Cognitive Skill Formation and Physical Growth of Boys:

Long-term Experimental Evidence on Critical Ages for Early Childhood Interventions

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The effects of early-life circumstances on the formation of cognitive skills are important for the subsequent development of human capital, for labor market outcomes, and for many aspects of people's health and well-being (Grantham-McGregor et al. 2007; Heckman 2007). 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) and the risk of growth faltering from birth to age 2 (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 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 the 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).

This paper tests 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

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

benefits from 2000 to 2003, and a late-treatment group received program benefits from 2003 to 2005. To maximize the strength of the results, we focus on boys because they are more vulnerable in early life than girls, particularly during the pre-natal 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 (ITT) effects on differential cognitive and physical development of 10-year old boys benefiting from the program starting in utero and up to age 2 in the early-treatment group, versus those benefiting from the program between ages 2 and 5 in the late-treatment group. Seven years after the households in the early-treatment group stopped receiving transfers, boys who participated in the program earlier in life had better cognitive, but not physical, outcomes.

I.   The Conditional Cash Transfer Program and Experimental Design[3]

The Nicaraguan CCT program—the Social Protection Network (*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 constituted approximately 18 percent of pre-program expenditures. Funds were delivered bimonthly to a designated female caregiver. Separate amounts were transferred for, and different

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

[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.

conditions applied to, the health and education components of the program. For health, all households were eligible for a fixed amount.[4] The transfer was conditional upon the designated caregiver attending bimonthly health education workshops and children under 5 going to regular preventive healthcare 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 delivery of free private health services to them continued.

The short-term evaluation was conducted in 42 localities in six rural municipalities with initial poverty rates of 80 percent. Localities were randomized into early- and late-treatment groups using 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. The program ended in late 2005. 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.

II.   Data

We use data from a pre-program 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 RPS administrative data, included children born during the six months after the start of the transfers in 2000.

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[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 enrollment and regular school attendance of those children.

Children born to women who lived in the household at the time of the pre-program census were administered seven cognitive tests, weighed, and measured.[5] The sample included 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 99 and 93 percent, respectively, for the early- and late-treatment groups. Substantial effort went into minimizing attrition. Respondents were tracked through repeated visits throughout Nicaragua and Costa Rica. As a result, attrition 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: .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 ITT effects with the following equation:

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

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[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.

where Y_k is the z-score of the kth outcome of the cognitive and anthropometric measures;[6] T takes on the value one for boys in localities that were randomly assigned to the early-treatment group and zero otherwise, and 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 benefiting from the program at least partially in utero and fully during the first two years of life (in early treatment) versus participating in the program 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 effects (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 during the six months after the start of the transfers and hence were conceived prior to the start of the program.

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[6] The z-scores are calculated within the sample in order to facilitate comparison across outcomes. For anthropometrics, we use height and weight. Results are qualitatively similar when using height-for-age and body-mass-index-for-age z-scores based on international standards.

[7] The coefficient on T also captures any differences between the programs in the early- versus late-treatment localities. In particular, in the early-treatment localities, the absolute amount of transfers was higher and there was a continued supply of health services after the transfers ended. 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.

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 pre-intervention characteristics, including locality-average height and weight for children under age 3 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 during the first 12 months of the transfers and six months after the start of the transfers. Cognitive outcomes for boys benefiting from the program in utero are a statistically significant 0.15 standard deviation larger than for boys participating later. Results are similar for both samples and robust to the inclusion of the additional controls. In contrast, for anthropometrics there is an insignificant –0.07 standard deviation effect. Hence, receiving treatment starting in utero and for the first two years of life did not lead to higher physical growth 10 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.

Table 1. Intent-to-Treat Differential Effects on Cognition and Anthropometrics					
	Born during First 12 Months of Program			Born Six Months after Start of Program	
	Cognition	Anthropometrics		Cognition	Anthropometrics
Age and Strata Controls					
T	0.147**	-0.068		0.173***	-0.086
	(0.060)	(0.100)		(0.063)	(0.118)
All Controls					
T	0.145**	-0.096		0.155**	-0.146
	(0.062)	(0.096)		(0.069)	(0.101)
Number of Observations	368	368		267	267

To explore whether the zero effect on anthropometrics reflects catch-up growth for the late-treatment group or no program effect, we examine height-for-age *z*-scores for boys under age 4 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. The figure first compares 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 deviations 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 the program for the late-treatment localities, the height differential narrows substantially and is no longer significantly different, suggesting this 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 a related study, we show similar patterns for short-term health inputs (Barham, Macours, and Maluccio 2013).

Figure 1. Height-for-Age *z*-Score for Children under Age 5
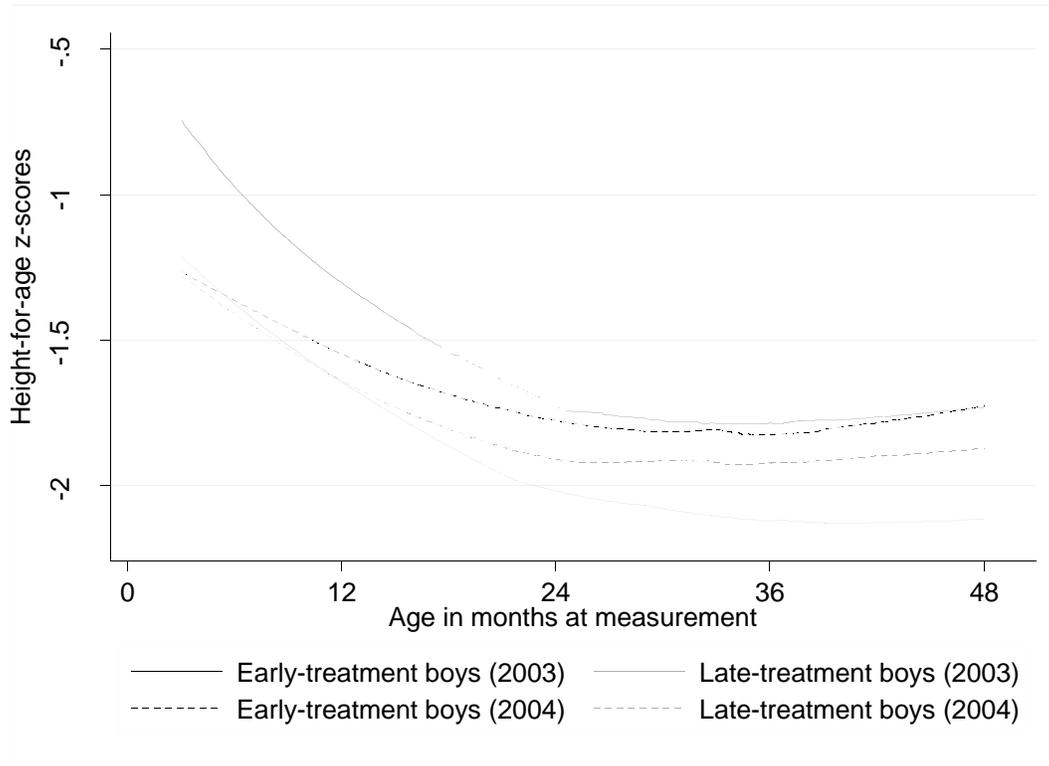
Source: Administrative data from the Social Protection Network (*Red de Protección Social - RPS*).

IV. Conclusions

The importance of early-life conditions is well known, but much of the evidence comes from the effects of severe "negative" shocks in utero or during early childhood, rather than from "positive" interventions. Moreover, experimental evidence on the longer-term effects of interventions in general, and on cognitive functioning in particular, is rare. This paper has used 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 benefiting from the program in utero and during the first two years of life have better cognitive outcomes when they are 10 years old than those

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benefiting from the program 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 effects on cognitive development for children. However, there are no differential effects on anthropometrics, despite short-term differences resulting from the program, demonstrating that complete catch-up in anthropometrics was possible. In a related study, we also find catch-up in physical growth for girls (Barham, Macours, and Maluccio, 2013). These results 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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