1 reports descriptive statistics of all study variables.

Analysis Plan

We first estimate a series of random-effects models (REM) to examine the effects of exposures to socioeconomic disadvantage and poor health on children's cognitive achievement. These models take the following generic form:

[7]Given the research design of the FFCWS, family structure at baseline refers only to a mother's relationship with her child's biological father.

$$
\begin{aligned}
\boldsymbol{Y}_{ti}=&\beta_0+\beta_1(D,H)_{ti}+\beta_2 Y5_{ti}\\
&+\beta_3 Y9_{ti}\\
&+\beta_4 Month_{ti}\\
&+\beta_5 Month^2_{ki}\\
&+\boldsymbol{TC}_i\gamma\\
&+\boldsymbol{TV}_{t-1,i}\theta\\
&+u_{oi}+u_{1i}(D,H)_{ti}+u_{2i}Y5_{ti}\\
&+u_{3i}Y9_{ti}+\varepsilon_{ti},
\end{aligned} \quad (1)
$$

where the cognitive achievement of child *i* at age *t* (*Y*) is a function of socioeconomic disadvantage (*D*) or child health (*H*), time (*Year3* (reference), *Year5* and *Year9*), child *i*'s age in month at age *t* (*Month* and *Month*^{2}), a vector of baseline covariates (*TC*), a vector of time-varying covariates at age $t-1$ (*TV*), and random components (*u*'s). Note that Equation 1 represents two models, one estimating the effect of socioeconomic disadvantage and the other estimating the effect of child health. This means that child health is part of *TV* when socioeconomic disadvantage is the time-varying treatment, whereas socioeconomic disadvantage is part of *TV* when child health is the time-varying treatment. The models are estimated with a piecewise function of time to allow nonlinearity. The parameter estimate of interest is β_1, which provides estimates for the effect of each treatment.

The REM produces unbiased estimates of the treatment effects if socioeconomic disadvantage and child health are independent of the random effects and the idiosyncratic error (ε_{ti}), conditional on measured covariates. As discussed earlier, however, even with this assumption the REM may be prone to bias because of its inappropriate handling of the reciprocal relationship between socioeconomic disadvantage and child health. To assess bias due to the presence of time-varying covariates that can affect, as well as be affected by, time-varying treatments, we employ marginal structural models (MSM). The MSM applies an inverse probability of treatment (IPT) weighting estimator by which children who are exposed to different levels of treatment—socioeconomic disadvantage or poor health—are sequentially balanced on prior histories of treatment and covariates (Robins 1999; Robins, Hernán, and Brumback 2000). Specifically, for child *i*, the IPT weighting first calculates the probability of actual exposure to treatment at age *t*, conditional on his/her treatment assignment and observed time-constant and time-varying covariates up to and at age $t-1$; then it weights each child by the inverse of his/her conditional probability. At each age, children who are overrepresented in terms of their treatment are given lower weights, while children who are underrepresented are given higher weights. The IPT weighting thus generates a pseudo-population in which children's age-specific exposure to socioeconomic disadvantage or poor health is independent of prior observed confounders.

Let $(D, H)_t = (d, h)$ denote child *i*'s actual exposure to socioeconomic disadvantage or poor health at age *t* and *TC* be a vector of baseline covariates. For time-varying covariates, overbars denote covariate history up to age $t-1$: $\overline{\boldsymbol{TV}}_{t-1}=\{\boldsymbol{TV}_0,\boldsymbol{TV}_1,\ldots,\boldsymbol{TV}_{t-1}\}$, which contains child health history, $\overline{H}_{t-1}$, in the case of socioeconomic disadvantage as a treatment and socioeconomic disadvantage history, $\overline{D}_{t-1}$, in the case of child health as a treatment. We follow standard practice that computes stabilized IPT weights because a small number of observations with extreme weights (outliers) may distort the estimation process (Hernán, Brumback, and Robins 2002):

$$\mathrm{IPTW}(D,H)_{ti}=\prod_{t=0}^{T}\frac{Pr\left((D,H)_t=(d,h)\,|\left(\overline{D},\overline{H}\right)_{t-1},\boldsymbol{TC}\right)}{Pr\left((D,H)_t=(d,h)\,|\left(\overline{D},\overline{H}\right)_{t-1},\boldsymbol{TC},\overline{\boldsymbol{TV}}_{t-1}\right)}, \quad (2)$$

where Π is the product operator; the denominator is the probability that child *i* received his/her actual treatment of socioeconomic or health disadvantage at age *t*, conditional on prior socioeconomic or health disadvantage history, baseline covariates, and time-varying covariates up to and at time $t-1$; and the numerator is the probability that child *i* received his/her actual treatment of socioeconomic or health disadvantage at age *t*, conditional on prior socioeconomic or health disadvantage history and time-constant covariates. We compute IPT weights by fitting age-specific ordered logit regression models that obtain the conditional probabilities of exposure to different levels of socioeconomic disadvantage or health (see Tables A1 and A2).[8] While we caution interpreting parameter estimates in causal terms, Tables A1 and A2 demonstrate that poor health and socioeconomic disadvantage at age $t-1$ are positively associated with each other at age *t*.

In Figure 2, we consider exposure to socioeconomic disadvantage as a time-varying treatment to illustrate how the IPT weighting modifies the pathways linking the time-varying treatment and children's cognitive development. Since the IPT weights incorporate adjustment for time-varying child health and other time-varying covariates as confounders into estimation, the pathways from time-varying child health to time-varying socioeconomic disadvantage can be removed ($H_0 \rightarrow D_1$ and $H_1 \rightarrow D_2$). With the IPT weights, conditioning on time-varying child health and other time-varying covariates as mediators is no longer necessary in models predicting children's cognitive achievement, which resolves the problem of over-controlling. We take analogous steps when we examine child health as a time-varying treatment and socioeconomic disadvantage as a time-varying covariate.

Recall that the MSM shares with the REM the assumption of no unobserved heterogeneity. The REM, however, must make a further assumption that observed time-varying covariates function as either exogenous factors or confounders of time-varying exposures to socioeconomic disadvantage and poor health. By minimizing the risk of confounding by, and over-controlling for, observed time-varying covariates, the MSM overcomes a key drawback of conventional panel models: namely, their inability to properly account for the reciprocal relationship socioeconomic disadvantage and child health have with each other along with other time-varying covariates.

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

Sample attrition is inevitable in any panel data. If attrition occurs non-randomly, it may yield biased results. To address this issue, we construct weights for time-varying exposure to censoring (Robins et al. 2000). Let $L_t = 1$ if child i was lost to follow-up by age t and $L_t = 0$ if otherwise. $\overline{L}_{t-1}=0$ denotes that child i was not lost to follow-up by age $t - 1$. The stabilized censoring weights are given by

$$\mathrm{CW}_i=\prod_{t=0}^{T}\frac{Pr\left(L_t=0|\overline{L}_{t-1}=0,\overline{D}_{t-1},\overline{H}_{t-1},\boldsymbol{TC}\right)}{Pr\left(L_t=0|\overline{L}_{t-1}=0,\overline{D}_{t-1},\overline{H}_{t-1},\boldsymbol{TC},\overline{\boldsymbol{TV}}_{t-1}\right)}. \quad (3)$$

We estimate two MSMs—one for a socioeconomic disadvantage effect and the other for a child health effect—with the product of the IPT and censoring weights as final weights ($\mathrm{FW}(D)_{ti} = \mathrm{IPTW}(D)_{ti} \times \mathrm{CW}_{ti}$ and $\mathrm{FW}(H)_{ti} = \mathrm{IPTW}(H)_{ti} \times \mathrm{CW}_{ti}$, respectively), fitting random-effects models.[9] The MSMs control for baseline covariates as they enter into both the numerator and denominator of the stabilized weights. Throughout the analysis, we compute robust standard errors to correct for within-individual correlation (Robins et al. 2000). All models are estimated using Stata 14.

RESULTS

Overall Effects

Table 2 reports estimates of the effects of socioeconomic disadvantage and child health on children's cognitive achievement during early to middle childhood. For the purpose of comparison, we estimate four models: (1) random-effect models (REMs) with a main effect only; (2) REMs with time-constant covariates; (3) REMs with time-constant and time-varying covariates; and (4) marginal structural models (MSMs).[10] One set of models estimates the effects of exposure to socioeconomic disadvantage, while the other estimates the effects of exposure to poor health.

To begin with the results for the overall effects of socioeconomic disadvantage and child health (panel A), the unadjusted estimates (Model 1) show that exposures to socioeconomic disadvantage and poor health are significantly and negatively associated with children's cognitive achievement. Growing up in a higher quartile of each circumstance lowers children's PPVT scores by .21 SDs ($p < .001$) and .07 SDs ($p < .001$), respectively, compared to growing up in a lower quartile. Model 2 indicates that differences in baseline characteristics substantially account for the effects of socioeconomic and health disadvantage. The effect of socioeconomic disadvantage is reduced by 75 percent (= 100[{−.206 − (−.051)/−.206}], while that of child health by 55 percent (= 100[{−.065 − (−.029}/−.065]). However, both effects still remain statistically significant. These results should be

[9]If our MSMs are correctly specified, in expectation, the distributions of stabilized IPT, censoring, and final weights should be centered around values close to 1, have small variance, and be symmetric (Hernán et al. 2002). As shown in Table A3, all three weights meet these conditions. They have a mean close to 1, are highly clustered around the mean, and are only slightly skewed to the right. Furthermore, Tables A4 and A5 document that the IPT weighting achieves covariate balance, suggesting that socioeconomic disadvantage and poor health are largely independent of observed time-constant and time-varying covariates in the IPT weighted data.

[10]For the purpose of consistency, the analysis incorporates censoring weights into all models.

interpreted with caution as they do not account for time-varying confounding. In Model 3, we further control for child health (socioeconomic disadvantage) as a time-varying covariate in estimating the effect of socioeconomic disadvantage (child health), in addition to a common set of time-varying covariates. Socioeconomic disadvantage and poor health have significant adverse effects on children's PPVT scores, although slightly smaller in magnitude than in Model 2 ($b = -.047$, $p < .001$ and $b = -.028$, $p < .01$, respectively). Both estimates are problematic, however, because they cannot distinguish the confounding role of time-varying covariates from their mediating role.

To deal with this potential source of bias, we estimate the MSMs in Model 4. On average, exposures to the highest quartile of socioeconomic disadvantage and poor health, compared to the lowest quartile, significantly reduce children's cognitive achievement by .15 SDs (= (4 − 1) × (−.048)) and .09 SDs (= (4 − 1) × (−.028)), respectively. The MSM estimates are only slightly smaller in magnitude than those in Model 2 and similar to those in Model 3, suggesting that time-varying confounding plays a minor role in estimating the effects of socioeconomic and health disadvantage. The reciprocal relationship between family SES and child health does not severely influence their independent effects on children's cognitive achievement in early and middle childhood. In addition, given the robustness of the results to the inclusion of other time-constant and time-varying covariates, these results are not consistent with the indirect selection hypothesis, which would predict that the effects of SES and health are spurious and driven by other factors.

Age-Specific Effects

Next, we examine age-specific effects of exposures to socioeconomic disadvantage and poor health (panel B, Table 2). We re-estimate all models by interacting time-varying socioeconomic disadvantage or child health with the year of the survey, in order to test whether processes of cumulative disadvantage or "social timing" are at work. In Model 1, the unadjusted estimates indicate that exposures to each circumstance significantly affect children's PPVT scores, regardless of their timing in early or middle childhood. One exception is children's exposure to poor health at age 3, which is not significantly associated with PPVT scores. Model 2 shows that, after accounting for time-constant covariates, the effects of socioeconomic disadvantage and poor health at age 3 become small and insignificant, but their effects at ages 5 and 9 remain statistically significant (socioeconomic disadvantage: $b = -.075$, $p < .001$ at age 5 and $b = -.116$, $p < .001$ at age 9; poor health: $b = -.070$, $p < .01$ at age 5 and $b = -.047$, $p < .05$ at age 9).

Controlling for time-varying covariates in Model 3 does not alter the estimates. Finally, the MSM estimates in Model 4 are only slightly smaller than the adjusted REM estimates. On average, exposure to the highest quartile of socioeconomic disadvantage, compared to the lowest quartile, lowers children's cognitive achievement by .21 SDs at age 5 (= (4 − 1) × (−.069)) and .33 SDs (= (4 − 1) × (−.111)) at age 9. The corresponding differences in the effects of poor health are .21 SDs at age 5 and .13 SDs at age 9, respectively. Similar to the overall effects, the age-specific effects of socioeconomic disadvantage (child health) are fairly insensitive to confounding by observed time-varying covariates including child health (socioeconomic disadvantage).

Figure 3 displays predicted PPVT scores across ages from our MSMs. For ages 3, 5, and 9, we contrast the predicted scores for children in the highest quartile of socioeconomic disadvantage or poor health with those for children in the lowest quartile, holding all other covariates at their mean or modal values. Differences are greater as they move farther away from zero.

The results reveal divergent patterns of the effects of socioeconomic disadvantage and child health. The gap in the PPVT scores at age 3 between the most disadvantaged and the least disadvantaged quartiles is small (.05 SDs) and not statistically significant. However, the gap increases in magnitude and becomes significant by age 5 (−.16 SDs, $p < .01$), and further widens by age 9 (−.28 SDs, $p < .001$). We observe a different pattern for child health. At age 3, the gap in the PPVT scores between the least healthy and the healthiest quartiles is only .03 SDs and statistically insignificant. By age 5, the gap becomes larger in magnitude and significant (−.18 SDs, $p < .01$). By age 9, however, while remaining significant, the gap in the PPVT scores due to varying exposure to poor health levels off (−.10 SDs, $p < .05$).

These findings indicate that an exclusive focus on the overall effect estimates of family SES and child health obscures their age-varying effects. On the one hand, age-varying exposure to socioeconomic disadvantage leads to widening inequality in children's cognitive achievement as they transition from early to middle childhood. As children's experience of socioeconomic disadvantage accumulates and becomes more chronic over time, its effects reflect not only immediate but also cumulative effects. This increasing pattern of socioeconomic disadvantage effects is thus consistent with the cumulative disadvantage perspective. On the other hand, the age-specific effects of poor health exhibit a leveling-off pattern, indicating that its negative effects are most pronounced around the time of school entry, and then decline as schooling progresses. This finding supports the turning points perspective, whereby children's circumstances play a more salient role in influencing development at key transition periods because of significant changes in life stages, environments, and roles. For most children, the beginning of schooling is the first major transition period beyond the family.[11] The leveling-off pattern of health effects also underscores the role of formal schooling as a countervailing mechanism, given the finding that children's developmental trajectories are altered or deflected after their transition to school.[12]

Because family SES and child health can be measured in various ways, we also re-estimate the MSMs to examine the sensitivity of our results to alternative measures (see Table A6). We find that the age-specific effects of socioeconomic disadvantage and poor health are substantively similar across different operationalizations, whether using dichotomous or ordinal measures, or measuring child health based only on mother-rated general health. Although the effects of child health at age 9 do not reach statistical significance in some cases, the direction and size of the coefficients remain similar. These results suggest that our

[11]Supplemental analysis (not shown) indicates that the effect of poor health at age 5 is mostly driven by children who transition to formal schooling.

[12]Descriptive evidence also supports divergent age-specific patterns of socioeconomic disadvantage and poor health. Nearly one fourth of children (24 percent) experience long-term exposure to the highest level of socioeconomic disadvantage (being on the 4th quartile at least two time points out of three), whereas only one eighth (13 percent) do so with respect to poor health.

findings are robust to alternative ways of measuring socioeconomic and health disadvantages. More importantly, the widening pattern for SES effects and the leveling-off pattern for child health effects hold regardless of the measures during early to middle childhood.[13]

Racial/Ethnic Differences

In the final step of the analysis, we investigate racial/ethnic heterogeneity in the effects of socioeconomic disadvantage and child health on children's cognitive achievement. Given the varying degree of prevalence, severity, and treatment of socioeconomic and health disadvantages across racial/ethnic groups, the effects of these circumstances may differ by race/ethnicity. Here we replicate our MSMs separately for each racial/ethnic group.[14]

In Table 3, panel A shows that the overall effects of socioeconomic disadvantage on children's PPVT scores are about −.04 SDs for blacks ($p < .05$), −.06 SDs for Hispanics ($p < .05$), and −.05 SDs for whites ($p < .10$). For Hispanic children, exposure to the highest quartile of socioeconomic disadvantage as compared to the lowest quartile, on average, lowers their cognitive scores by .16 SDs (= (4 − 1) × (−.055)). Although the effects of socioeconomic disadvantage are somewhat larger for Hispanic children and only marginally significant for white children, the differences in the coefficients across racial/ethnic groups are not statistically significant.

Racial/ethnic differences are more evident for the effects of poor health, which has the strongest effects among whites ($b = -.07$ SDs, $p < .01$), small and marginally significant effects among blacks ($b = -.02$ SDs, $p < .10$), and virtually null effects among Hispanics ($b = -.003$ SDs, $p = .90$). For white children, exposure to the highest quartile of poor health as compared to the lowest quartile, on average, reduces cognitive achievement by .21 SDs (= (4 − 1) × (−.070)). Differences in the coefficients across racial/ethnic groups are statistically significant, suggesting that the adverse effects of poor health are largely driven by white children.

Panel B of Table 3 shows that the age-specific effects of socioeconomic disadvantage do not differ across racial/ethnic groups. Although its effects are strongest among Hispanics, followed by blacks and then whites, group differences are not statistically meaningful. In contrast, the age-specific effects of child health differ statistically across racial/ethnic groups, especially between white and black children. The deleterious effects of poor health are mostly concentrated among white children ($b = -.14$ SDs, $p < .01$ at age 5 and $b = -.12$ SDs, $p < .05$ at age 9). Although exposure to poor health is also adversely associated with the cognitive achievement of black and Hispanic children at ages 5 and 9, these effects are not significant.

[13]While the main goal of this study is to examine how the reciprocity between social causation and health selection processes affects children's cognitive trajectory, unobserved confounding remains a concern. To address this issue, we estimate child fixed-effects models. By utilizing within-child variation in exposures to socioeconomic and health disadvantages and cognitive achievement, these models account for selection bias due to unobserved time-constant characteristics. The results (see Table A7) suggest that the age-specific patterns of socioeconomic disadvantage and child health effects are substantively similar to those reported here.

[14]We exclude other racial/ethnic groups due to their small sample size.

Figure 4 shows predicted PPVT scores by race/ethnicity, analogous to those shown in Figure 3. All racial/ethnic groups experience widening inequality in cognitive trajectories due to exposure to socioeconomic disadvantage, with a less pronounced pattern among whites (panel A). For Hispanic children, the gap in cognitive achievement between the most disadvantaged and the least disadvantaged quartiles is −.17 SDs at age 5 and −.34 SDs at age 9. On the other hand, the leveling-off pattern of child health effects is most pronounced among white children (panel B), among whom the gap in cognitive development between the least healthy and the healthiest quartiles is −.34 SDs at age 5 and then reduced to −.29 SDs at age 9. As reported above, the age-specific effects of poor health are not significant for black and Hispanic children, who exhibit a weaker leveling-off pattern for their cognitive trajectories due to exposure to poor health. In sum, we generally find a widening pattern of SES effects and a leveling-off pattern of child health effects across all racial/ethnic groups, although the latter pattern is most pronounced among white children.

DISCUSSION

Hypotheses about social causation and health selection have enriched our understanding of the roles that socioeconomic disadvantage and health play in stratification processes within and across generations, and established that both circumstances have dynamic and reciprocal effects that (re)produce inequality over the life course. In this paper, we explicitly account for those reciprocal relationships with focus on childhood, because of the strong influence of children's social environments and health on their development, the importance of early skill development for inequality over the life course, and the growth of recent research that emphasizes child health as a possible mechanism in the intergenerational transmission of poverty. Using the FFCWS data, we incorporate the time-varying nature of SES and health into a conceptual and empirical model of children's cognitive development; identify age-specific patterns of the effects of socioeconomic and health disadvantages in early to middle childhood; and assess heterogeneity in their effects across racial/ethnic groups. In doing so, we are able to consider the possibility that child health is a pathway leading from family SES to child development; that the effects of family SES and/or child health on child development are driven by the other factor and/or are spurious; or that each circumstance has strong direct effects on child development that we cannot explain.

A key finding is that the effects of socioeconomic disadvantage and child health on cognitive developmental trajectories are not influenced by measurable time-varying confounding. We find that socioeconomic disadvantage (poor health) has a significant negative impact on children's cognitive achievement, even in marginal structural models that account for time-varying confounding by poor health (socioeconomic disadvantage) alongside other time-varying covariates. These results suggest that the reciprocal relationship between socioeconomic disadvantage and poor health does not undermine their independent effects, and that both factors simultaneously shape children's cognitive development. This finding complicates the common conceptualization of health as a mechanism through which family SES affects individuals' socioeconomic progression (e.g., Aizer and Currie 2014; Palloni 2006). Our findings suggest that both family SES and health are important independent predictors of human capital development. While this finding is not inconsistent with the possibility that health acts as a pathway through which socioeconomic disadvantage affects children's achievement and attainment, the robustness of the socioeconomic disadvantage coefficient after accounting for time-varying confounding from health and other factors (e.g., Table 2, Models 3 and 4) suggests that the indirect effects of socioeconomic disadvantage through poor health, and vice versa, are likely small.

However, our analysis also reveals divergent patterns of the effects of socioeconomic and health disadvantages as children age. The deleterious effects of socioeconomic disadvantage grow larger between ages 3 and 9. The widening gap in cognitive skills among children with differing exposure to socioeconomic disadvantage is consistent with a cumulative inequality perspective that emphasizes how early exposure leads to persistent exposure, and to amplifying effects of socioeconomic disadvantage with age. The finding underscores the strong association between family SES and children's development, and the difficulty of rebounding from exposure to socioeconomic disadvantage at an early life stage. In contrast, the age-specific effects of poor health indicate that its negative effects on children's cognitive achievement are strongest at age 5 and weaken by age 9. This leveling-off pattern supports the hypothesis of social timing and countervailing mechanisms, whereby a health problem that coincides with the important transition into schooling may have a substantial but short-term effect on children's development from which they can rebound and adjust in later years. Our findings therefore illustrate the ways in which the effects of children's health on their development are contingent on their participation in other institutional settings.

Finally, our assessment of racial/ethnic heterogeneity in the effects of socioeconomic and health conditions suggests that the widening pattern of socioeconomic disadvantage effects in early and middle childhood is similar across racial/ethnic groups, although age-specific effects are larger among Hispanic and black children than among white children. In contrast, the age-specific effects of poor health are more pronounced for whites than for blacks and Hispanics, though the leveling-off pattern of child health effects is present across all racial/ethnic groups. These results indicate that, while exposures to socioeconomic disadvantage and poor health have a variable influence on children's cognitive trajectories across racial/ethnic groups, the life course patterns of their effects throughout early and middle childhood are similar across groups.

Several limitations of our analysis warrant further discussion and future research. First, our approach cannot rule out the possibility of selection bias in estimating the causal effects of socioeconomic and health disadvantages. We employ marginal structural models to address observed time-varying confounding, and we further estimate child fixed-effects models to evaluate the sensitivity of our results to selection bias due to unobserved time-constant characteristics. Though we find great consistency across the several models we consider, our models cannot fully account for selection bias due to unobserved time-varying confounding.

Second, we measure exposures to socioeconomic disadvantage and poor health in a way that allows for comparable and efficient estimation. In supplementary analyses, we find that our results are robust to a variety of alternative measures of each construct. Yet, our measures remain imperfect. For example, there may be racial/ethnic variation in perceptions about children's health, whereby the weaker effects of child health among blacks and Hispanics may reflect the tendency of some groups to underreport children's poor health (Andersen, Mullner, and Cornelius 1987; but see Finch et al. 2002 for immigrants). Although the leveling-off pattern of child health effects with age is similar across all racial/ethnic groups, group differences in the intercept may still be present. Future research should continue to work on conceptualizing and measuring socioeconomic disadvantage and child health in the context of diverse populations. Finally, because the FFCWS data are based on children residing in large urban cities, our results may not be generalized into the U.S. population as a whole.[15] Nevertheless, the findings reported here are pertinent to children whose exposures to socioeconomic and health disadvantage are relatively high.

These limitations notwithstanding, our results highlight how processes of social causation and health selection operate interdependently in shaping children's cognitive development. There has been an increasing recognition that socioeconomic conditions and health affect one another from the earliest years of life, and that they function as a key mechanism in the intergenerational reproduction of inequality (Jonsson 2010; Miech et al. 1999; Palloni 2006). However, we know little about the implications of such reciprocal relationships for the effects of each circumstance on children's development. By explicitly testing the importance of reciprocity, while also accounting for other simultaneously operating circumstances, we are able to reveal that the effects of socioeconomic disadvantage and poor health are coexisting rather than competing, and that both circumstances have significant independent effects on children's cognitive development.

Moreover, the findings that the adverse effects of socioeconomic disadvantage grow as children age, but that the effects of poor health level off as children transition from early to middle childhood, point to the need to identify early life course variation in children's developmental trajectories. Examining age variation is especially important during childhood, when skills are sensitive to the timing and duration of exposures. In this light, policymakers will benefit from better understanding the ways in which cumulative and age-specific circumstances manifest in inequalities in children's development. It will be useful in future work to cross-validate our findings with other data that have more observed time points, as such data become available. In addition, though we focus on childhood, it is critical to address how the reciprocal relationship between social causation and health selection evolves into adulthood, when the skills formed during childhood are rewarded in higher education and the labor market. In so doing, it is important to examine how different age-varying patterns of the effects of socioeconomic and health disadvantages unfold in adolescence and adulthood.

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[15]Although we utilize IPT and censoring weights in the analysis, an additional examination that incorporates survey weights produces similar results (not shown). Our findings are therefore relevant to children growing up in large urban cities.

Appendix

Table A1

Parameter Estimates from Models Predicting Exposure to Socioeconomic Disadvantage

	Age 3		Age 5		Age 9	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Baseline covariates						
Age (in year) (M)	0.009	0.004	−0.006	−0.009	−0.002	−0.003
Black (M)	0.299**	0.383***	0.527***	0.563***	0.294**	0.326**
Hispanic (M)	0.266*	0.333**	0.230*	0.279*	0.019	0.069
White (M) (ref.)						
Other (M)	0.379†	0.412*	0.030	0.050	0.268	0.267
Immigrant (M)	0.052	0.019	0.102	0.088	−0.236	−0.276
Less than high school (M)	0.345***	0.259**	0.167†	0.121	0.289**	0.239*
High school or GED (M) (ref.)						
Some college (M)	−0.360***	−0.331***	−0.432***	−0.440***	−0.333**	−0.324**
College or more (M)	−1.213***	−1.185***	−1.297***	−1.284***	−0.800***	−0.781***
Poverty	0.502***	0.480***	0.310***	0.294***	0.288***	0.270***
Married-bio (M) (ref.)						
Cohab-bio (M)	0.310**	0.453***	0.166†	−0.021	0.476***	0.218
Single (M)	0.408***	0.475**	0.357**	0.138	0.411**	0.113
Not employed (M)	0.326*	0.167	0.308*	0.255†	0.224	0.132
Part-time (M)	0.211**	0.171*	0.012	0.005	0.058	0.060
Full-time (M) (ref.)						
Age at first birth (M)	−0.004	0.001	0.009	0.012	0.025*	0.029*
Cognitive ability (M)	−0.059***	−0.059***	−0.025†	−0.024†	−0.014	−0.010
Impulsivity (M)	0.021*	0.017†	0.018†	0.010	0.013	0.006
Living with parent at age 15 (M)	−0.037	−0.048	0.018	0.023	−0.249**	−0.253**
Living with parent (M)	0.187*	0.181*	0.062	0.070	0.296**	0.323**
Number of children (M)	0.063*	0.020	0.064*	0.028	0.084*	0.034
Alcohol/drug problem (M)	0.006	−0.023	0.212*	0.194†	−0.034	−0.042
General health (M)	0.162***	0.136***	0.069†	0.036	0.083*	0.051
Age (in year) (F)	0.000	−0.001	−0.003	−0.004	−0.009	−0.008
Mixed-race couple (F)	0.009	0.052	0.199†	0.201*	−0.044	−0.030
Immigrant (F)	−0.160	−0.142	−0.012	0.013	0.184	0.215
Less than high school (F)	−0.038	−0.030	0.165†	−0.168*	0.153	0.145
High school or GED (F) (ref.)						
Some college (F)	−0.219*	−0.239**	−0.020	−0.170†	−0.112	−0.110
College or more (F)	−0.493**	−0.588***	−0.340*	−0.531**	−0.769***	−0.797***
Not employed (F)	0.303	0.244	−0.067	0.074	−0.330	−0.306
Part-time (F)	0.289**	0.295**	0.008	0.051	−0.087	−0.073
Full-time (F) (ref.)						
Ever incarcerated (F)	0.236**	0.219**	0.102	0.071	0.113	0.075
Male (C)	−0.016	0.000	−0.077	−0.078	−0.153*	−0.167*

	Age 3		Age 5		Age 9	
	(1)	(2)	(1)	(2)	(1)	(2)
First born (C)	−0.056	−0.017	−0.249 **	−0.202 *	−0.278 **	−0.194 †
Low birthweight (C)	0.141	0.107	0.168	0.143	0.118	0.084
Time-varying covariates at t − 1						
Poverty	0.722 ***	0.642 ***	1.012 ***	0.946 ***	0.918 ***	0.846 ***
Poor health		0.034		0.055 †		0.082 *
Married-bio (M) (ref.)						
Married-social (M)		0.829 †		0.981 *		1.044 †
Cohab-bio (M)		−0.135		0.292 *		0.393 **
Cohab-social (M)		0.044		0.428 *		0.220
Single (M)		0.135		0.385 **		0.508 **
Not employed (M)		0.725 ***		0.321 ***		0.371 ***
Part-time (M)		0.337 **		0.140		0.025
Full-time (M) (ref.)						
Living with parent (M)		−0.030		−0.058		0.036
Number of children (M)		0.102 **		0.085 *		0.140 ***
Depression (M)		0.075		0.171 †		0.072
Alcohol/drug problem (M)		0.014		0.014		−0.014
General health (M)		0.066 †		0.060		0.059

Note : Models 1 and 2 are used for computing the numerator and denominator, respectively, of the stablized IPT weights. M, F, and C refer to mother, father, and focal child.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

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

Table A2

Parameter Estimates from Models Predicting Exposure to Poor Health

	Age 3		Age 5		Age 9	
	(1)	(2)	(1)	(2)	(1)	(2)
Baseline covariates						
Age (in year) (M)	0.005	0.003	−0.009	−0.012	0.002	−0.003
Black (M)	−0.017	−0.006	−0.126	−0.106	−0.025	−0.049
Hispanic (M)	0.070	0.076	−0.121	−0.106	−0.115	−0.117
White (M) (ref.)						
Other (M)	0.134	0.137	0.143	0.168	−0.160	−0.144
Immigrant (M)	0.200	0.179	0.300 †	0.308 *	−0.203	−0.198
Less than high school (M)	0.038	−0.010	−0.191 *	−0.195 *	−0.134	−0.163 †
High school or GED (M) (ref.)						
Some college (M)	−0.192 *	−0.196 *	−0.055	−0.073	−0.079	−0.053
College or more (M)	−0.117	−0.051	−0.162	−0.129	0.264	0.383 *
Poverty	0.070 †	0.023	0.000	−0.010	0.091 *	0.053

	Age 3		Age 5		Age 9	
	(1)	(2)	(1)	(2)	(1)	(2)
Married-bio (M) (ref.)						
Cohab-bio (M)	0.175†	0.140	0.254*	0.174	−0.063	−0.124
Single (M)	0.180†	0.092	0.358**	0.283†	0.006	−0.080
Not employed (M)	0.045	0.033	0.087	0.080	−0.009	−0.056
Part-time (M)	−0.023	−0.052	0.078	0.058	0.071	0.041
Full-time (M) (ref.)						
Age at first birth (M)	−0.002	−0.002	0.007	0.007	0.000	0.000
Cognitive ability (M)	−0.041**	−0.039**	−0.016	−0.017	0.026†	0.026†
Impulsivity (M)	0.093***	0.088***	0.053***	0.047***	0.035**	0.028**
Living with parent at age 15 (M)	0.035	0.058	0.064	0.086	0.063	0.069
Living with parent (M)	−0.139†	−0.175*	−0.037	−0.056	0.144	0.151
Number of children (M)	0.026	0.027	−0.008	0.011	0.012	0.037
Alcohol/drug problem (M)	0.241*	0.193†	0.189†	0.175†	0.089	0.099
General health (M)	0.256***	0.197***	0.242***	0.184***	0.258***	0.199***
Age (in year) (F)	−0.011	−0.009	−0.008	−0.008	0.000	0.000
Mixed-race couple (F)	0.043	0.052	−0.064	−0.084	0.105	0.095
Immigrant (F)	−0.109	−0.107	0.108	0.104	0.068	0.059
Less than high school (F)	0.103	0.103	0.051	0.064	0.114	0.127
High school or GED (F) (ref.)						
Some college (F)	−0.029	−0.022	0.020	0.036	0.046	0.051
College or more (F)	−0.084	−0.078	−0.141	−0.103	−0.212	−0.172
Not employed (F)						
Part-time (F)	−0.147	−0.132	−0.109	−0.048	−0.156	−0.120
Full-time (F) (ref.)	−0.022	−0.047	−0.034	−0.035	0.043	0.046
Ever incarcerated (F)	0.179*	0.128	0.197*	0.195*	−0.006	−0.017
Male (C)	0.206**	0.208**	0.161*	0.164*	0.202**	0.217**
First born (C)	0.083	0.103	−0.101	−0.130	0.096	0.098
Low birthweight (C)	0.095	0.076	0.152	0.166	0.062	0.049
Time-varying covariates at t − 1						
Poverty		0.113*		0.008		0.107*
Poor health	0.414***	0.398***	0.835***	0.802***	0.777***	0.741***
Married-bio (M) (ref.)						
Married-social (M)		0.726		0.615		−0.023
Cohab-bio (M)		−0.021		0.090		0.060
Cohab-social (M)		0.061		−0.059		0.185
Single (M)		0.050		0.061		0.047
Not employed (M)		0.086		0.059		0.097
Part-time (M)		0.161		0.073		0.015
Full-time (M) (ref.)						
Living with parent (M)		0.101		0.015		−0.151
Number of children (M)		0.003		−0.048		−0.059

	Age 3		Age 5		Age 9	
	(1)	(2)	(1)	(2)	(1)	(2)
Depression (M)		0.317 ***		0.231 **		0.181 †
Alcohol/drug problem (M)		0.185		0.006		−0.120
General health (M)		0.134 ***		0.181 ***		0.186 ***

Note : Models 1 and 2 are used for computing the numerator and denominator, respectively, of the stablized IPT weights. M, F, and C refer to mother, father, and focal child.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

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

Table A3

Stabilized Inverse Probability of Treatment (IPT), Censoring, and Final Weights

			Percentile				
Weight	Mean	S.D.	1st	25th	Median	75th	99th
A. *Stabilized IPT weight (IPTW)*							
Socioeconomic disadvantage							
Age 3	1.00	0.18	0.61	0.90	0.98	1.06	1.62
Age 5	1.00	0.24	0.53	0.85	0.96	1.09	1.84
Age 9	0.99	0.29	0.45	0.80	0.95	1.13	2.04
Poor health							
Age 3	1.00	0.12	0.69	0.94	0.99	1.05	1.39
Age 5	1.00	0.17	0.61	0.90	0.98	1.08	1.53
Age 9	1.00	0.22	0.53	0.86	0.98	1.11	1.73
B. *Stabilized censoring weight (CW)*							
Age 3	1.00	0.03	0.94	0.99	1.00	1.01	1.10
Age 5	1.00	0.03	0.93	0.98	1.00	1.01	1.11
Age 9	1.00	0.05	0.90	0.97	1.00	1.02	1.13
C. *Final stabilized weight (IPTW × CW)*							
Socioeconomic disadvantage							
Age 3	1.00	0.18	0.62	0.90	0.97	1.06	1.62
Age 5	0.99	0.24	0.54	0.85	0.96	1.10	1.81
Age 9	0.99	0.30	0.47	0.80	0.95	1.13	1.99
Poor health							
Age 3	1.00	0.12	0.70	0.93	0.99	1.06	1.38
Age 5	1.00	0.17	0.62	0.90	0.98	1.08	1.51
Age 9	1.00	0.23	0.53	0.86	0.98	1.11	1.70

Table A4

Balancing Check for Socioeconomic Disadvantage

	Age 3		Age 5		Age 9	
	Coefficient	**Robust S.E.**	**Coefficient**	**Robust S.E.**	**Coefficient**	**Robust S.E.**
Baseline covariates						
Age (in year) (M)	0.027	(0.018)	0.000	(0.023)	0.042†	(0.024)
Black (M)	−0.073	(0.194)	−0.242	(0.223)	−0.012	(0.220)
Hispanic (M)	0.109	(0.203)	−0.054	(0.234)	0.254	(0.320)
White (M) (ref.)						
Other (M)	0.504	(0.394)	−0.104	(0.334)	−0.326	(0.467)
Immigrant (M)	−0.296	(0.219)	0.165	(0.219)	−0.498	(0.349)
Less than high school (M)	0.089	(0.178)	−0.055	(0.183)	0.093	(0.178)
High school or GED (M) (ref.)						
Some college (M)	0.104	(0.155)	0.080	(0.163)	−0.037	(0.195)
College or more (M)	−0.039	(0.390)	−0.022	(0.305)	−0.648†	(0.390)
Poverty	0.335*	(0.157)	0.245	(0.211)	0.224	(0.182)
Married-bio (M) (ref.)						
Cohab-bio (M)	0.256	(0.236)	0.121	(0.238)	0.007	(0.274)
Single (M)	0.151	(0.258)	−0.005	(0.280)	0.178	(0.277)
Not employed (M)	−0.580†	(0.317)	0.059	(0.264)	0.114	(0.244)
Part-time (M)	−0.133	(0.134)	0.088	(0.146)	−0.181	(0.155)
Full-time (M) (ref.)						
Age at first birth (M)	−0.008	(0.021)	0.019	(0.023)	0.001	(0.025)
Cognitive ability (M)	0.021	(0.027)	−0.024	(0.025)	0.025	(0.032)
Impulsivity (M)	0.018	(0.018)	0.007	(0.022)	0.009	(0.019)
Living with parent at age 15 (M)	−0.100	(0.131)	−0.160	(0.159)	−0.001	(0.176)
Living with parent (M)	0.035	(0.181)	−0.121	(0.184)	−0.288	(0.182)
Number of children (M)	0.069	(0.068)	−0.157†	(0.081)	0.052	(0.070)
Alcohol/drug problem (M)	−0.230	(0.251)	0.110	(0.338)	−0.049	(0.189)
General health (M)	0.055	(0.076)	−0.019	(0.081)	0.091	(0.086)
Age (in year) (F)	0.014	(0.011)	−0.007	(0.015)	−0.038	(0.040)
Mixed-race couple (F)	−0.220	(0.189)	−0.071	(0.216)	0.129	(0.232)
Immigrant (F)	−0.036	(0.198)	−0.093	(0.218)	−0.066	(0.386)
Less than high school (F)	−0.019	(0.164)	0.363*	(0.178)	−0.131	(0.163)
High school or GED (F) (ref.)						
Some college (F)	−0.113	(0.169)	−0.212	(0.195)	−0.174	(0.210)
College or more (F)	−0.148	(0.385)	−0.343	(0.312)	−0.642†	(0.384)
Not employed (F)	0.336	(0.576)	0.966	(0.694)	0.367	(0.563)
Part-time (F)	0.072	(0.196)	0.675	(0.538)	0.209	(0.203)
Full-time (F) (ref.)						

	Age 3		Age 5		Age 9	
	Coefficient	**Robust S.E.**	**Coefficient**	**Robust S.E.**	**Coefficient**	**Robust S.E.**
Ever incarcerated (F)	0.008	(0.142)	0.225	(0.159)	0.113	(0.156)
Male (C)	−0.326	(0.247)	−0.178	(0.152)	−0.148	(0.142)
First born (C)	0.208	(0.201)	−0.089	(0.195)	−0.012	(0.209)
Low birthweight (C)	−0.053	(0.222)	−0.236	(0.250)	0.123	(0.240)
Time-varying covariates at t − 1						
Socioeconomic disadvantage	−0.186	(0.156)	−0.180	(0.126)	−0.199	(0.178)
Poor health	−0.006	(0.057)	−0.074	(0.065)	0.030	(0.076)
Married-bio (M) (ref.)						
Married-social (M)	0.322	(0.717)	−0.149	(0.440)	−0.017	(0.391)
Cohab-bio (M)	−0.073	(0.236)	−0.116	(0.230)	−0.426	(0.339)
Cohab-social (M)	−0.351	(0.382)	−0.350	(0.343)	−0.359	(0.270)
Single (M)	−0.104	(0.240)	−0.168	(0.229)	−0.394	(0.327)
Not employed (M)	0.256	(0.159)	0.389	(0.288)	−0.037	(0.168)
Part-time (M)	0.041	(0.205)	0.349	(0.230)	0.207	(0.235)
Full-time (M) (ref.)						
Living with parent (M)	−0.058	(0.187)	−0.098	(0.208)	−0.270	(0.209)
Number of children (M)	−0.001	(0.081)	−0.008	(0.093)	−0.045	(0.077)
Depression (M)	−0.228	(0.187)	−0.030	(0.223)	−0.353	(0.273)
Alcohol/drug problem (M)	−0.021	(0.325)	0.121	(0.294)	0.242	(0.255)
General health (M)	0.033	(0.070)	0.025	(0.091)	−0.084	(0.087)

Note : All age-specific models predicting family socioeconomic disadvantage are estimated using IPT weights. M, F, and C refer to mother, father, and focal child.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

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

Table A5

Balancing Check for Child Health

	Age 3		Age 5		Age 9	
	Coefficient	**Robust S.E.**	**Coefficient**	**Robust S.E.**	**Coefficient**	**Robust S.E.**
Baseline covariates						
Age (in year) (M)	−0.007	(0.013)	0.001	(0.017)	0.003	(0.016)
Black (M)	−0.004	(0.118)	0.000	(0.147)	0.055	(0.131)
Hispanic (M)	−0.065	(0.130)	0.018	(0.174)	0.056	(0.155)
White (M) (ref.)						
Other (M)	−0.099	(0.213)	−0.042	(0.264)	0.271	(0.351)
Immigrant (M)	0.084	(0.142)	0.065	(0.211)	−0.052	(0.226)
Less than high school (M)	0.056	(0.101)	−0.028	(0.126)	−0.047	(0.121)
High school or GED (M) (ref.)						

	Age 3		Age 5		Age 9	
	Coefficient	**Robust S.E.**	**Coefficient**	**Robust S.E.**	**Coefficient**	**Robust S.E.**
Some college (M)	−0.023	(0.112)	0.083	(0.129)	0.018	(0.125)
College or more (M)	−0.126	(0.219)	0.340	(0.243)	0.107	(0.219)
Poverty	−0.004	(0.046)	−0.076	(0.053)	0.070	(0.057)
Married-bio (M) (ref.)						
Cohab-bio (M)	0.062	(0.154)	0.063	(0.178)	0.026	(0.148)
Single (M)	0.098	(0.167)	0.075	(0.191)	−0.039	(0.164)
Not employed (M)	0.011	(0.163)	0.238	(0.212)	0.022	(0.203)
Part-time (M)	−0.059	(0.087)	0.030	(0.103)	−0.080	(0.104)
Full-time (M) (ref.)						
Age at first birth (M)	0.007	(0.013)	0.007	(0.017)	0.005	(0.015)
Cognitive ability (M)	0.018	(0.016)	−0.004	(0.020)	0.005	(0.020)
Impulsivity (M)	0.004	(0.011)	0.006	(0.014)	−0.005	(0.013)
Living with parent at age 15 (M)	0.010	(0.081)	0.003	(0.099)	−0.069	(0.101)
Living with parent (M)	−0.004	(0.109)	−0.063	(0.124)	0.039	(0.121)
Number of children (M)	0.025	(0.042)	0.074	(0.045)	−0.042	(0.042)
Alcohol/drug problem (M)	−0.055	(0.115)	0.069	(0.140)	−0.042	(0.144)
General health (M)	0.055	(0.046)	0.016	(0.057)	−0.009	(0.053)
Age (in year) (F)	0.003	(0.008)	−0.003	(0.010)	0.002	(0.009)
Mixed-race couple (F)	0.057	(0.114)	0.035	(0.134)	−0.148	(0.139)
Immigrant (F)	−0.067	(0.134)	0.005	(0.183)	−0.008	(0.212)
Less than high school (F)	−0.098	(0.098)	−0.111	(0.118)	0.079	(0.118)
High school or GED (F) (ref.)						
Some college (F)	−0.072	(0.109)	−0.226	(0.131)†	0.059	(0.119)
College or more (F)	0.023	(0.193)	−0.502	(0.214)*	−0.184	(0.205)
Not employed (F)	0.035	(0.296)	0.004	(0.327)	0.082	(0.355)
Part-time (F)	0.033	(0.123)	−0.059	(0.132)	−0.069	(0.150)
Full-time (F) (ref.)						
Ever incarcerated (F)	0.004	(0.089)	−0.047	(0.117)	0.012	(0.111)
Male (C)	0.052	(0.077)	−0.064	(0.093)	−0.033	(0.093)
First born (C)	−0.091	(0.110)	−0.051	(0.135)	0.170	(0.134)
Low birthweight (C)	−0.062	(0.131)	−0.002	(0.148)	0.020	(0.148)
Time-varying covariates at t − 1						
Socioeconomic disadvantage	0.063	(0.049)	0.099	(0.061)	0.034	(0.065)
Poor health	0.003	(0.037)	−0.077	(0.055)	0.010	(0.046)
Married-bio (M) (ref.)						
Married-social (M)	−0.435	(0.589)	−0.184	(0.319)	0.088	(0.285)
Cohab-bio (M)	−0.025	(0.152)	−0.017	(0.170)	−0.077	(0.167)
Cohab-social (M)	−0.131	(0.237)	0.057	(0.224)	0.130	(0.203)
Single (M)	−0.084	(0.145)	0.092	(0.170)	−0.035	(0.156)

	Age 3		Age 5		Age 9	
	Coefficient	Robust S.E.	Coefficient	Robust S.E.	Coefficient	Robust S.E.
Not employed (M)	−0.045	(0.096)	0.045	(0.113)	−0.055	(0.111)
Part-time (M)	−0.016	(0.122)	0.025	(0.159)	−0.058	(0.134)
Full-time (M) (ref.)						
Living with parent (M)	0.102	(0.107)	0.042	(0.147)	−0.083	(0.164)
Number of children (M)	−0.009	(0.043)	−0.031	(0.044)	0.066	(0.048)
Depression (M)	−0.097	(0.102)	0.057	(0.119)	−0.087	(0.122)
Alcohol/drug problem (M)	0.006	(0.132)	0.080	(0.196)	0.166	(0.186)
General health (M)	0.039	(0.043)	0.035	(0.052)	0.041	(0.054)

Note : All age-specific models predicting poor health are estimated using IPT weights. M, F, and C refer to mother, father, and focal child.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

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

Table A6

Effects of Socioeconomic Disadvantage and Child Health Using Alternative Measures

	Binary/Conservative	Binary/liberal	Binary/general health	Ordinal/general health
	(1)	(2)	(3)	(4)
Socioeconomic disadvantage				
Age 3	0.047(0.042)	0.046(0.042)	0.047(0.042)	0.016(0.020)
Age 5	−0.175 ** (0.051)	−0.175 ** (0.051)	−0.175 ** (0.051)	−0.069 ** (0.022)
Age 9	−0.248 *** (0.049)	−0.248 *** (0.049)	−0.248 *** (0.049)	−0.111 *** (0.022)
Poor health				
Age 3	0.203(0.140)	0.000(0.050)	0.227 † (0.137)	0.018(0.025)
Age 5	−0.697 ** (0.232)	−0.127 † (0.065)	−0.716 ** (0.228)	−0.106 ** (0.034)
Age 9	−0.248(0.155)	−0.060(0.060)	−0.282 † (0.153)	−0.041(0.030)

Note : N = 6,525 person-years. Robust standard errors in parentheses. In Models 1 to 3, socioeconomic disadvantage is coded 1 if below the poverty threshold, and 0 if otherwise. In Model 4, socioeconomic disadvantage is measured in ordinal quartiles. In Model 1, poor health is coded 1 if “poor/fair” on general health status or above the borderline clinical cut point on total problem behaviors, and 0 if otherwise. In Model 2, poor health is coded in a similar manner to Model 1 but intead using the 90th percentile cut point on total problem behaviors. In Models 3 and 4, poor health is measured as binary and ordinal, respectively, using general health status only.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

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

Table A7

Effects of Socioeconomic Disadvantage and Child Health, Fixed-Effects Models

	Socioeconomic disadvantage	Poor health
Age 3	0.064 ** (0.020)	0.051 ** (0.019)

	Socioeconomic disadvantage	Poor health
Age 5	−0.069 ** (0.021)	−0.084 *** (0.023)
Age 9	−0.107 *** (0.021)	−0.064 ** (0.021)

Note: N = 6,525 person-years. Robust standard errors in parenthesis. All models include survey year dummies, child's age, and its square term.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

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

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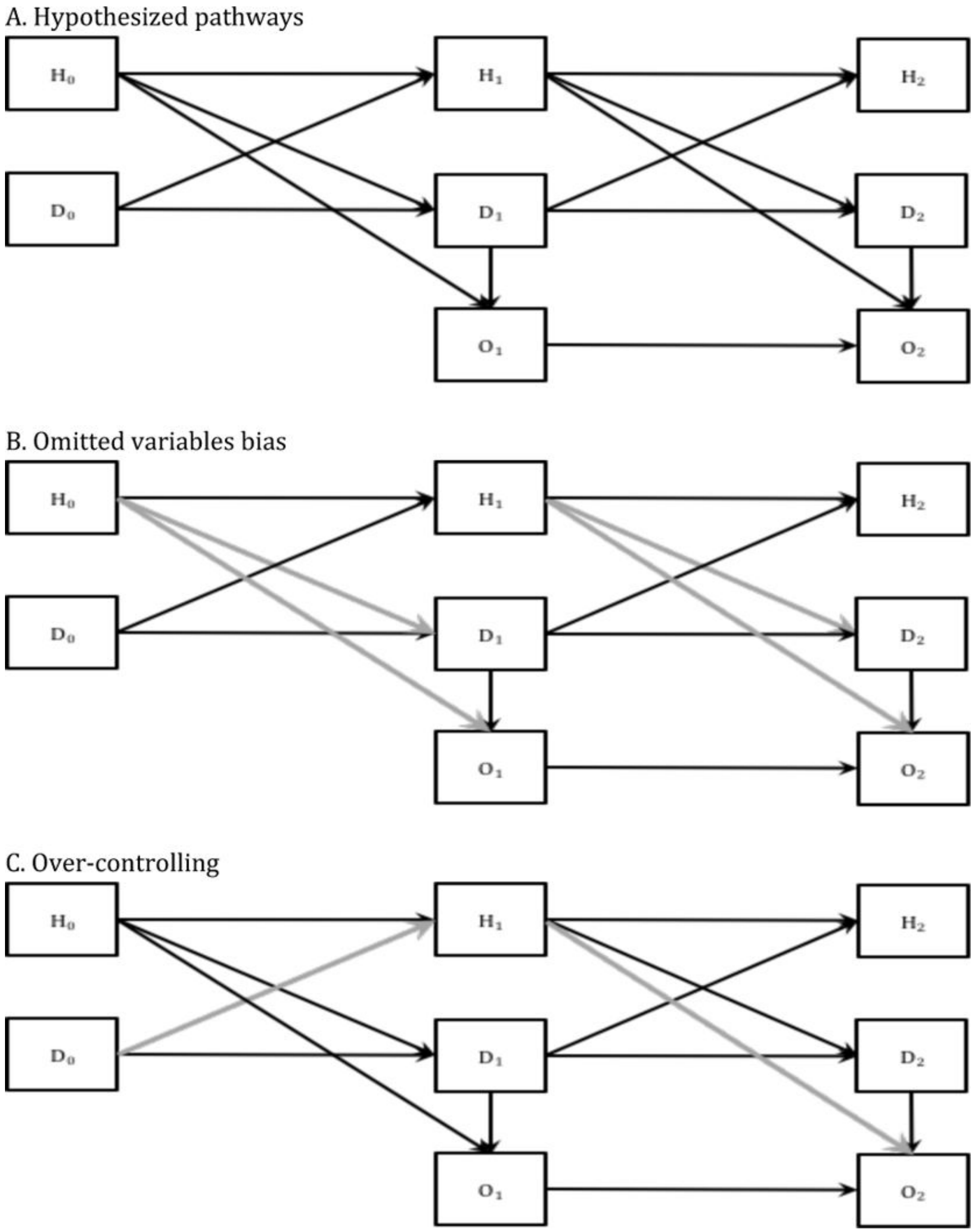

Figure 1.

Pathways Linking Socioeconomic Disadvantage and Child Health to Children's Cognitive Achievement

Note: D = socioeconomic disadvantage, H = child health, and O = cognitive achievement

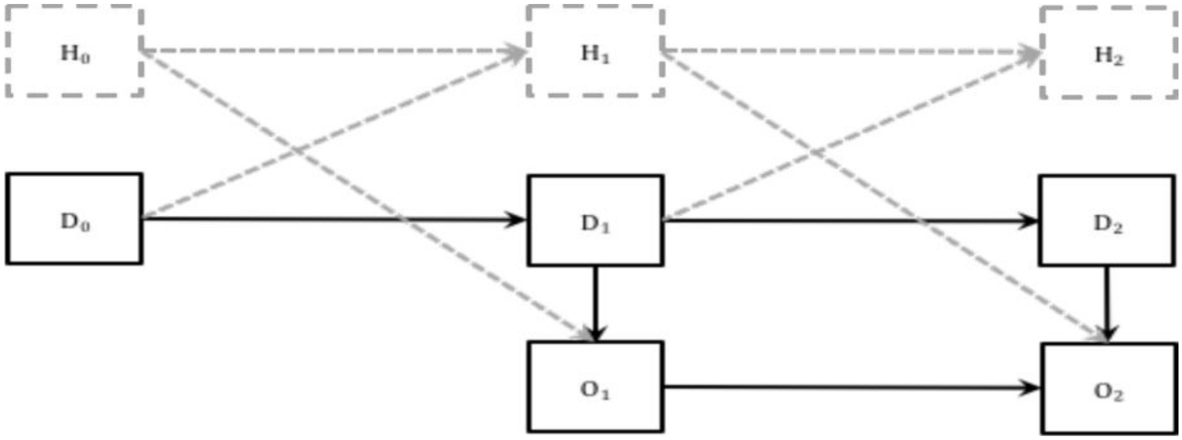

Figure 2.
Inverse Probability of Treatment (IPT) Weighted Pathways Linking Socioeconomic Disadvantage and Child Health to Children's Cognitive Achievement
Note: D = socioeconomic disadvantage, H = child health, and O = cognitive achievement

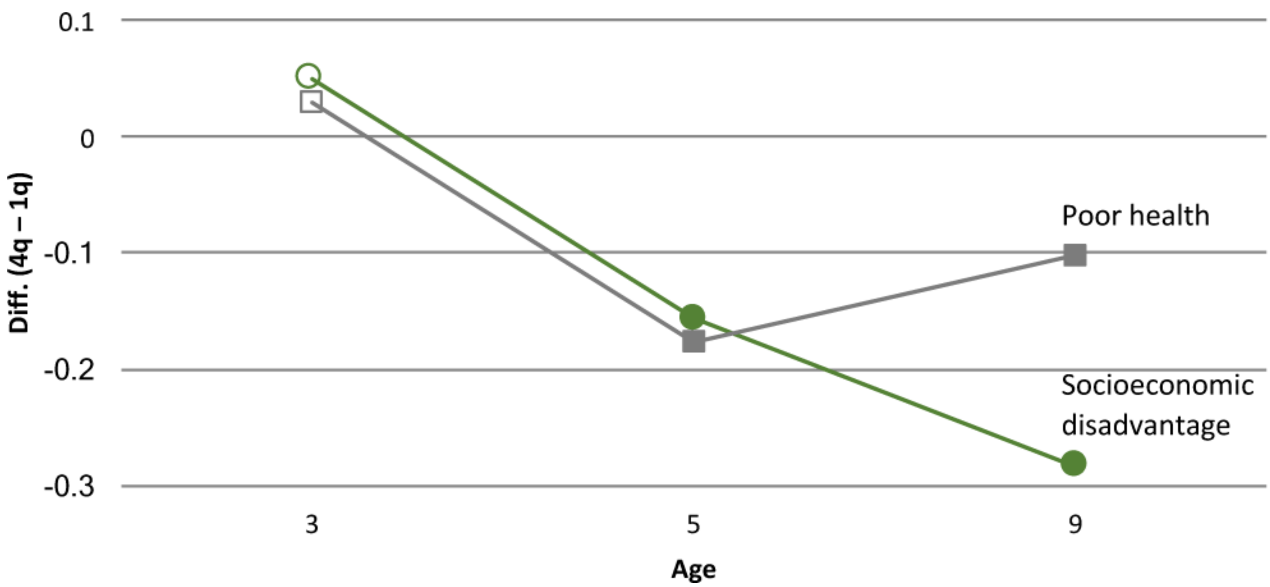

Figure 3.

Age-Specific Differences in Predicted Cognitive Achievement Scores by Socioeconomic Disadvantage and Child Health

Note : Based on the MSMs in Table 2, differences are computed between predicted PPVT scores at the 4th quartile of socioeconomic disadvantage (child health) and those at the 1st quartile of socioeconomic disadvantage (child health). The farther away from zero, the greater the difference. Shaded symbols indicate statistical difference, whereas hollow symbols indicate no statistical difference.

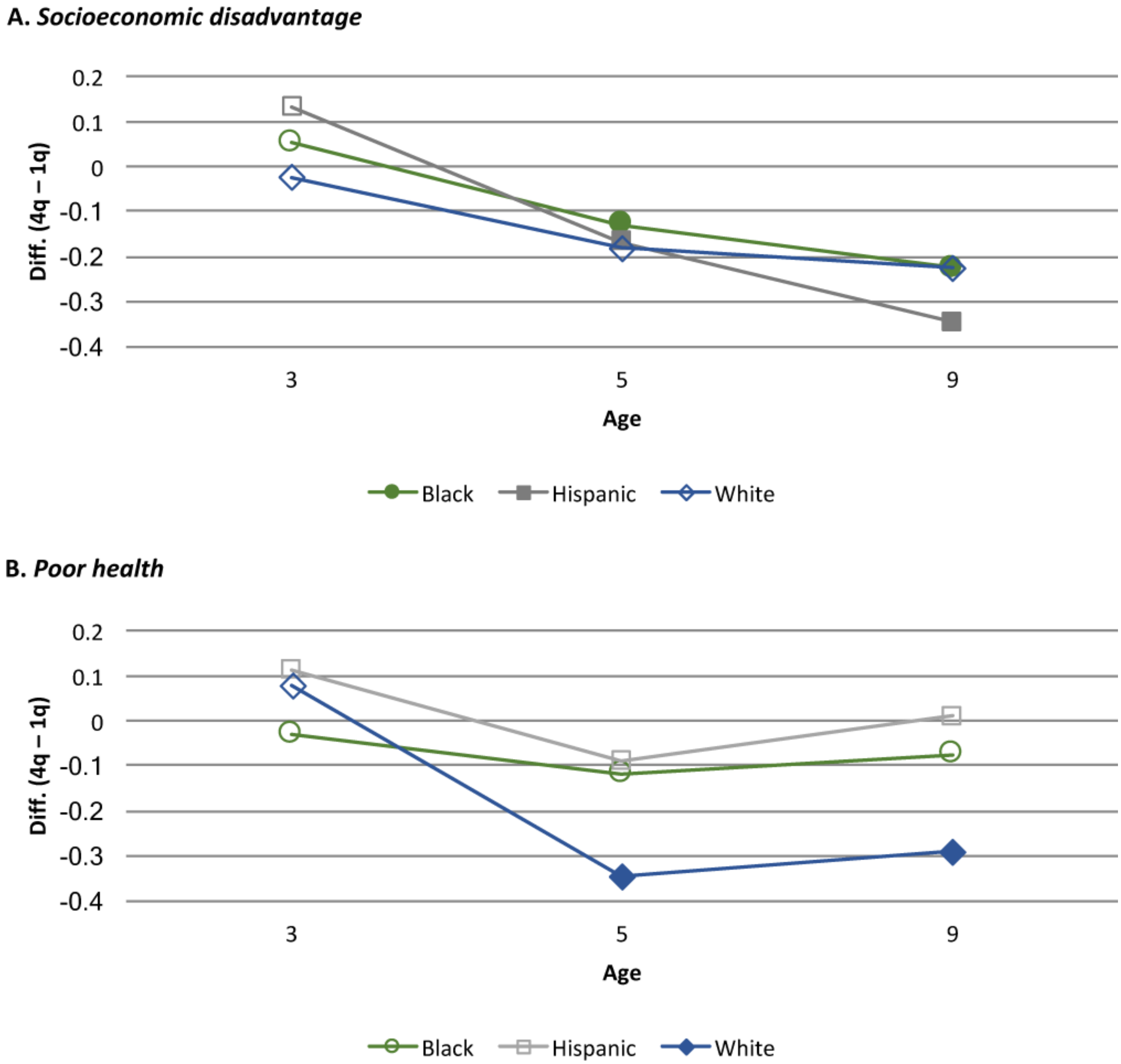

Figure 4.

Age-Specific Differences in Predicted Cognitive Achievement Scores by Socioeconomic Disadvantage and Child Health, by Race/Ethnicity

Note : Based on the MSMs in Table 3, differences are computed between predicted PPVT scores at the 4th quartile of socioeconomic disadvantage (child health) and those at the 1st quartile of socioeconomic disadvantage (child health). The farther away from zero, the greater the difference. Shaded symbols indicate statistical difference, whereas hollow symbols indicate no statistical difference.

Table 1

Descriptive Statistics of Study Variables

	Baseline		Age 3		Age 5		Age 9	
	Mean/%	**(SD)**	**Mean/%**	**(SD)**	**Mean/%**	**(SD)**	**Mean/%**	**(SD)**
Dependent variable								
PPVT (standardized)			0.04	(0.98)	0.05	(0.98)	0.03	(1.01)
Main explanatory variables								
Socioeconomic disadvantage								
1st quartile	25.44%		22.90%		22.66%		22.17%	
2nd quartile	24.46%		25.85%		24.80%		26.35%	
3rd quartile	22.46%		24.25%		26.96%		28.84%	
4th quartile	27.64%		27.00%		25.58%		22.64%	
Child health								
1st quartile			39.79%		38.38%		38.01%	
2nd quartile			23.08%		23.11%		21.16%	
3rd quartile			22.52%		23.49%		21.77%	
4th quartile			14.61%		15.01%		19.06%	
Maternal characteristics								
Age (in year)	25.25	(6.04)						
Race/ethnicity								
Black	50.24%							
Hispanic	24.20%							
White	22.04%							
Other	3.52%							
Immigrant	13.46%							
Education								
Less than high school	30.44%							
High school or GED	31.47%							
Some college	26.10%							
College or more	11.99%							
Family structure								

	Baseline		Age 3		Age 5		Age 9	
	Mean/%	(SD)	Mean/%	(SD)	Mean/%	(SD)	Mean/%	(SD)
Married-bio	25.61%		30.70%		32.98%		32.87%	
Married-social			0.58%		1.59%		3.90%	
Cohab-bio	35.09%		26.85%		19.10%		12.94%	
Cohab-social			4.16%		7.12%		10.95%	
Single	39.30%		37.71%		39.21%		39.34%	
Employment								
Not employed	6.87%		43.55%		40.88%		39.01%	
Part-time	29.91%		16.65%		15.54%		16.62%	
Full-time	63.22%		39.80%		43.58%		44.37%	
Age at first birth	21.73	(5.29)						
Cognitive ability	6.87	(2.67)						
Impulsivity	6.06	(3.61)						
Living with parent at age 15	42.37%							
Living with parent	26.43%		20.59%		14.96%		11.97%	
Number of children	1.25	(1.28)	2.29	(1.30)	2.32	(1.31)	2.52	(1.32)
Depression			15.83%		20.41%		16.89%	
Alcohol/drug problem	13.09%		7.50%		7.48%		7.22%	
General health								
Excellent	32.67%		30.32%		27.38%		23.47%	
Very good	35.12%		32.93%		34.20%		33.99%	
Good	25.06%		24.12%		25.51%		29.12%	
Fair/poor	7.16%		12.64%		12.92%		13.42%	
Father characteristics								
Age (in year)	27.79	(7.24)						
Mixed-race couple	14.46%							
Immigrant	14.74%							
Education								
Less than high school	31.13%							
High school or GED	35.30%							
Some college	22.47%							

	Baseline		Age 3		Age 5		Age 9	
	Mean/%	(SD)	Mean/%	(SD)	Mean/%	(SD)	Mean/%	(SD)
College or more	11.10%							
Employment								
Not employed	2.06%							
Part-time	11.66%							
Full-time	86.28%							
Ever incarcerated	26.90%							
Child characteristics								
Age (in month)			35.55	(2.40)	61.52	(2.64)	112.35	(4.38)
Male	52.44%							
First born	39.17%							
Low birthweight	10.03%							

Note : N= 2,952. Figures for time-varying covariates are lagged to prior survey values.

Table 2

Effects of Socioeconomic Disadvantage and Child Health on Cognitive Achievement

	REM unadjusted	REM w/o TV	REM w/ TV	MSM
	(1)	(2)	(3)	(4)
A. *Overall effects*				
Socioeconomic Disadvantage	−0.206*** (0.012)	−0.051*** (0.012)	−0.047*** (0.013)	−0.048*** (0.013)
Poor health	−0.065*** (0.011)	−0.029** (0.010)	−0.028** (0.011)	−0.028** (0.011)
B. *Age-specific effects*				
Socioeconomic Disadvantage				
Age 3	−0.130*** (0.018)	0.018 (0.019)	0.020 (0.019)	0.016 (0.020)
Age 5	−0.078*** (0.022)	−0.075*** (0.021)	−0.072*** (0.022)	−0.069** (0.022)
Age 9	−0.129*** (0.022)	−0.116*** (0.021)	−0.111*** (0.022)	−0.111*** (0.022)
Poor health				
Age 3	−0.028 (0.018)	0.011 (0.018)	0.014 (0.018)	0.010 (0.019)
Age 5	−0.072** (0.023)	−0.070** (0.022)	−0.073** (0.022)	−0.069** (0.023)
Age 9	−0.039† (0.021)	−0.047* (0.021)	−0.049* (0.021)	−0.044* (0.021)

Note: N = 6,525 person-years. Robust standard errors in parentheses. Random-effects models (REM) and marginal structural models (MSM) are estimated. Censoring weights are incorporated in all models. The effects of socioeconomic disadvantage and poor health are estimated separately in each model. TV refers to time-varying covariates. All models include survey year dummies, child's age, and its square term. Models 2 to 4 also control for baseline covariates.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

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

Table 3

Effects of Socioeconomic Disadvantage and Child Health, by Race/Ethnicity

	Black	Hispanic	White
A. *Overall effects*			
Socioeconomic disadvantage	−0.036 * (0.016)	−0.055 * (0.027)	−0.053 † (0.031)
Poor health	−0.024 †c (0.014)	0.003 c (0.022)	−0.070 **a,b (0.025)
B. *Age-specific effects*			
Socioeconomic disadvantage			
Age 3	0.018 (0.027)	0.044 (0.042)	−0.008 (0.054)
Age 5	−0.061 † (0.033)	−0.100 † (0.054)	−0.052 (0.056)
Age 9	−0.092 ** (0.032)	−0.159 ** (0.048)	−0.066 (0.057)
Poor health			
Age 3	−0.010 (0.024)	0.037 (0.038)	0.026 (0.049)
Age 5	−0.029 c (0.030)	−0.067 (0.049)	−0.141 **a (0.055)
Age 9	−0.015 c (0.028)	−0.035 (0.044)	−0.123 *a (0.052)
N (person-years)	3,474	1,469	1,356

Note : Robust standard errors in parentheses. The effects of socioeconomic disadvantage and poor health are estimated separately from MSM. All models include survey year dummies, child's age, its square term, and baseline covariates.

[a] indicates that the coefficient differs statistically from blacks.

[b] indicates that the coefficient differs statistically from Hispanics.

[c] indicates that the coefficient differs statistically from whites.

† $p < 0.1$;

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$ (two-centertests).