Windows of Opportunity? Participation in U.S. Childhood Nutritional Interventions, Cognition and Attainment

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BACKGROUND

Using longitudinal data from the United States, I will examine whether the timing of health-related intervention during childhood is of long-term importance for cognition and educational attainment. Specifically, I will examine two nutritional programs targeted toward children and youth: WIC and the National School Lunch Program. Research on children and adolescents is motivated by the large and robust relationship between the quality of early-life conditions and subsequent social and economic success (Heckman 2006; Shonkoff and Phillips 2000). I build on a growing body of evidence implicating child health in particular in the production of educational and socioeconomic inequalities. Whether measured physically or psychologically, early-life health is a meaningful contributor to mortality (Bengtsson and Lindstrom 2003), educational attainment (Conley and Bennett 2000; Jackson 2009), earnings and occupational attainment (Case, Fertig and Paxson 2005; Jackson 2010a). This analysis will focus on two questions: 1) Are health interventions most effective when participation occurs in the early years of life?; and 2) Does the duration of intervention matter, whereby children benefiting from both early and late intervention experience especially large gains, relative to their peers receiving only short-term intervention, or no intervention at all?

Windows of Importance

Research on the social and economic consequences of children's health is complicated by a central tenet of life course theory and human development—that children's developmental pathways are sensitive to not only the quality, but also the timing, duration and variability of their environments (e.g., Elder 1998). Put more specifically, health is not a permanent state, nor should its influence be the same at all ages. Depending on its timing in the early life cycle, health status can trigger particular biological and institutional pathways to outcomes in adulthood. Mothers' behaviors while pregnant and during the child's infancy, for example, may produce changes in placental development, as well as affect the neurobiological mechanisms responsible for infants' motor and reactive skill (e.g., Scott et al. 1989; Wakschlag et al. 2002). At later stages of development, children with anemia may face debilitating fatigue that limits their capacity to learn effectively (Haas 2001) and ultimately enjoy educational and occupational success. Research that does consider the early life course in its entirety highlights the importance of a longitudinal consideration. Case, Fertig and Paxson (2005), for example, find that health during both infancy and adolescence has lasting associations with the socioeconomic status of a British cohort in middle age, and that the timing of a health problem in the early life course is important: having a chronic condition at age seven is more strongly associated with educational attainment at age 16 than is having a chronic condition in adolescence.

Just as the timing of a health problem may trigger different developmental pathways, and therefore result in varying relationships with adulthood outcomes, the duration of exposure to a health problem or a health-promoting intervention may be important. Jackson (2010a) finds that children in persistently poor health face the most severe educational detriment during the schooling process and as adults; by mid-adulthood, gaps in attainment are largest between the healthiest and most persistently unhealthy children. These findings suggest that a static conceptualization of childhood health is inadequate to fully understand the dynamic process through which social status and health over the course of childhood have long-run consequences for the adult life course.

Does Early Health Intervention Matter? The Case of Nutrition

I examine the importance of timing and duration in the context of childhood health-related interventions, which should be similarly sensitive to life course stages. Specifically, I consider nutritional interventions focused on child development: the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), and the National School Lunch Program (NSLP). Nutrition is an important case study for examining the influence of health-related public policies focused on children, given the strong relationship between nutrition and brain development. Observational and experimental studies demonstrate a large impact of nutrient deficiency—or, conversely, nutrient supplementation—on cognition and labor market outcomes. Evidence among children, for example, shows that anemic children receiving iron supplementation experience improvements in test performance and learning capacity (see Grantham-McGregor and Ani 2001 for a review). Thomas et al. (2007) demonstrate that the social and economic benefits of improved nutrition exist later in the life course as well; using experimental data from a representative population of Indonesian adults, they demonstrate a large effect of iron supplementation on economic productivity. With a few exceptions, the majority of research linking nutrition and cognitive development, or nutrition and socioeconomic success more broadly, has been conducted in developing settings with high levels of under-nutrition. Research in the United States in clearly warranted, however, for two important reasons. First, about 20% of American children live in poverty, with over 14 million children living in food-insecure or food-insufficient households (Hamilton et al. 1997; U.S. Census Bureau 2010). Secondly, the sizeable long-term socioeconomic impact of children's health (Jackson 2010a), and of nutritional proxies such as height more specifically (Case and Paxson 2008) highlights the importance of health-related intervention even in a relatively wealthy context.

WIC and NSLP focus on maintaining proper nutrition among low-income children, with WIC providing nutrition supplementation to pregnant women and young children ages five and below, and NSLP providing reduced-cost or free lunches to school-aged children (between ages 5-18) in public and private schools. Both programs have income-defined eligibility cutoffs, targeting children in families at or below 185% of the federal poverty threshold. Participation in the programs is high, with WIC serving 9.3 million women, infants and children in 2009, and NSLP serving an estimated 60% of all school-age children in varying degrees of subsidization; 56% of lunches served in 2002 were to children eligible for free or reduced-price meals (USDA 2008, 2010). Though a large body of research examines the implications of WIC and NSLP, and of food insufficiency more generally, for birth outcomes and nutrient intake (e.g., Fox, Hamilton and Lin 2004), few studies extend this examination to children's cognition or to other outcomes relevant to socioeconomic success. Studies that do report mixed results. Whereas Alaimo et al. (2001) document a negative association between food-insufficiency and both cognitive and psychosocial outcomes, Dunifon and Kowaleski-Jones (2003) find no evidence of a positive influence between NSLP participation and test scores, in a cross-sectional analysis of a very small sample of U.S. siblings.

Existing research considering the possible importance of early-life nutritional intervention assumes that the timing of an investment toward a child, or of a particular environment, is unimportant—in other words, it assumes what Cunha and Heckman (2010) describe as a scenario of perfect substitution. In contrast, as is true in studying the influence of health, the timing and duration of a health intervention is of potential importance, given the complexity of children's brain development, as well as the realities of change and continuity over the life cycle (Elder 1998). The very early years of the life course—particularly between birth and age three—are an extremely sensitive period of development for the brain, with many neural circuits highly affected by experiences during that period (see Tanner and Finn-Stevensen 2002 for a review, and Knudsen 2004). Though little is known about the effects of later health intervention on cognitive development and subsequent socioeconomic attainment, evidence from

other contexts suggest that later intervention is often less effective (e.g., O'Connor et al. 2000). This research suggests that very early experiences, whether defined by environmental circumstances, health or intervention, may be especially consequential. Though the effects of early experience may be observed in the short-term, they may also persist and accrue over the life course, given theories of cumulative disadvantage that emphasize the possibility for widening inequalities with age (Diprete and Eirich 2006; Jackson 2010b).

At the same time, however, children's cognition has the potential for recovery or catch-up development. Evidence from developing settings demonstrates long-term cognitive improvements among children who receive nutritional supplementation even after the period of peak growth (e.g., Pollitt 1994). These improvements may be especially pronounced if later environments are favorable (e.g., Brown and Pollit 1996), or if additional investments occur at a later period. Cunha and Heckman (2010) describe this latter idea as a scenario of dynamic complementarity, whereby early investments are particularly effective if supplemented with additional, later investment.

The Current Study

Life course theory and evidence on the short and long-run influence of child health, nutrition, and childhood intervention, suggests the need to dynamically examine health-focused public policies and children's outcomes. Nutritional-based public policies in the U.S. provide an excellent case study for this examination, given high levels of food-insecurity in the young population, as well as documented strong links among nutrition, cognitive development and socioeconomic attainment. I focus on two questions in particular: 1) Are health interventions most effective when participation occurs very early in life?; and 2) Does the duration of intervention matter, whereby children benefiting from both early and late intervention experience especially large gains, relative to their peers receiving only short-term intervention, or no intervention at all?

DATA AND METHODOLOGY

Data

Data will come from two subsets of the Panel Study of Income Dynamics (PSID): the Child Development Supplement (CDS) and the Transition to Adulthood (TA) study. The PSID-CDS was launched in 1997 with the goal of collecting detailed information about economic and social disparities in child development on a national level (PSID-CDS User Guide 2010). Respondents from the main PSID sample were selected to participate in the CDS if they had at least one child under the age of 13. The 1997 CDS contains information on 2,394 PSID families and 3,563 children ages 0-12, with a response rate of 88%. In 2002 and 2007, follow-up waves were conducted—both waves had response rates around 90% (PSID-CDS User Guide 2010). Beginning after the 2002 wave, the TA supplement began in order to continue to follow youth ages 18 and over until they become core PSID respondents after age 24. The TA data provide information on youths' post-secondary schooling, labor force participation, family formation and health. I will use data from all available CDS and TA waves, which includes three waves of the CDS and two waves of the TA study, to date (the third wave of the TA study is forthcoming and may be available in time to analyze for PAA). Mean age in 1997 is six years.

A useful feature of the CDS/TA design is its inclusion of siblings; over 2,000 children in the 1997 wave have a sibling in the sample. As I will describe in more detail below, this feature of the sample design will allow me to control for many potential sources of unobserved heterogeneity.

Measures

Nutrition Supplementation will be measured by children's participation in WIC and/or the NSLP. In 1997 children's primary caregivers (most often the mother) indicate whether they participated in WIC while pregnant with the child, as well as whether the child currently participates in WIC (if the child is at or

under age 5). For older children in 1997, mothers indicate whether children usually (defined as 3 or more days/week) eat a hot lunch at school; whether the lunch is full-priced, reduced-price or free; and whether the parent applied for free or reduced-price lunches through the NSLP that year. This measure is repeated in 2002 and 2007, in the later waves of the CDS. I will use these questions to create measures of both the timing and duration of exposure to nutrition intervention, creating categories for very early exposure (prenatal WIC participation); school-aged exposure (participation in NSLP); and multiple exposures (WIC and NSLP). I will also be able to examine school-aged exposure at multiple points—two for older children (in 1997 and 2002) and three for younger children (in 1997, 2002 and 2007)—possibly adding an additional duration category. Though these measures are imperfect—children could have participated during the survey's off years, for example—having multiple measures of participation represents a substantial improvement over previous research, which has ignored timing and duration.

Cognition and Attainment. I will examine cognitive performance and/or educational attainment, depending on the age of the child, at the latest available date. For younger respondents who have not yet aged into the TA study, and for whom attainment measures will not yet be available, I will measure performance on the Woodcock-Johnson Revised (WJ-R) tests of achievement in reading and math. Among older respondents, I will examine two markers of attainment: timely high school graduation (distinguishing those who receive a regular high school diploma by the age of 19 from those who do not, conditional on reaching that age by the wave), and college attendance, conditional on high school completion. [If sample sizes allow, I will distinguish among no college, two and four-year programs, given their different relationship with labor market returns (e.g., Kane and Rouse 1995).] It may be that too few respondents have reached college completion age by 2007 to examine college completion separately.

Examining how health-related intervention is related to cognition and attainment, in particular, is important. Disparities in skill development have received substantial attention as the primary channel through which negative environments adversely impact social, physical and economic success during adulthood (Farkas 2003; Heckman 2008). There is evidence that children's performance on cognitive assessments (which likely reflects both inherited ability and learned skill) is malleable and strongly predicted by educational quality and environmental factors (Shonkoff and Phillips 2000; Winship and Korenman 1997). Moreover, evidence exposes child health as a non-trivial predictor of disparities in cognitive development and academic achievement, and as an importance pathway linking school-age health and mid-adulthood attainment (e.g., Jackson 2009). Given the paramount important of educational attainment in the process of socioeconomic mobility (e.g., Featherman and Hauser 1978), it is vital to understand the development of and variability in the relationship between health and skill development during the schooling years, and how health may influence progression through this key social institution.

Sociodemographic Measures. I will measure a large number of family background characteristics, including maternal and paternal education, logged family income at each wave, family size, birth order, sex and race/ethnicity. I will also test the sensitivity of the findings to the inclusion of children's health markers, including birthweight and childhood health.

Empirical Strategy

The analysis will proceed in several stages. First, I will estimate models that control for observable heterogeneity; depending on the outcome, these estimates will be from OLS and logistic regression models. A model of timely high school graduation and college attendance, for example, would be:

$$\log[\frac{p_i}{1-p_i}] = \beta_0 + \beta_1 N_i + \beta_2 X_i \qquad (1)$$

where $\log[\frac{p_i}{1-p_i}]$ equals the log odds of *p,* the probability that each adolescent, *i,* graduates from high school in a timely manner or attends some college. N_i denotes children's participation in nutritional interventions (at various ages), and X_i is a vector of sociodemographic characteristics.
I will estimate these models among two groups of respondents—the total sample and the sibling sample alone, in order to enable comparison with the next step in the analysis.

The extensive data collection of the CDS and TA studies permit measurement of many sources of variation between children, and between families, that are correlated with participation in WIC or NSLP, and with cognitive development and eventual educational attainment. Because income is a core determinant of program participation, for example, a negative coefficient for WIC participation could simply reflect the economic disadvantages that participating children face. At the same time, however, this model assumes that there are no other unmeasured factors that are correlated with both program participation and educational attainment—this is likely to be an unrealistic assumption. Mothers choose to enroll their children in WIC or the NSLP, for example; a positive WIC coefficient could therefore reflect not the impact of the program itself, but instead those mothers' investments toward their children's development. To account for many of these unmeasurable differences between mothers, I will estimate models with mother fixed-effects, which will control for all linear and additive differences between mothers, whether observed or unobserved:

$$\log[\frac{p_{im}}{1-p_{im}}] = \beta_0 + \beta_1 N_{im} + \beta_2 X_{im} + \mu_m \qquad (2)$$

where N_{im} indicates sibling differences in program participation; X_{im} indicates observed characteristics that vary between siblings (e.g., sex), and μ_m is a mother fixed effect. This model will permit examination of sibling differences in the influence of nutritional intervention timing and duration on cognitive development and attainment. Do respondents who participate in WIC or NSLP demonstrate higher cognitive performance or educational attainment than their siblings who do not? Is this advantage particularly pronounced among youth who receive very early intervention through WIC, or who participate continuously in WIC and NSLP, relative to their siblings with a shorter duration of participation? I will compare the fixed-effects estimates to those from OLS and logistic regression models identified from the total and sibling samples. Because fixed-effects models reply on outcome variation between siblings who did and did not participate in nutritional interventions, sample size is an important consideration. Examination of the 1997 sample indicates non-trivial sibling differences in program participation: about 12% and 18% of siblings differ in WIC and NSLP participation, respectively. The NLSP difference will increase when I incorporate the remaining waves into the analysis.

Though this model will measure may family-level differences that would otherwise be unobserved, parental behaviors that vary between siblings will remain a source of bias. To be more specific, if mothers invest greater resources, in the form of time or money, toward children perceived to be healthier, the intervention coefficient will remain upwardly biased. Nonetheless, the model will represent a substantial improvement over the previous step.

CONCLUSIONS

Public policies targeted toward children face the challenge of deciding not only how to intervene, but also when and for how long. This is of particular concern with health-focused interventions, which must grapple with the complex ways in which health and health deficiencies are related to sensitive periods of

brain development. The questions examined in this analysis, as well as the empirical strategy applied, will provide an important contribution to our understanding of timing and duration in the context of health-related childhood policy, and more generally to life course variation in the relationship between health and social inequality.

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