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## Fetal growth and neurobehavioral outcomes in childhood



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### ABSTRACT

Using a sample of sibling pairs from a nationally representative U.S. survey, we examine the effects of the fetal growth rate on a set of neurobehavioral outcomes in childhood measured by parent-reported diagnosed developmental disabilities and behavior problems. Based on models that include mother fixed effects, we find that the fetal growth rate, a marker for the fetal environment, is negatively associated with lifetime diagnosis of developmental delay. We also find that the fetal growth rate is negatively associated with disruptive behaviors among male children. These results suggest that developmental disabilities and problem behaviors may play a role in explaining the well-documented association between birth weight and human capital outcomes measured in adulthood.

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## 1. Introduction and background

It is well-documented that birth weight has a lasting impact on human capital outcomes measured later in the life course such as educational achievement and labor market outcomes (Behrman and Rosenzweig, 2004; Black et al., 2007; Oreopoulos et al., 2008; Royer, 2009). Prior research indicates that cognitive ability may play an important mediating role in this association between birth weight and human capital outcomes by determining the rate of return on educational investments and an individual's productivity in the labor market (Strauss, 2000; Matte et al., 2001; Boardman et al., 2002; Black et al., 2007; Johnson and Schoeni, 2007; Torche and Echevarría, 2011; Figlio et al., 2013; Cook and Fletcher, 2014; Chatterji et al., 2014). Recent evidence, however, suggests that noncognitive abilities and mental health may be as important as

cognitive abilities in determining human capital outcomes. For example, Lindquist and Westman (2011) using data from military enlistees in Sweden find that both cognitive and noncognitive skills are associated with earnings, but noncognitive skills actually matter more at the lowest part of the earnings distribution. Currie and Stabile (2006) find a large deficit in test scores and educational achievement among children having symptoms of Attention Deficit Hyperactivity Disorder (ADHD), which is one of the most common developmental disabilities in the United States. These findings suggest that the effect of birth weight on noncognitive outcomes in childhood may constitute another mechanism through which birth weight determines later human capital outcomes (Datta Gupta et al., 2013).

In this paper, we estimate the effect of birth weight on a set of noncognitive outcomes termed neurobehavioral outcomes; this category includes behavior problems and diagnosed developmental disabilities (Anderson et al., 2003). Early studies indicate that low birth weight is associated with neurobehavioral problems in childhood.

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For example, [McCormick et al. \(1992\)](#), using data from two multisite cohort studies of infants born in the late 1970s and early 1980s, find that low birth weight (less than 2.5 kg) is associated with more mother-reported behavior problems, and very low birth weight (less than 1.5 kg) is associated with higher risk for diagnosed learning problems. Similarly, [Hoy et al. \(1992\)](#), using data on infants born during the late 1970s and early 1980s at a hospital in Ireland, find that very low birth weight (less than 1.5 kg) is associated with higher scores for meanness/unhappiness and social withdrawal, and less peer acceptance. These studies, however, are based on older data and do not include extensive controls for other observed variables that may be correlated with both birth weight and behavioral outcomes.

In a few more recent studies, researchers have included extensive controls for potential confounding factors that may be correlated with both behavior problems and low birth weight. [Kelly et al. \(2001\)](#) use the 1997 Health Survey for England and find a linear association between birth weight and behavior problems (measured using the Strengths and Difficulties Questionnaire) over the full birth weight distribution, after controlling for other factors, with lower birth weight children experiencing more problem behaviors than higher birth weight children. On the contrary, [Corman and Chaikind \(1998\)](#) use the 1988 National Health Interview Survey and find that low birth weight is not associated with an index of problem behaviors after controlling for socioeconomic status, although they find low birth weight children are more likely to repeat a grade in school and attend special education classes. Similarly, using the ALSPAC cohort in Bristol, United Kingdom, [Wiles et al. \(2006\)](#) show that the estimated effect of birth weight on behavior problems (also based on the Strengths and Difficulties Questionnaire) disappears after controlling for potential confounders including birth length and gestational age. Most recently, [Datta Gupta et al. \(2013\)](#) use a large panel data set of Danish children who are born around the same time and examine the potentially dynamic effects of birth weight on behavioral outcomes. They find some evidence that the adverse effects of low birth weight on behavior problems increase as children age, but the effect on overall behavior problems is statistically insignificant ([Datta Gupta et al., 2013](#)).

While some of these studies suggest that there may be omitted variables correlated with both birth weight and behavior problems, to our knowledge, existing studies do not directly address this problem. This is partly due to lack of data – panel survey data which include behavioral outcomes information as well as data on siblings are scarce. On the other hand, one advantage of the cohort studies which have been used in previous research is they follow children born around the same time, allowing researchers to investigate dynamic effects, the approach taken by [Datta Gupta et al. \(2013\)](#). However, cohort data do not allow researchers to control for unobserved mother heterogeneity since these surveys necessarily exclude biological siblings.

In addition to this mixed evidence on birth weight and behavior problems among children, another strand of

literature demonstrates an association between poor fetal growth and developmental disabilities in childhood such as ADHD and learning disability.<sup>1</sup> In a comprehensive study that uses data from the 1997–2005 National Health Interview Survey (NHIS), [Boulet et al. \(2011\)](#) find that birth weight is negatively associated with a range of developmental disabilities in childhood including mental retardation, learning disability, ADHD, seizures, cerebral palsy, hearing impairment, and stuttering. Other studies attempt to control for omitted variable bias by comparing siblings or twins, but they tend to focus on specific conditions. Using a large sample of U.S. siblings, [Fletcher \(2011\)](#) finds heightened probability of self-reported learning disability and ADHD symptoms among low-birth-weight children after controlling for family fixed effects. Within-twin studies provide stronger causal evidence regarding the association between fetal growth measured by birth weight and ADHD. Using a sample of Swedish twin pairs, [Hultman et al. \(2007\)](#) find that among male twins, the twin with a lower birth weight has a 13% higher ADHD-symptom score than the other male twin at age 8–9 and a 12% higher score at age 13–14. It is notable that their findings are robust regardless of sex and zygosity. Similarly, [Groen-Blokhuys et al. \(2011\)](#) use a Dutch sample of twins and find positive and significant effects of low birth weight on the incidence of ADHD.

In this paper, we explore the association between fetal growth rate and a range of neurobehavioral outcomes using three waves of the Child Development Supplement of the Panel Study of Income Dynamics (PSID-CDS).<sup>2</sup> We build on recent work by [Datta Gupta et al. \(2013\)](#), by using mother fixed effects (hereafter MFE) estimation to address unobserved family background and (to some extent) genetic factors that may be correlated with both birth weight and neurobehavioral outcomes. Also, because our models include both the fetal growth rate and a set of indicators for preterm birth, we attempt to separate out the effect of the fetal growth rate, which is known in the literature to better capture the accumulated net nutrition intake in utero, on neurobehavioral outcomes.

We also build on prior work by examining the effect of the fetal growth rate on a broader set of diagnosed developmental disabilities in childhood, while previous within-twin or within-sibling studies have focused on ADHD. Unlike other studies that relied on self-reported or mother-reported symptoms of developmental disabilities, we use both measures of diagnosis and symptom scores. Finally, since PSID-CDS respondents continue to be surveyed as they enter adulthood through the Transition into Adulthood (PSID-TA) survey, we are able to use the PSID-TA data to estimate the association between childhood behavioral outcomes and educational attainment in young adulthood. These models allow us to gauge whether or not neurobehavioral outcomes may be an important set

<sup>1</sup> See [Nelson \(2006\)](#) for an overview.

<sup>2</sup> The Panel Study of Income Dynamics is a public use dataset produced and distributed by the Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI (1993–2009). See <http://psidonline.isr.umich.edu/> for more information.

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