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Early Childhood WIC Participation, Cognitive Development and Academic Achievement

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Abstract

For the half of American children who live in or near poverty, nutritional policy is part of the safety net against hunger and its negative effects on children's development. The Special Supplemental Nutrition Program for Women, Infants and Children (WIC) provides steadily available food from the food groups essential for physical and cognitive development. The effects of WIC on dietary quality among participating women and children are strong and positive. Furthermore, there is a strong influence of nutrition on cognitive development and socioeconomic inequality. Yet, research on the non-health effects of U.S. child nutritional policy is scarce, despite the ultimate goal of health policies directed at children—to enable productive functioning across multiple social institutions over the life course. Using two nationally representative, longitudinal surveys of children—the Early Childhood Longitudinal Study, Birth Cohort (ECLS-B) and the Child Development Supplement (CDS) of the Panel Study of Income Dynamics—I examine how prenatal and early childhood exposure to WIC is associated in the short-term with cognitive development, and in the longer-term with reading and math learning. Results suggest that early WIC participation is associated with both cognitive and academic benefits. These findings suggest that WIC meaningfully contributes to children's educational prospects.

Introduction

Among children in the United States, poverty and low economic status are pervasive and consequential. Over 16 million, or about 22% of U.S. children, live in poverty, with an additional 30 million children living just above the poverty line—close to 50% of U.S. children and youth live in poor or low-income families, and several decades of research reveal the negative effects of early childhood economic disadvantage on skill development, health and socioeconomic attainment (Duncan, Ziol-Guest and Kalil 2010; Finch 2003; Reiss 2013; Schmeer 2012). Poverty and food insecurity (uncertainty about the financial ability to provide the next meal) go hand in hand and, for children in economically disadvantaged and food-insecure households, nutritional policy is part of the social safety net to protect against the negative effects of hunger. One such program, the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), provides the benefit of steadily available food from the food groups essential for physical and cognitive development, as well as educational resources to enable healthy choices. Unlike the federal food stamp program (SNAP), WIC vouchers can be used on only specific food products. The program serves a large segment of American children—in 2009, 50% of U.S. infants participated in WIC, and about 25% of pregnant women, postpartum women, and children ages 1–4 (Oliveira and Frazao 2009).

Beyond its broad reach, the influence of WIC on dietary quality among pregnant women and young children is strong and positive, and there is a strong influence of nutrition on cognitive development and socioeconomic inequality (Behrman et al. 2009; Bitler and Currie 2005; Kowaleski-Jones and Duncan 2002). Moreover, WIC overlaps with critical and sensitive periods of developmental plasticity, and mounting evidence suggests that intervention during the first five years of life is particularly beneficial for brain development (Gluckman et al. 2005; Shonkoff and Phillips 2000). Yet, research on the cognitive and academic effects of U.S. childhood nutritional policy is scarce, despite substantial evidence of the effects of nutritional intervention on human capital development in developing countries (e.g., Behrman et al. 2009). Using data from two nationally representative, longitudinal surveys of children—the Early Childhood Longitudinal Study Birth Cohort (ECLS-B) and the Child Development Supplement (CDS) of the Panel Study of Income Dynamics—along with rigorous statistical techniques, I examine how children's early WIC participation is associated in the short-term with cognitive development, and in the longer-term with reading and math achievement.

Background

Child Health and Educational Opportunity

The socioeconomic gradient in children's health is well-established, whereby those in highly educated and higher-income families have better health than those with fewer resources to draw from (e.g., Chen, Martin and Matthews 2006; Dowd 2007; Finch 2003). Building on longstanding evidence on the social distribution of health, mounting evidence reveals an equally strong association between early-life health and both opportunities for academic progress in the short-term (e.g., skill development, achievement) and socioeconomic attainment in the longer-term (e.g., job loss, prohibitive health care costs) (Conley, Strully and Bennett 2003; Palloni et al. 2009).

Most research on health and social stratification examines long-term processes. However, much of the influence of child health on longer-term social processes works through the emergence of disparities in cognitive development and academic learning early in life. Birthweight and other markers of prenatal and infant health, as well as health around the time of school entry, are associated with academic achievement (e.g., Cheadle and Goosby 2010; Crosnoe 2006). Moreover, adjusting for differences in cognitive skills and academic achievement explains the influence of child health on socioeconomic attainment (Jackson 2010; Palloni et al. 2009). Overall, the weight of evidence suggests that unhealthy exposures or health disadvantages in a sensitive period of human development affect children's readiness to learn and to effectively participate in academic curricula, producing baseline inequalities in skill development and learning. These inequalities may compound as children age and result in striking differences in attained education and earnings.

WIC as a Marker of Early Childhood Health Environments

Though the policy debate surrounding nutrition in Western nations often emphasizes the effects of overweight and obesity, micronutrient deficiencies are also prevalent and increasing (CDC 2002). Rather than targeting one deficiency, WIC provides steadily available nutritious food. Target families are at or below 185% of the federal poverty threshold and women must also demonstrate that they are nutritionally at risk, which is true for the overwhelming majority of participants. Women who participate in other federal assistance programs (SNAP, TANF, Medicaid) are also automatically eligible. WIC is fully federally funded and administered by states.

In contrast to SNAP, nutritional content from major food groups is federally mandated for WIC. A pregnant woman, for example, can purchase cereal, milk, fruits and vegetables, whole grains and legumes. An older infant (ages 6–11 months) is eligible to receive formula, infant cereal and baby food (fruit, vegetables, meat) (Oliveira and Frazao 2009). Perhaps because of the strong nutritional component of WIC benefits, program participation has positive effects on birth outcomes and the quality of children's diets. Pregnant women and their young children who participate in WIC have higher nutrient intake than their similar peers who do not, based on both observational and experimental study designs (Fox, Hamilton and Lin 2004; Metcoff et al. 1985; Rush et al. 1988). In addition, mothers who participate in WIC are more likely to have babies with a healthy birthweight, an important indicator of fetal growth and maternal nutrition (Bitler and Currie 2005, Foster, Jiang and Gibson-Davis 2010; Kowaleski-Jones and Duncan 2002; Owen and Owen 1997; Rossin-Slater 2013). A parallel body of research documents the relationships among nutrition, cognitive development and academic achievement around the world, whether measured by irondeficiency anemia, height, or policy participation (Behrman et al. 2009; Glewwe and King 2001). Appropriate weight gain during childhood and iron supplementation among anemic children, for example, increases test performance and learning capacity, with the primary pathway believed to operate physiologically through changes in the structure and function of the central nervous system, and structurally through a heightened ability to focus in the classroom (Martorell et al. 2010; Grantham-McGregor and Ani 2001; Roncogliolo et al. 1998).

While the nutritional aim of WIC—namely, providing supplemental access to healthy foods that improve the dietary quality and health of participating pregnant women and their babies—is key, the program also has educational aims. WIC participants are offered the opportunity to enroll in nutrition education classes that inform caregivers about the nutritional needs of children, the benefits of breastfeeding, and the importance of physical activity. Participants also receive assistance in accessing other health care services. The availability of different types of benefits via WIC means that participants likely benefit directly (via their ability to obtain foods essential to healthy child development) and indirectly (via increased knowledge about healthy choices).

WIC Participation, Cognitive Development and Academic Achievement

WIC participation is a good marker of prenatal and early childhood nutrition and health environments, which are in turn strongly linked to cognitive development, academic learning, and eventual socioeconomic attainment. Such evidence provides a strong rationale for examining the non-health effects of children's participation in the program. Little evidence, however, extends this examination to cognitive development and academic progress. A small body of research links children's WIC participation to improvements in cognitive functioning and academic progress, finding that children who participate in the program at some point during the period of eligibility have stronger skill development in early childhood (Hicks, Langham and Takenaka 1983; Rush et al. 1988). Much existing work relies on clinical samples and uses cross-sectional data, making it difficult to track children's progress and appropriately measure their other circumstances.

I use national data to examine the association of WIC participation with cognitive development in the short term and academic progress in the longer term. Research examining how child health influences the development of academic inequality throughout the school years suggests a cumulative process that begins early and grows over time (e.g., Cheadle and Goosby 2010). Whether disparities in skill development and learning grow as children age (Magnuson, Waldfogel and Washbrook 2012) or emerge early but remain stable as children age (Schady et al. 2015), WIC participation may be associated with a learning advantage that persists beyond the period of program participation into the school years.

Despite an active body of research on the effects of WIC participation, methodological challenges make it difficult to identify an unbiased estimate. The greater socioeconomic disadvantage of WIC enrollees compared to both the ineligible population, and potentially the eligible population who does not enroll, means that there is a substantial correlation between socioeconomic measures and both WIC participation and children's outcomes (Bitler and Currie 2005; Kowaleski-Jones and Duncan 2002). An increasingly common approach to examining the effects of WIC is to use statistical techniques well-suited to address the problem of non-random selection into the program, including fixed-effects models and matching approaches (Foster, Jiang and Gibson-Davis 2010; Rossin-Slater 2013). In this study, I use coarsened exact matching to thoroughly control for observable characteristics associated with the probability of participating in WIC, generating "treatment" and "control" groups that have highly similar empirical distributions on observed variables. Sibling data and within-family variation in WIC participation also permit me to estimate models with maternal fixed effects, which control for both observed and unobserved characteristics that do not vary within mothers, including many dimensions of economic circumstances and maternal behavior.

Data

To examine the short-term association between early WIC participation and cognitive development, I analyze data from the birth cohort of the Early Childhood Longitudinal Study (ECLS-B). The ECLS-B represents the national population, contains rich longitudinal information on families' and children's health, and oversamples ethnic minority families, following about 11,000 children over four waves between ages 9 months (2001) and kindergarten (2008). To examine the longer-term association of WIC participation with reading and math achievement, I analyze data from the Child Development Supplement

(CDS) of the Panel Study of Income Dynamics (PSID). The PSID is a nationally representative, longitudinal study of families that began in 1968 and provides data on more than 65,000 individuals. Beginning in 1997, respondents from the main PSID sample were selected to participate in the CDS if they had at least one child under age 13, yielding 3,563 children ages 0–12. Mean age in 1997 is six years. In 2002 and 2007, follow-up waves were conducted with response rates of 90%. A useful feature of the CDS design, described in greater detail below, is its inclusion of siblings.

These two data sources are complementary and well-suited for the goals of this research. The ECLS-B provides data on a large cohort of children at very young ages, as well as repeated measures of WIC participation from the prenatal period to school entry. The CDS enables longer-term examination of the relationship between WIC and academic achievement. While it would be ideal to follow one sample of children from birth through the school years, available data source for doing so (e.g., the children of the NLSY79 sample) provide a much smaller sample of children for whom WIC participation is measured, born to a sample of older than average mothers. In descriptive analyses below, I demonstrate the similarity and representativeness of the two data sources used here.

Measures

WIC Participation

I create comparable measures of WIC participation across surveys that capture children's exposure to the program very early in life. In both surveys, my final models compare children who are exposed to WIC in utero to those who are not. In the ECLS-B, women were asked during the nine-month survey if they used WIC vouchers to buy food for themselves during pregnancy. The vast majority of children (97%) who are exposed to WIC in utero also participate at some point prior to age three. Using this measure therefore captures the relationship of prenatal *and* early childhood WIC participation with cognitive development. In supplementary analyses, I explore several additional measures of WIC timing and duration, including the timing/duration of enrollment during pregnancy, and during the child's first two years. The relative continuity of children's participation in the program, combined with ECLS-B samples sizes, makes it difficult to identify potentially meaningful timing and duration effects.

In the CDS, I also compare children who received prenatal WIC exposure to those who did not. In 1997, the first wave of the survey, mothers were asked whether they were in the WIC program while pregnant with the child. It is possible that both children who were and were not exposed in utero also participated during early childhood—in fact, this is likely among those exposed in utero—though CDS data do not permit me to directly observe this possibility. As in the ECLS-B, any positive effect of the program may be driven by both prenatal and early childhood participation.

Cognitive Development and Academic Achievement

I examine two separate constructs—cognitive skill development before school entry, and academic achievement during the school years. In the ECLS-B, I measure children's performance on the mental scale of the Bayley Short Form-Research Edition (BSF-R). The

Bayley mental assessment includes a subset of items from the larger Bayley Scale of Infant Development, an assessment of general mental ability that indicates problem solving and language acquisition skills. I examine z-scores at age two, though results using nine month scores do not substantively differ. Academic achievement measures, available in the CDS, come from the Woodcock-Johnson Revised reading and math achievement tests, administered to children ages three and older at all waves. I present results from 2002, when children are 11 years old, on average. Analyses using the 2007 wave, when children are older but sample sizes are smaller, yield very similar findings. I use z-scores on three achievement scales—applied problems, letter-word identification and broad reading—in order to evaluate children's performance relative to their sample peers. While the use of z-scores means that the sample average will be 0, upward or downward deviation will indicate performance relative to the mean.

Other Variables

In both surveys, I impute missing data on predictors and outcomes due to item non-response, but not wave non-response, using multiple imputation procedures (five imputations). I compare these results to those using mean value replacement and listwise deletion, and do not find substantively different results. In the ECLS-B, I limit analyses to children whose families were *eligible* for participation during each year. Eligible children are those at or below 185% of the federal poverty threshold during the year leading up to the survey, or those whose mothers participate in other federal assistance programs (SNAP, TANF, and Medicaid) and are automatically eligible to enroll themselves (while pregnant or post-partum) or their children in WIC. I also measure household poverty ratio (above 185%, 130–185%, below 130%) and other program participation (food stamps, Medicaid, TANF) during the year leading up to the survey as separate covariates in analyses. I measure several other variables that are strong correlates of WIC participation and child development (Bitler and Currie 2005; Kowaleski-Jones and Duncan 2002): children's *race/ethnicity* (non-Hispanic white, reference; non-Hispanic black; Hispanic; Asian; other), *sex* (male=reference), *number of siblings*, *maternal education* (less than high school, reference; high school; some college; college or higher), *maternal immigrant status* (native-born=reference), *maternal marital status*, *maternal age at birth* and *maternal paid employment* (including both part and full-time work). Finally, I measure smoking behavior during the last trimester of pregnancy (number of cigarettes) and the frequency of mothers' reading with children (ranging from 1, not at all, to 4, every day), in order to capture parental behaviors that may be related to the likelihood of enrolling in WIC and, more broadly, investing in children's development (Harkonen et al. 2012; Parcel, Dufur and Zito 2010). All measures are taken from the nine-month survey to capture circumstances in the first year of life, though analyses using measures at age two do not yield different findings.

In the CDS, the sibling analytic design controls for many family-level measures. I control for several measures that may vary between siblings during the year of mothers' WIC participation, in order to capture within-family differences in both economic circumstances and parental behavior. To capture economic circumstances during pregnancy and the time of children's birth, I measure the child's *household poverty ratio* in the birth year, as well as the receipt of assistance from other public agencies during the birth year. In OLS (between-family) models, I also measure the child's poverty ratio in 2002, the year at which achievement is measured, to capture recent economic circumstances. Poverty ratios are measured consistently across years and adjusted for inflation and family size, using thresholds constructed by Grieger, Danziger and Schoeni (2009). I also measure *maternal education* (in years), *maternal marital status* in the birth year (and in 2002 in OLS models), *child race* (non-Hispanic white, reference; non-Hispanic black; other), *child sex* (male=reference), *child age in 2002* (in years), *birth order* (older=reference) and maternal employment in the birth year (and in 2002 for OLS models). Finally, I measure the number of days/week that mothers read with their children in 1997, when parents are asked about this behavior for all children.

Given the broader aims of the WIC program beyond improving nutrition (e.g., referring families to other services, providing education about breastfeeding and offering regular health visits), in both surveys I conduct analyses with and without measures of children's *low birth weight* status and whether the mother *breastfed* the child.

Methods

The analysis proceeds in several steps that permit examination of the cognitive and academic benefits associated with WIC participation. After estimating OLS models to establish baseline associations in both surveys, I extend the OLS approach to more rigorously control for child and family-level characteristics. While the extensive data collection of both surveys permits measurement of many between-child and between-family differences that are correlated with both WIC participation and children's development, an OLS approach does not address at least two concerns. First, because WIC participation does not vary randomly in the population, it is possible that children who do and do not participate have varying distributions of correlated characteristics. Matching provides a way of generating "treatment" and "control" groups that have highly similar empirical distributions on observed variables—as such, it provides a method of thoroughly controlling for observable selection in the program. In the ECLS-B I use coarsened exact matching (CEM) to adjust for nonrandom assignment to WIC among eligible children. CEM, an increasingly applied matching technique, creates balanced strata according to user-defined cutpoints for each covariate, and uses those strata to generate weights used in estimating the average treatment effect (Blackwell et al. 2009; Sharkey 2012).

In this approach, the effect of the treatment—in this case, WIC participation in the first two years of life—on cognitive development is unbiased under the assumption of ignorable treatment assignment within strata. Other matching techniques, including propensity score matching, match respondents into treatment and control groups based on the probability of being in the treatment group (e.g., Rosenbaum 2002). In contrast, CEM automatically restricts the matched data to areas of common empirical support, within bounds of imbalance determined by the analyst. (Sensitivity analyses using propensity score matching (radius matching) yield very similar results and are available by request.) This approach avoids arbitrary bounding cutoffs that are more likely in other matching techniques, permitting the analyst to make substantive decisions about appropriate bounds of imbalance. Final matching variables and categories, chosen because of their demonstrated correlation with WIC in previous research, are listed in Table 1. Results are robust to several alternative bounds for each matching variable. The analytic sample consists of 5,323 matched WIC-eligible children (out of 6,120 eligible children), of whom 3,528 are in the treatment group and 1,855 in the control group.

CDS data permit me to address a second limitation of a traditional regression approach in studying the effects of WIC—the possibility that unobserved differences between families are driving the observed association between WIC and child development. In particular, a simple comparison of children who do and do not participate in WIC is likely to be biased downward because children who participate in WIC come from disadvantaged families. I use sibling data to estimate models with mother fixed effects, which control for many unmeasurable differences between children in the same household and restrict the comparison to children in the same family, who share highly similar socioeconomic environments but vary in their WIC participation. Estimates are identified from siblings who differ in their exposure to WIC. There are sizeable sibling differences in program participation: about 14% (N=263) of the 1,856 CDS children who are siblings differ in their WIC participation. This sample size and proportion is comparable to or larger than those used in existing sibling examinations of early childhood environments (including Head Start) and academic achievement (e.g., Deming 2009; Dunifon and Kowaleski-Jones 2003; Garces, Thomas and Currie 2002). I compare fixed effects estimates to OLS (between-family) estimates identified from the sample of siblings who vary in their participation, while adjusting standard errors for clustering at the mother level. Restricting the comparison to siblings controls many sources of variation between children (e.g., economic disadvantage), whether observed or not, that could downwardly bias the estimated influence of WIC participation.

The inclusion of mother fixed effects also controls for many sources of variation between children that could upwardly bias estimated WIC effects. For example, approaches to parenting that are correlated with WIC enrollment and child development, but are stable within mothers, are controlled for in a sibling comparison. However, sibling comparisons do not control for factors that vary between siblings, such as differing economic circumstances around the time of birth, or differential parental behavior toward siblings. If differential selection into WIC within families is driven by unobserved processes that are not correlated with the outcomes (e.g., changing awareness about WIC between births), then estimates will not be biased. If unobserved processes are correlated with the outcomes, however, then estimates may be biased upward. Changes in parents' approach to "healthy" parenting, for example, may make it more likely for one sibling to be exposed to the program—though this possibility is not consistent with evidence that the most disadvantaged eligible mothers are the most likely to enroll in WIC, as will be confirmed below (Currie 2008). I address the possibility for non-random WIC enrollment within families by: 1) controlling for several family-level measures that vary between siblings and may be correlated with WIC enrollment and cognitive/academic development; and 2) describing observable variation between siblings who do and do not participate, in order to provide a sense of sources of sibling variation.

Findings

Sample Characteristics and WIC Participation/Takeup

Table 1 presents weighted summary statistics for the ECLS-B and CDS total and analytic samples. About 40% of ECLS-B children were exposed to WIC at some point in utero (and 97% of these children also participate prior to age three). Participation is substantially higher among the analytic sample of WIC-eligible children, with almost 70% of children in this group receiving prenatal exposure. The sample of matched children has very similar characteristics. In the CDS (bottom panel), 31% of children in the total sample were exposed to WIC in utero, and 47% of children in the analytic sample of siblings who vary in their WIC participation.

Examining cognitive development and academic learning is consistent with a pattern of greater disadvantage among the analytic samples in each survey, relative to the total samples. The mean Bayley mental development z-score is −0.208 among the WIC-eligible sample and −0.190 among the matched sample. Similarly, reading and math achievement z-scores in 2002 are lower among the CDS sibling sample than among the total sample. With respect to sociodemographic characteristics, children in the analytic samples are less likely to be non-Hispanic white than those in the overall sample, less likely to have a mother with a college degree, and more likely to have a lower household poverty ratio. They are slightly more likely to be born with a low birthweight (in the ECLS-B only), and slightly less likely to have ever been breastfed.

The descriptive patterns in Table 1 demonstrate that the analytic samples here are more socially and economically disadvantaged than the total ECLS-B and CDS samples, but that they represent the more disadvantaged, WIC-eligible population well. Children who are not successfully matched in the ECLS-B have generally similar profiles to those who are matched, but they are disproportionately non-Hispanic black children whose mothers have above-average education and receive TANF benefits in the year of children’s birth. The estimates from ECLS-B analyses should therefore be taken as estimates of the relationship between WIC participation and cognitive development among disproportionately non-black children.

Table 2 presents the characteristics of analytic sample children who do and do not receive prenatal WIC exposure. The first panel compares characteristics of ECLS-B treatment and control groups, conditioning on WIC eligibility for the matching process. Mean characteristics of the matched treatment and control children are quite similar, suggesting that the matching procedure substantially reduces variability in the observable background characteristics of participating and non-participating children. Sensitivity analyses that omit parenting behaviors (breastfeeding, reading frequency, smoking during pregnancy) from the matching and compare differences in treatment and control group means also yield near-zero differences on matching variables, suggesting that the matching procedure is successful at balancing on not only observable characteristics, but also on many measures that are often unobserved by researchers.

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In the CDS sibling sample, mothers of siblings who receive prenatal exposure have a slightly lower household poverty ratio in the year of the child's birth, on average, but do not practice meaningfully different breastfeeding or reading behavior with their participating children. Participating siblings are also less likely to be born with a low birth weight. Younger siblings are more likely to be exposed to WIC in utero than their older siblings (60% vs. 40%). This difference suggests that an important reason for sibling variation in WIC participation is families' increased knowledge of the program by the time a second child is born, rather than striking variation in families' economic circumstances or parents' childrearing behaviors—though I am not able to measure changes in program information or knowledge between births. (Among the sibling analytic sample I examine variation in mothers' reports of prenatal WIC participation by children's age, and do not observe a pattern consistent with the possibility of recall bias.)

These descriptive comparisons suggest two points. First, evidence from the CDS that mothers who enroll during pregnancy are more socioeconomically disadvantaged is not consistent with the idea that WIC-participating mothers and families are disproportionately committed or prepared to invest in their children's development compared to similar mothers who do not enroll, which could be a possible interpretation of a positive WIC participation coefficient. Secondly, WIC-enrolled children are no more likely to be born with a low birth weight than their similar non-enrolled peers, despite a greater likelihood of experiencing the socioeconomic disadvantages associated with low birth weight. This pattern is consistent with the idea that WIC provides nutritional and educational resources to offset coexisting disadvantage. The multivariate analysis will test this possibility more rigorously.

Prenatal WIC, Cognitive Development and Academic Learning

Table 3 presents estimates from regression analyses of the relationship between WIC participation and cognitive development at age two, using ECLS-B data. One column displays OLS results and one column displays results from the matching analysis. Prenatal/early childhood WIC exposure is associated with significantly stronger cognitive development. This finding is consistent across both OLS and matching analyses, with results from the matching models slightly reduced in magnitude but still significant. Children who receive prenatal/early childhood exposure score about 0.062 standard deviations higher on the Bayley Mental Development assessment than their similar peers who do not receive exposure in utero. The magnitude of this coefficient is meaningful. While about a quarter of the size of the striking race/ethnic and maternal education gaps in early cognitive development (e.g., 0.238 SD gap between non-Hispanic black and white children; 0.246 SD gap between children of the highest and lowest educated mothers), this difference is comparable in size to the relationship between breastfeeding and cognitive development.

Table 4 extends the analysis to consider whether a learning benefit persists into the school years. Separate panels display the findings for children's applied problems, letter-word identification and broad reading achievement z-scores. The first column in each panel shows estimates from analyses with mother fixed effects, comparing siblings who vary in the timing of their WIC exposure. These models control for circumstances that differ between siblings (e.g., household income in birth year, maternal behaviors, sex). Findings from these analyses demonstrate that children who receive prenatal/early childhood WIC exposure perform significantly better on reaching assessments than their siblings who do not receive exposure in utero. Whether measured by passage comprehension or broad reading scores, this advantage is close to 0.3 of a standard deviation. Prenatal/early childhood WIC exposure is associated with a 0.09 SD advantage in math achievement relative to a non-participating sibling, though this coefficient is not significant at the 0.05 level.

These findings support the idea that the benefits of WIC participation are not confined to the years of program participation, but extend into the school years. Consistent with evidence that early skill differences compound as children age, the magnitude of the association between WIC participation and reading achievement is larger than its observed association with early childhood cognitive development, though formal comparison of these differences is not possible. In order to understand whether these findings reflect unobserved factors correlated with WIC participation, OLS regression estimates from the same sample, which compare children both within and between families, are presented in adjacent columns in Table 4. Though smaller in magnitude, the findings are quite similar, suggesting that the within-family estimates are not substantially different than OLS estimates that do not control for unobserved factors that vary between families, such as housing quality and parental decision-making.

Additional Analyses

CDS analyses described above include some non-participating children whose families may not have been eligible for WIC during their birth year. As a sensitivity analysis, I limit the analysis to children whose births were paid for by Medicaid, in order to conservatively restrict the economic circumstances of participating and non-participating children. Bitler and Currie (2005) and Foster, Jiang and Gibson-Davis (2010) perform similar sensitivity analyses. While statistical significance varies and sample sizes become smaller, the substantive results remain unchanged. In a separate sensitivity analysis with CDS data, I examine the possibility for variation in the effects of WIC by birth order, interacting WIC participation with birth order. WIC may have a larger effect on younger children's development if there are spillover benefits from older siblings' participation. I find no evidence for spillover effects, potentially because younger siblings are more likely to participate.

Discussion

For the large fraction of American children living in economically disadvantaged circumstances, WIC is an important part of the social safety net meant to facilitate healthy child development. By providing steadily available nutritious food to pregnant women and their young children, the program leads to improved nutrition among participants and increases in the birthweight of exposed children. This article uses national and longitudinal data to examine the extent to which WIC is associated with the cognitive development and academic achievement of similar children who do and do not receive in utero exposure to the program. While much evidence links WIC participation to birth outcomes and dietary quality, we know little about whether these improvements enable healthy development in other domains.

Results suggest that there are meaningful short-term cognitive benefits associated with prenatal/early childhood exposure to WIC. This association is comparable in size to that between breastfeeding and cognitive development, and about one quarter of the size of the race/ethnic and socioeconomic gradient. Second, the benefit associated with WIC participation persists into the school years. Within-family comparisons of siblings who vary in the timing of their WIC participation suggest that children who receive prenatal/early childhood exposure to WIC perform significantly better on reading assessments—up to 0.3 of a standard deviation—than their siblings who do not. This association is not explained by measurable differences in parental behavior toward siblings, such as time spent reading with children or breastfeeding behavior, nor is it explained by differences in families' economic circumstances during the child's birth year. Within-family estimates are very similar to, and usually slightly larger than, between-family estimates identified from the same sample of children. This finding is consistent with a pattern of negative selection into WIC, whereby those most in need of the program's benefits are most likely to enroll. Thoroughly controlling for the characteristics of participants yields the most positive association with children's development.

While available data do not yet permit a benefit-cost analysis of WIC over the life cycle, it is worth considering the magnitude of the associations observed here by comparing them to those observed for other programs. Previous analyses of comprehensive early childhood interventions in the U.S., including Head Start and the Perry Preschool project, suggest that their average impact on teenage outcomes is 0.26 standard deviations (e.g., Deming 2009). The associations observed here for school-age outcomes (mean age of 10.5) range from 0.09 to 0.26 SD. While some degree of "fadeout" is expected as children age, this suggests that the benefits of WIC may be sizeable. Because the costs of WIC are smaller than those of other early childhood intervention programs, at an estimated cost of $49/month per participant, the "break-even" effect size may be small. As data become available, it will be useful to estimate benefit-cost ratios for WIC in order to assess the long-term economic benefits of the program, as has been done for similar programs in developing countries.

The results of this analysis should be interpreted in the context of the study's limitations. First, the results should not be interpreted as evidence that WIC is positively associated with cognitive and academic development only if exposure occurs during the prenatal period. Though only prenatal exposure is measured in the CDS, and I measure prenatal exposure in the ECLS-B in order to construct comparable measures across surveys, the great majority of children who receive prenatal exposure also participate in early childhood, making it impossible to separately examine the influence of participation during these two periods. The associations observed here should be interpreted as a positive influence of early childhood WIC participation, which could be driven by either prenatal or early childhood participation. Second, as with any statistical model applied to observational data, the analyses do not rule out the possibility of bias due to unmeasured factors that determine both WIC participation and children's cognitive and academic development. Despite the highly similar samples of participating and non-participating children created by the matching and sibling designs, the results should be interpreted as upper-bound estimates of the impact of WIC. Matching techniques control exclusively for observable selection into the program, while sibling designs do not account for unmeasurable differences between siblings that may be related to both WIC participation and development. The fact that more economically disadvantaged eligible mothers are the most likely to enroll in WIC suggests that take-up is not limited to the parents who are best prepared to invest in children’s development, and that WIC participation is not simply a proxy for parenting behavior. However, it is possible that exposed children have other unmeasured advantages at a very young age compared to their similar unexposed counterparts, such as access to books and developmental toys. This type of unobserved difference could result in an overestimate of the WIC participation coefficient estimated here. At the same time, the results reported here may be underestimates. If WIC is not perfectly measured, or if WIC participation results in parents investing fewer compensatory resources toward children than they otherwise would, the results may be downwardly biased (e.g., Hoddinott et al. 2013).

Finally, and relatedly, a rich examination of the mechanisms that link prenatal WIC exposure to cognitive development and academic achievement is beyond the scope of this study and the data analyzed here, and of most data sources. The mechanisms that link WIC participation to improvements in cognitive and academic development are simultaneously nutritional, health-related and educational. Variation in pregnant women’s and children’s dietary intake, health and use of WIC educational resources remain unmeasured in this study. Though controlling for children’s breastfeeding status and birth weight does not explain the association between WIC exposure and children’s development, it is surely the case that the estimated WIC coefficients reflect, in part, the multifaceted aims of the program. While these underlying processes could be thought of as a form of bias, they are equally part of the mechanisms through which WIC works. Exploring these processes is an important task for future research.

In addition to their relevance to public policy, the findings provide evidence in support of two central tenets of life course models of health and social stratification. First, the early life course is a sensitive period that manifests in developmental inequality well before children enter school. The findings reported here are consistent with the growing body of evidence implicating early environmental circumstances, and early health environments in particular, in generating durable cognitive and social inequality. Second, the persistence of a learning advantage associated with WIC participation into the school years is consistent with the idea that the development of inequality during childhood is cumulative, as inequality emerges early and is maintained as children age. Finally, this research has implications for understanding the mechanisms underlying the intergenerational reproduction of disadvantage. Social scientists have long been concerned with the mechanisms underlying the social distribution of child health and development, with explanations for a socioeconomic gradient among young children often emphasizing maternal behavior, and nutrition in particular. These findings suggest that WICmeaningfully contributes to children’s educational prospects.

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Table 1

Descriptive Statistics, ECLS-B and PSID-CDS

ECLS-B (Matching categories in parentheses)	Total	Eligible at Birth	Matched	Unmatched
Prenatal WIC Participation	40	68	67	74
Cognitive Development				
Bayley Cognitive Development Z-Score, Age 2	0	−0.208	−0.19	−0.28
Sociodemographic Characteristics				
Male	50	50	50	50
Non-Hispanic White (reference)	57	37	30	24
Non-Hispanic Black	14	20	20	39
Hispanic	26	36	28	22
Asian	3	2	7	8
Other	4	5	12	7
Number of Siblings, 9 Months (0, 1, 2, 3+)	1	1	1.2	1.6
Mom Immigrant	22	28	25	32
Mom Age at Birth (Under 18, 5 year interval thereafter)	27.4	25.1	25.5	27.3
Mom Less than HS (reference)	20	33	34	32
Mom HS	32	41	41	35
Mom Some College	24	21	21	19
Mom College or Higher	24	5	4	13
Household Poverty Ratio Below 130%	36	65	66	65
Household Poverty Ratio 130–185%	12	23	22	20
Household Poverty Ratio Above 185% (reference)	52	12	10	15
Medicaid, Age 9 months	38	69	69	67
Food Stamps, Age 9 months	20	37	38	49
TANF, Age 9 months	8	15	14	28
Mother Married, Age 9 months	67	47	49	52
Mother Employed Full/Part Time, 9 Months	50	43	43	41
Average # Cigarrettes/Day During Last Trimester (0, 1, 2, 3+)	0.17	1.05	0.7	0.77
Average Reading to Child, 9 Months (1=not at all, 4= every day)	2.69	2.52	2.64	2.93
Ever Breastfed	69	62	59	61
Low Birthweight	7	9	9	10
N	10,221	6,120	5,323	727

PSID-CDS	Total	Sibling Varying Sample
Prenatal WIC Participation	31	47
Academic Achievement		
Applied Problems Z-Score, 2002	0	−0.085
Passage Comprehension Z-Score, 2002	0	−0.101
Broad Reading Z-Score, 2002	0	−0.061
Sociodemographic Characteristics		
Non-Hispanic White	64	39

ECLS-B (Matching categories in parentheses)	Total	Eligible at Birth	Matched	Unmatched
Non-Hispanic Black	16	14		
Other	21	47		
Female	50	50		
Mean Age, 2002	11	10.5		
Mother Married, Birth Year	71	69		
Mother Married, 2002	64	67		
Mother Employed Full/Part Time, Birth Year	45	47		
Mother Employed Full/Part Time, 2002	51	59		
Maternal Education (mean years)	12.68	11.28		
Mean Household Poverty Ratio, Birth Year	2.75	1.82		
Mean Household Poverty Ratio, 2002	2.85	2.05		
Mean Number of Children in Household, 2002	2.3	2.8		
Other Program Participation, Birth Year	16	20		
Younger Sibling	37	45		
Mean Read to Child, 1997 (# Days/week)	4.36	4.18		
Low Birthweight	7	6		
Ever Breastfed	58	54		
N	2,904	263		

Cells include percentages unless otherwise specified.

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Table 2

Differences between Similar WIC Participants and Non-Participants

ECLS-B WIC Eligible, 9 mos.

	Post-Match (N=5,323)	**Pre-Match (N=6,120)**
Male	0	0
Non-Hispanic White	0	0.08
Black	0	0.09
Hispanic	0	0.05
Asian	0	0.07
Other	0	0.03
Number of Siblings, 9 Months (0, 1, 2, 3+)	0	0.07
Mom Immigrant	0	0.07
Mom Age at Birth (Under 18, 5 year interval thereafter)	0.05	2.3
Mom Less HS	0	0.08
Mom HS	0	0.06
Mom Some College	0	0.07
Mome College or Higher	0	0.07
HH Pov. Ratio Below 185%, 9 Months	0	0.06
HH Pov. Ratio Below 130%, 9 Months	0	0.2
Medicaid, 9 Months	0	0.21
Food Stamps, 9 Months	0.01	0.22
TANF, 9 Months	0.01	0.09
Married, 9 Months	0	0
Mother Employed Full/Part Time, 9 Months	0.02	0
# Cigarettes/Day During Last Trimester (0, 1, 2, 3+)	0.02	0.54
# Days/Week Read to Child (0, 1–2, 3–6, 7)	0.02	0.05
Breastfed	0	0.09

PSID-CDS, Sibling Sample

	Sibling, Enrolled Prenatally (N=123)	**Sibling, Not Enrolled Prenatally (N=140)**
Female	50	50
Mean Age, 2002	9.8	11.3
Mother Married, Birth Year	69	69
Mean Household Poverty Ratio, Birth Year	1.76	1.96
Other Program Participation, Birth Year	36	17
Mother Employed Full/Part Time, Birth Year	50	48
Younger Sibling	60	40
Read to Child, 1997 (# Days per week)	4.2	4
Low Birthweight	8	12
Ever Breastfed	46	44

*Treatment is prenatal WIC exposure.

Cells include percentages unless otherwise specified.

Table 3

Regression of Age 2 Cognitive Development (Bayley Mental Development Z-score) on WIC Participation: Eligible ECLS-B Children

	OLS	Matching
WIC	0.0686* (0.03)	0.0625* (0.03)
Child Race/Ethnicity		
NH Black	−0.261** (0.04)	−0.238** (0.04)
Hispanic	−0.195** (0.04)	−0.256** (0.04)
Asian	0.150* (0.07)	0.006 (0.08)
Other	−0.054 (0.04)	−0.065 (0.05)
Male	−0.278** (0.03)	−0.275** (0.03)
Number of Siblings	−0.052** (0.02)	−0.051** (0.02)
Maternal Age at Birth (years)	−0.0045 (0.01)	−0.0057 (0.01)
Mom Immigrant	−0.205** (0.04)	−0.238** (0.04)
HH Poverty Ratio		
Below 185%	0.029 (0.05)	−0.031 (0.04)
Below 130%	−0.028 (0.04)	−0.011 (0.04)
Maternal Education		
HS	0.021 (0.03)	0.076 (0.03)
Some College	0.191** (0.04)	0.212** (0.04)
College or more	0.256** (0.06)	0.246** (0.09)
Unmarried, 9 Months	−0.011 (0.03)	−0.0070 (0.03)
Mother Employed Full/Part Time, 9 Months	0.082* (0.03)	0.071* (0.03)
Food Stamps	−0.016 (0.03)	−0.015 (0.03)
Medicaid	−0.118** (0.03)	−0.083* (0.04)
TANF	−0.097* (0.04)	−0.188* (0.06)
Smoked during pregnancy	−0.0037 (0.00)	−0.006* (0.00)
N	6,120	5,323

Sample limited to children in WIC-eligible families during year of birth. Reference categories are as follows: race (non-Hispanic white); poverty ratio (above 185%); maternal education (less than high school).

Table 4

Regression of 2002 Academic Achievement on WIC Participation, PSID-CDS Siblings (N=263)

	Applied Problems Z-Score		Letter-Word Identification		Broad Reading Z-Score	
	Within-Family	Between-Family	Within-Family	Between-Family	Within-Family	Between-Family
	FE	OLS	FE	OLS	FE	OLS
Prenatal WIC	0.091 (0.12)	0.029 (0.11)	0.256* (0.12)	0.194* (0.09)	0.260* (0.11)	0.197* (0.09)
Age, 2002 (Years)	−0.032 (0.02)	−0.035** (0.01)	0.017 (0.02)	−0.021** (0.01)	−0.023 (0.02)	−0.037 (0.03)
Male	−0.034 (0.06)	−0.121 (0.05)	0.187** (0.06)	−0.074 (0.13)	0.208* (0.10)	−0.020 (0.13)
Black	–	−0.654** (0.15)	–	−0.159** (0.05)	–	−0.121 (0.20)
Other	–	−0.618** (0.25)	–	−0.10 (0.09)	–	−0.187 (0.24)
Number of Kids in Household, 2002	–	−0.015 (0.08)	–	−0.245* (0.11)	–	−0.204* (0.08)
Maternal Education	–	0.076* (0.04)	–	0.034** (0.01)	–	0.036* (0.02)
Unmarried, 2002	–	−0.235 (0.19)	–	−0.296 (0.07)	–	−0.068 (0.07)
Unmarried, Birth	−0.0075 (0.11)	−0.215 (0.16)	−0.101 (0.12)	−0.070 (0.06)	−0.031 (0.11)	−0.024 (0.06)
Mother Employed Full/Part Time, Birth Year	0.016 (0.01)	0.019 (0.01)	0.017 (0.01)	0.018 (0.01)	0.014 (0.01)	0.015 (0.01)
Household Poverty Ratio at Birth	0.010 (0.02)	0.150* (0.07)	0.034 (0.02)	0.028** (0.01)	0.024 (0.02)	0.070 (0.08)
Household Poverty Ratio, 2001	–	0.148* (0.08)	–	0.030 (0.01)	–	0.057 (0.10)
Other Program Particiaption, Birth Year	−0.026 (0.13)	−.057 (0.17)	−0.121 (0.27)	−0.080 (0.06)	−0.160 (0.19)	−0.058 (0.15)
Younger Sibling	0.011 (0.08)	−0.081 (0.14)	0.089 (0.08)	−0.041 (0.16)	0.034 (0.08)	−0.026 (0.16)

Reference categories are as follows: race (non-Hispanic white).