

Boys' Cognitive Skill Formation and Physical Growth: Long-Term Experimental Evidence on Critical Ages for Early Childhood Interventions[†]

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The effects of early life circumstances on cognitive skill formation are important for later human capital development, labor market outcomes, and many aspects of well-being (Grantham-McGregor et al. 2007; Heckman 2007). Nonexperimental evidence in economics shows negative shocks in early childhood result in worse outcomes later in life (Almond and Currie 2010). And the medical literature highlights the importance of in utero development (Barker 1992) as well as the risk of growth faltering from birth to age two (Victora et al. 2010). Policies are, therefore, often targeted to the first 1,000 days of a child's life—from conception to the second birthday. However, experimental evidence on the longer-run effects of *interventions* targeted and designed to improve early life health and nutrition is sparse, and results are mixed.¹ These mixed results may be due in part to differences in timing of the various interventions, including the possibility that interventions later in life (even if still in early childhood) can

partly or even fully compensate for earlier deficits (Adair 1999; Doyle et al. 2009).

In this paper, we test the hypothesis that the first 1,000 days are the critical window for both cognitive skill formation and physical development by exploiting a randomized conditional cash transfer (CCT) program in Nicaragua, in which an early treatment group received program benefits from 2000 to 2003, and a late treatment group from 2003 to 2005. To maximize power, we focus on boys since they are more vulnerable in early life than girls, particularly during the prenatal period (Eriksson et al. 2010). The short-term evaluation of the program showed large and significant improvements in nutrition and health during early childhood (Maluccio and Flores 2005; Barham and Maluccio 2009),² in line with evidence from similar programs in many other countries (Fiszbein and Schady 2009). Using 2010 data and taking advantage of the randomized phase-in, we estimate intent-to-treat effects on differential cognitive and physical development of ten-year-old boys exposed to the program starting in utero and up to age two in the early treatment group, versus those exposed between ages two and five in the late treatment group. Seven years after the households in the early treatment group stopped receiving transfers, boys exposed to the program earlier in life had better cognitive, but not physical, outcomes.

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¹ See Barnett (1995); Garces, Thomas, and Currie (2002); Walker et al. (2005); Maluccio et al. (2009); and Barham (2012).

² The short-term evaluation did not collect data to measure impacts on cognition, but sustained cognitive gains in early childhood have been found for another CCT in Nicaragua (Macours, Schady, and Vakis 2012).

I. The Conditional Cash Transfer Program and Experimental Design³

The Nicaraguan CCT program, *Red de Protección Social (RPS)*, provided cash transfers to poor rural households conditional upon beneficiaries engaging in behaviors beneficial to their children's health, nutrition, and education. Social marketing emphasized that the money was intended for food and education. On average, the transfers were approximately 18 percent of preprogram expenditures and delivered bimonthly to a designated female caregiver. Separate amounts were transferred for, and different conditions applied to, the health and education components of the program. For health, all households were eligible for a fixed amount per household.⁴ The transfer was conditional on the designated caregiver attending bimonthly health educational workshops and children under five going to regular preventive health-care visits that included growth monitoring. Health services were free and delivered by private health providers contracted by *RPS*. While households in the early treatment group were no longer eligible for the cash transfers after 2003, the provision of free private health services to them continued through 2005.

The short-term evaluation took place in 42 localities in six rural municipalities with initial poverty rates of 80 percent. Localities were randomized into early and late treatment groups at a public lottery, with stratification based on poverty levels. The 21 early-treatment localities became eligible for transfers in November 2000 and were eligible for three years, receiving their last transfer in late 2003. The 21 late-treatment localities were phased in at the beginning of 2003 and were also eligible for three years' worth of transfers. In late 2005, the program ended. Overall, compliance with the experimental design was high. The sample was balanced at baseline, and there was very little contamination in the late treatment localities.

³ See Maluccio and Flores (2005); Barham and Maluccio (2009); and Barham, Macours, and Maluccio (2013) for additional details on the program, the experimental design, and the data.

⁴ Households with children ages 7–13 who had not yet completed the fourth grade of primary school were eligible for an additional fixed cash transfer contingent on enrolment and regular school attendance of those children.

II. Data

We use data from a preprogram census in 2000, the *RPS* administrative system, and a 2010 follow-up survey. The latter survey targeted all households in the original short-term evaluation survey, as well as an oversample of additional households that, according to the *RPS* administrative data, had children born during the six months after the start of the transfers in 2000. Children who were born to women who lived in the household at the time of the preprogram census were administered seven cognitive tests, weighed and measured.⁵ The sample includes 171 boys in the early treatment group and 197 boys in the late treatment group born up to one year after the start of the transfers, between November 2000 and October 2001. Program take-up for households with children in the sample was high: 99 and 93 percent, respectively, for the early and late treatment groups. Substantial effort went into minimizing attrition. Respondents were tracked through repeated visits anywhere in Nicaragua or Costa Rica. As a result, the attrition rate for the specific cohort analyzed in this paper is 6 percent (including two boys who had died by 2010). There is no significant difference between early and late treatment in attrition (coefficient -0.03 ; p -value 0.203).

III. Estimation Strategy and Results

A. Identification and Empirical Specification

To determine the differential long-term effects of *RPS*, we exploit the exogenous variation in early versus late treatment assignment provided by the randomized phase-in of the program. Using seemingly unrelated regressions (SURE), we estimate individual-level intent-to-treat (ITT) effects with the following equation:

$$(1) \quad Y_k = \alpha_k T + \beta_k \mathbf{X} + \varepsilon_k, k = 1, \dots, K,$$

where Y_k is the z-score of the k th outcome of the cognitive and anthropometric measures.⁶

⁵ The cognitive tests capture various age-appropriate aspects of processing speed, short and longer-term memory, visual integration, and receptive vocabulary. See Barham, Macours, and Maluccio (2013) for more details.

⁶ The z-scores are calculated within sample in order to facilitate comparison across outcomes. For anthropometrics

TABLE 1—ITT DIFFERENTIAL EFFECTS ON COGNITION AND ANTHROPOMETRICS FOR BOYS

	Born in first 12 months of program		Born in first 6 months of program	
	Cognition	Anthropometrics	Cognition	Anthropometrics
<i>Age and strata controls</i>				
T	0.147** (0.060)	-0.068 (0.100)	0.173*** (0.063)	-0.086 (0.118)
<i>All controls</i>				
T	0.145** (0.062)	-0.096 (0.096)	0.155** (0.069)	-0.146 (0.101)
Observations	368	368	267	267

Notes: Standard errors are clustered at the locality level and in parentheses. SURE estimates of seven cognitive and two anthropometric measures following Kling, Liebman, and Katz (2007). Controls include monthly age, strata and test administrator dummies, mother's education, birth order, baseline household size, living standard (estimated proxy means), assets (number of rooms, land, radio, animals, tools), distance to school, and locality means for anthropometrics of under-three-year-olds.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

T takes on the value one for boys in localities that were randomly assigned to the early treatment and zero otherwise, and \mathbf{X} includes birth month fixed effects and stratification dummies to account for the stratification in the randomization. We estimate the effects for the nine outcomes individually and combine them into two families of similar outcomes to determine the ITT effect on cognition and anthropometrics. We use the estimated variance-covariance matrix from the SURE to calculate the standard error of the average impact for each family of outcomes (Kling, Liebman, and Katz 2007), adjusting for clustering at the locality level.

The coefficient on T captures the differential impact of being exposed to the program at least partially in utero and fully during the first two years of life (in early treatment) versus being exposed later in early childhood.⁷ If the first 1,000 days comprise the critical period for

interventions to affect cognitive and physical growth, we expect α_k to be positive. On the other hand, if intervention later in early childhood can have equal or even larger impacts (i.e., catch-up is possible), α_k would be zero or negative. A zero differential could also be consistent with no program effect for either treatment group.

A potential concern is that the program itself may affect fertility decisions. To address this issue, we also present results for children who were born in the first six months after the start of the transfers and, hence, were conceived prior to the start of the program.

Given the randomization, children's cognition and anthropometrics should be balanced at baseline; however, we cannot verify this assumption since these children were not yet born. As a robustness check, we present results controlling for a wide array of preintervention characteristics including locality-average height and weight for children under three at baseline.

B. Results

Table 1 shows the ITT effects of differential exposure in early versus late treatment on cognition and anthropometrics, separately for those born in the first 12 and 6 months after the start of the transfers. Cognitive outcomes for boys exposed to the program in utero are a statistically significant 0.15 standard deviation larger than boys exposed later. Results are similar for both samples and robust to the inclusion of the additional controls. In contrast, for anthropometrics

we use height and weight. Results are qualitatively similar when using height-for-age and BMI-for-age z -scores based on international standards.

⁷The coefficient on T also captures any differences between the programs in the early versus late treatment localities. In particular, in the early treatment, the absolute amount of transfers was higher, and there was continued supply of health services after the end of the transfers. These differences were relatively minor but might lead to a slight overestimate of the importance of exposure during the critical age window of 1,000 days. It is also possible that the program effect during the late treatment period differs from the early treatment period due to other contextual differences across calendar years, though this would not alter our conclusions regarding catch-up.

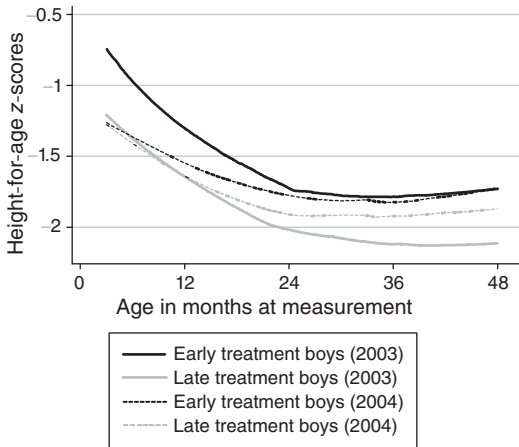


FIGURE 1. HEIGHT-FOR-AGE Z-SCORE FOR BOYS UNDER AGE 5

Source: RPS administrative data.

there is an insignificant -0.07 standard deviation effect. This indicates that receiving treatment starting in utero and for the first two years of life did not lead to higher physical growth ten years later. This zero differential effect could mean that the program had no effect on anthropometrics in either treatment group, or that there was catch-up growth in the late treatment group.

To explore whether the zero effect on anthropometrics reflects catch-up growth for the late treatment group rather than no program effect, we examine height-for-age z-scores for boys under age four in 2003 and 2004 for each experimental group (Figure 1). The overall pattern of z-scores is consistent with those seen in developing countries (Victora et al. 2010), with a sharp decline over the first 24 months. We first compare the curves in 2003 (the solid lines) at which point the early treatment localities had received their full three years of transfers, while the late treatment localities had only recently been incorporated. Children in early treatment were about 0.4 standard deviation taller. This difference is statistically significant over a large part of the age range providing evidence that the short-term absolute effects on height were positive for the early treatment group (results not reported). By 2004, however, with an additional year of program for the late treatment localities, the height differential narrows substantially and is no longer significantly different, suggesting

the late treatment group had begun to catch up. The difference likely continued to narrow in 2005, during the final year of transfers to late treatment localities. In related work, we show similar patterns for short-term health inputs (Barham, Macours, and Maluccio 2013).

IV. Conclusions

The importance of early life conditions is well known, but much of the evidence comes from impacts of “negative” shocks in utero or during early childhood, rather than “positive” interventions. Moreover, experimental evidence on the longer-term effects of interventions in general, and on cognitive functioning in particular, is rare. We use unique panel data, linking a randomized conditional cash transfer program in Nicaragua to child cognitive and anthropometric outcomes. The experiment is particularly well suited to test the hypothesis that intervention starting in utero and continuing in the first two years is critical.

The results demonstrate that boys exposed in utero and during the first two years of life have better cognitive outcomes when they are ten years old than those exposed in their second year of life or later. These results confirm that interventions that improve nutrition and/or health during the first 1,000 days of life can have lasting positive impacts on cognitive development for children. However, there are no differential impacts on anthropometrics, despite short-term differences resulting from the program, demonstrating that complete catch-up in anthropometrics was possible. In related work, we also find catch-up in physical growth for girls (Barham, Macours, and Maluccio 2013). These findings are consistent with other empirical evidence of catch-up for physical growth as well as with the medical literature on brain development.

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