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**Boys' Cognitive Skill Formation and Physical Growth:  
Long-term Experimental Evidence on Critical Ages  
for Early Childhood Interventions**

Tania Barham, Karen Macours, and John A. Maluccio\*

**Abstract.-** The effects of early life circumstances on cognitive skill formation are important for later human capital development, labor market outcomes and well-being. 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. We find that boys exposed in utero and during the first 2 years of life, have better cognitive, but not physical, outcomes when they are 10 years old compared to those also exposed, but 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. The finding that the results differ for cognitive functioning and anthropometrics highlights the importance of explicitly considering cognitive tests, in addition to anthropometrics, when analyzing impacts on early childhood development.

**JEL Classifications:** I12, J13, O15

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). Non-experimental 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 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* targeted and designed to improve early-life health and nutrition is sparse and results are mixed.<sup>1</sup> 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).

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 received program benefits from 2003 to 2005. To maximize power, we focus on boys since they are more vulnerable in early life than girls, particularly during the pre-natal period (Eriksson et al. 2010).

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

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),<sup>2</sup> 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 exposed to the program starting in utero and up to age 2 in the early-treatment group, versus those exposed between ages 2 and 5 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.

## I. The Conditional Cash Transfer Program and Experimental Design<sup>3</sup>

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 conditions applied to, the health and education components of the program. For health, all households were eligible for a fixed amount per household.<sup>4</sup> The transfer was conditional on the

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

<sup>3</sup> 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.

<sup>4</sup> 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.

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 provision of free private health services to them continued.

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 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, had children born during the six months after the start of the transfers in 2000. 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.<sup>5</sup> 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 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:

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

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<sup>5</sup> 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  $k$ th outcome of the cognitive and anthropometric measures;<sup>6</sup>  $T$  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 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.<sup>7</sup> If the first 1,000 days comprise the critical period for interventions to affect cognitive and physical growth, we expect  $\alpha_k$  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),  $\alpha_k$  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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<sup>6</sup>The  $z$ -scores are calculated within 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.

<sup>7</sup> 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 in the first 12 and six 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 for boys exposed 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.

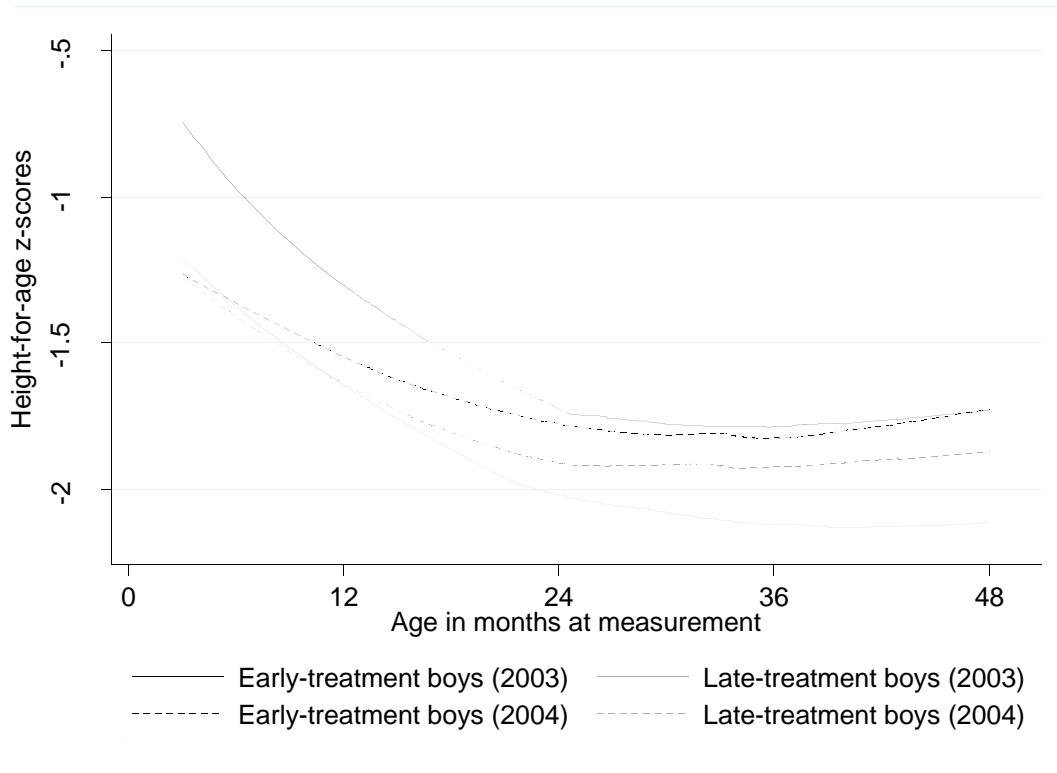
<b>Table 1. Intent-to-Treat Differential Effects on Cognition and Anthropometrics</b>				
	Born in first 12 Months of Program		Born in first 6 Months of Program	
	Cognition	Anthropometrics	Cognition	Anthropometrics
Age and Strata Controls				
<i>T</i>	0.147**	-0.068	0.173***	-0.086
	(0.060)	(0.100)	(0.063)	(0.118)
All Controls				
<i>T</i>	0.145**	-0.096	0.155**	-0.146
	(0.062)	(0.096)	(0.069)	(0.101)
Number of	368	368	267	267

Observations				
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*Note:* \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Standard errors are clustered at the locality level and in parentheses. Seemingly unrelated regression 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 and 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 for children under 3 years of age.

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 impacts 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. 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 10 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 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.

## References

- Adair, Linda S. 1999. Filipino Children Exhibit Catch-Up Growth from Age 2 to 12 Years. *The Journal of Nutrition* 129(6): 1140–148.
- Almond, Doug, and Janet Currie. 2011. Human Capital Development before Age Five. In *Handbook of Labor Economics*, Volume 4b, ed. Orley Ashenfelter and David Card. Amsterdam: Elsevier.
- Barham, Tania. 2012. The Effects of Child Health Interventions on Later Life Cognitive Functioning: Evidence from Matlab in Bangladesh. *American Economic Journal: Applied Economics* 4(1): 245–73.
- Barham, Tania, and John A. Maluccio. 2009. Eradicating Disease: The Effect of Conditional Cash Transfers on Vaccination Coverage in Nicaragua. *Journal of Health Economics* 38(3): 611–21.
- Barham, Tania, Karen Macours, and John A. Maluccio. 2013. Cognitive Skill Formation and Physical Growth: Long-term Experimental Evidence of Cash Transfers during Early Childhood. *American Economic Review Papers and Proceedings*. Forthcoming.
- Barker, David J.P. 1992. The Fetal and Infant Origins of Adult Disease. *British Medical Journal* 17; 301(6761): 1111.
- Barnett, Steven. 1995. Long-term Effects of Early Childhood Programs on Cognitive and School Outcomes. *The Future of Children* 5(3): 25–50.
- Doyle, Orla, Colm P. Harmon, James J. Heckman, and Richard E. Tremblay. 2009. Investing in Early Human Development: Timing and Economic Efficiency. *Economics and Human Biology* 7(1), 1–6.

- Eriksson, Johan G., Eero Kajantie, Clive Osmond, Kent Thornburg, and David J.P. Barker. 2010. Boys Live Dangerously in the Womb. *American Journal of Human Biology* 22(3): 330–35.
- Fiszbein, Ariel, and Norbert Schady. 2009. *Conditional Cash Transfers: Reducing Present and Future Poverty*. World Bank Policy Research Report. Washington, DC: World Bank.
- Garces, Eliana, Duncan Thomas, and Janet Currie. 2002. Longer-term Effects of Head Start. *The American Economic Review* 92(4): 999–1012.
- Grantham-McGregor, Sally, Yin Bun Cheung, Santiago Cueto, Paul Glewwe, Linda Richter, and Barbara Strupp. 2007. Developmental Potential in the First 5 Years for Children in Developing Countries. *The Lancet* 369(9555): 60–70.
- Heckman, James J. 2007. The Technology and Neuroscience of Human Capital Formation. *Proceedings of the National Academy of Sciences* 104(33): 13250–255.
- Kling, Jeffrey, Jeffrey Liebman, and Lawrence Katz. 2007. Experimental Analysis of Neighborhood Effects. *Econometrica* 75(1): 83–119.
- Macours, Karen, Norbert Schady, and Renos Vakis. 2012. Cash Transfers, Behavioral Changes, and Cognitive Development in Early Childhood: Evidence from a Randomized Experiment. *American Economic Journal: Applied Economics* 4(2): 247–73.
- Maluccio, John A., and Rafael Flores. 2005. *Impact Evaluation of the Pilot Phase of the Nicaraguan Red de Protección Social*. IFPRI Research Report No. 141. Washington, DC: International Food Policy Research Institute.
- Maluccio, John A., John Hoddinott, Jere R. Behrman, Reynaldo Martorell, Agnes R. Quisumbing, and Aryeh D. Stein. 2009. The Impact of Improving Nutrition during Early



Childhood on Education among Guatemalan Adults. *Economic Journal* 119(537): 734–63.

Victora, Cesar Gomes, Mercedes de Onis, Pedro Curi Hallal, Monika Blossner, and Roger Shrimpton. 2010. Worldwide Timing of Growth Faltering: Revisiting Implications for Interventions. *Pediatrics* 125(3): e473–e480.

Walker, Susan P., Susan M. Chang, Christine A. Powell, and Sally M. Grantham-McGregor. 2005. Effects of Early Childhood Psychosocial Stimulation and Nutritional Supplementation on Cognition and Education in Growth-Stunted Jamaican Children: Prospective Cohort Study. *The Lancet* 366(9499): 1804–807.