# 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 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 (Currie and Almond 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 specifically 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 to differences in timing of the interventions, including the possibility that later interventions (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,

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

we focus on boys since 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 effects on differential cognitive and physical development of 10-year old boys exposed to the program 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 of the early treatment group stopped receiving transfers, the boys exposed to the program earlier in life had better cognitive, though not physical, outcomes.

## I. The Nicaragua Conditional Cash Transfer Program and Experimental design[3]

The Nicaraguan CCT program, *Red de Protección Social* (*RPS*), provided cash transfers to poor rural households conditional upon beneficiaries engaging in behaviors designed to improve their 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 pre-program 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

[2] 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).
[3] See Maluccio and Flores (2005), Barham and Maluccio (2009) and Barham, Macours and Maluccio (2012) 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.

educational workshops and children under five going to regular preventive healthcare visits that included growth monitoring. Health services were free of charge and delivered in program areas 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 *RPS* 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 their first 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 that there was very little contamination of the late treatment group.

## II. Data

We use data from the original pre-program census and household evaluation survey in 2000 (IFPRI, 2005), the *RPS* administrative data 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 program. Children who were born to women living in the household at the time of the pre-program census were administered seven cognitive tests, weighed and measured.[5] The sample includes 171 boys in the early treatment group and

[5] The cognitive tests capture various age-appropriate aspects of processing speed, short and longer-term memory, visual integration and receptive vocabulary. See Barham, Maluccio and Macours (2012) for more details.

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, 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 intent-to-treat (ITT) effect with the following equation:

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

where $Y_k$ is the z-score of the $k$th outcome of the cognitive and anthropometric measures.[6] $T$ takes on the value of one for boys in localities that were randomly assigned to the early treatment and zero otherwise, and $\boldsymbol{X}$ 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

[6] The z-score 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 BMI z-scores based on international standards.

SURE to calculate the standard error of the average impact for each family of outcomes (see Kling, Liebman and Katz 2007), also 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 $\alpha_k$ 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.

A potential concern with using a sample of children born after the start of the program is that the program itself may affect fertility decisions. To address this issue, we also present results only for children who were born during the six months after the start of the intervention (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, therefore, we present results controlling for a wide array of pre-intervention characteristics including average locality 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 groups on cognition and anthropometrics, separately for those born in the first 12 months and first 6 months

[7] The coefficient on T also captures any differences between the programs in the early versus late treatment. 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.

after the start of the transfers. Cognitive outcomes for boys exposed to the program in utero are a statistically significant 0.15 standard deviation (SD) larger than boys exposed later. Results are similar for both samples and robust to inclusion of the additional controls. In contrast, for anthropometrics there is an insignificant -0.07 SD effect. Hence, receiving treatment in utero and within the first two years of life did not lead to higher physical growth 10 years later. This zero differential effect could either mean that the program had no effect on anthropometric outcomes in the early treatment group, or that there was catch-up growth in the late treatment group.

TABLE 1 —ITT EFFECT OF EXPOSURE IN UTERO AND DURING FIRST 2 YEARS OF LIFE

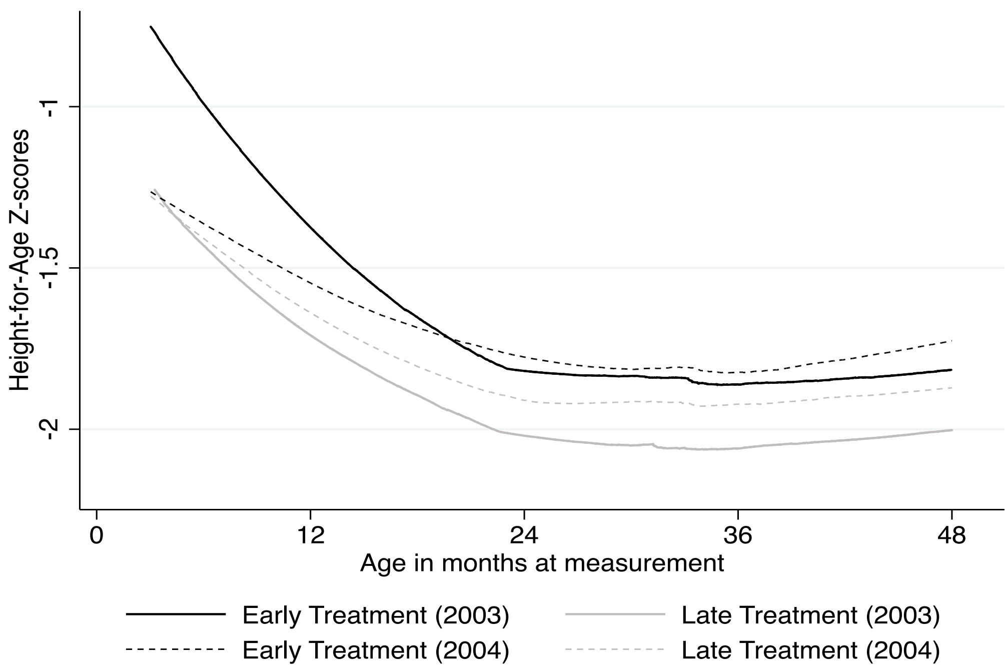
| | Born in first 12 months of program | | Born in first 6 months of program | |
|---|---|---|---|---|
| | Cognition | Anthropometrics | Cognition | Anthropometrics |
| Age and strata controls | 0.147** | -0.068 | 0.173*** | -0.086 |
| | (0.060) | (0.100) | (0.063) | (0.118) |
| All controls | 0.145**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

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at locality level and in parentheses. SURE estimates of 7 cognitive and 2 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 community means for anthropometrics 0-3 year olds.

To explore whether the zero effect reflects catch-up growth for the late treatment group or no program effect on anthropometrics, we examine height-for-age z-scores for boys under age five in 2003 and 2004 in Figure 1 for each experimental group. The overall pattern of z-scores is consistent with those seen in many developing countries (Victora et al. 2010), with sharp declines in the first 24 months. We first compare the curves in 2003 at which point early treatment localities had received their full three years of transfers while late treatment localities had only recently been incorporated. Children in early treatment were 0.2 to 0.4 SD taller. This

difference is statistically significant over almost the entire age range providing evidence that the short-term absolute effects on height were positive for the early treatment group. By 2004, however, with an additional year of program for the late treatment, the height differential narrows substantially and is no longer significantly different, suggesting the late treatment group caught-up. With an additional year of transfers to late treatment localities in 2005, this difference likely continued to decrease.

FIGURE 1 — HEIGHT-FOR-AGE Z-SCORE FOR CHILDREN UNDER AGE 5




Source: *RPS* administrative data.

## 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 “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 is critical.

The results demonstrate that boys exposed in utero and during the first 2 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 anthropometric measures, suggesting that complete catch-up in anthropometrics was possible later in early childhood. These results are consistent with other empirical evidence of catch-up for physical growth as well as with the medical literature on brain development. 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.

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