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DISCUSSION PAPER SERIES

IZA DP No. 15784

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ABSTRACT

The Effect of Brazil's Family Health Program on Cognitive Skills

This paper examines the effect of Brazil's Family Health Program (Programa Saude da Familia, FHP) on cognitive skills of fifth-grade students. We use biennial data from national exams between 2007 and 2015, and variation in the FHP implementation date across municipalities, birth cohort, and test year to identify the effect of the program on language and mathematics test scores. We find that, in northern municipalities, students exposed to FHP at or prior to birth have 0.88 points higher language and 1.30 points higher mathematics test scores compared to those exposed to FHP in childhood. The estimated effects are intent-to-treat effects and correspond to increases of 0.021sd and 0.030sd in language and mathematics test scores. We use an event-study analysis demonstrating that the largest effects of FHP on cognitive skills are for those students exposed at or prior to birth, with trivial effects if exposed after birth. We do not find evidence for changes in parental investment behavior or child school attendance, which suggests that the effects are likely due to the direct impact of the program on child cognitive development.

JEL Classification: I15, I18, I21

Keywords: early life interventions, cognitive skills, community healthcare, Brazil

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1. Introduction

Poor health in utero or early-life conditions have important adverse long-term socioeconomic consequences, such as reduced adult health and education (see Almond and Currie, 2011 for a review). Motivated by the "critical period" literature, which contends that health investments in later life might not compensate for disadvantages in early life, recent research has focused on the impact of policies designed to improve early-life health. These studies have investigated the effects of a wide range of policies, such as childhood exposure to Medicaid in the 1960s and the introduction of home visits in Scandinavian counties in the 1930s, finding that early-life health interventions significantly improve long-term health, education, and labor market outcomes.[1] We contribute to the literature by exploring the effect of a large-scale public health intervention on cognitive skills.

In this paper, we study the effects of a nationwide community healthcare program in a developing country on cognitive skills. In particular, we investigate the long-term implications of Brazil's Family Health Program (Programa Saude da Familia, or FHP) for child school performance using biennial data on national exam scores between 2007 and 2015 for children in 5th grade. Brazil's FHP was a large-scale healthcare reform that effectively used community health workers (CHWs) to provide primary health care (Macinko et al. 2015).

Brazil's FHP was largely implemented between 1998 and 2006 and by 2007, it was present in more than 90% of municipalities. We examine the effects of early exposure to FHP (i.e., exposure at or prior to birth) on cognitive skills as measured by language and mathematics test scores. Because students are exposed to the program at different ages, we also examine the effects of initial exposure to FHP at different ages to test whether the effect of the program extends beyond early exposure. To this end, we employ an event-study model that allows exploring the effects of initial exposure to the program in utero, at birth, and in childhood. Our main analysis focuses on the municipalities in the North and Northeast regions as these regions have been shown to benefit from the program the most (Rocha and Soares 2010). Furthermore, we test whether the effects depend on the gender of the student and parental education. Finally, we explore several mechanisms that link FHP and cognitive skills, including schooling (grade

[1] See Boudreaux et al. (2016); Butikofer et al. (2015); and Hjort et al. (2017) among others.

repetition and school dropout) and a wide range of indicators of parental behavior related to education.

We find that early exposure to FHP significantly increases cognitive skills in northern municipalities. That is, students exposed to FHP at or prior to birth have 0.88 and 1.30 points higher language and mathematics test scores, respectively, compared to students exposed to FHP in childhood. The estimated effects correspond to increases of about 0.021sd and 0.030sd in language and mathematics test scores, respectively. These intent-to-treat effects translate to treatment-on-the-treated effects of 0.123sd and 0.086sd in language and mathematics test scores. We also use an event-study analysis, demonstrating that the largest effects of FHP on cognitive skills are to those students exposed at or prior to birth. Exploring heterogeneous effects does not reveal significant differences in the effects by student's gender and mother's education. Investigating potential mechanisms does not indicate that the effects are the consequence of differences in grade repetition and school dropout, or parental behavior related to schooling (whether parents encourage their children to study, do homework, or read, ask their children about school, and attend parent-teacher meetings). This suggests that the FHP affects cognitive skills via direct channels, such as improved child and maternal health.

The results withstand a number of robustness checks. First, we employ alternative measures of early exposure to the program. Second, we estimate the effects of the intensity of the program as measured by the proportion of the population covered by FHP in a municipality at birth as well as one year prior to birth to account for the imperfect coverage of the program in its first years of implementation. Third, we control for additional variables or apply different sample restrictions to account for possible confounders and address selective fertility. Finally, we employ a placebo test where we allocate students to random placebo ages at initial exposure to the program.

Brazil's FHP was one of the earliest successful examples of large-scale community-based health interventions in developing countries, and includes one of the largest CHW networks in the world (Perry et al. 2014). The FHP aimed to provide preventative and basic healthcare through the use of professional healthcare teams that serve local communities. Each team is assigned to a specific geographic area covering 3,000 to 4,000 people, with a maximum of 150 families per CHW. The teams are responsible for registering every family in their area, monitoring living conditions and health status, and providing primary care, including immunizations and child development assessments, as well as providing advice related to healthy pregnancy and breastfeeding (Wadge et al. 2016). The use of CHWs is a relatively cost-effective approach to providing primary healthcare to a large share of the population, particularly the poor, and studies have shown that FHP was associated with improvements in health, such as reductions in fetal, neonatal, and infant mortality (Macinko 2006; Aquino et al. 2009; Bhalotra et al. 2019; Rocha and Soares 2010).

This study is related to a few papers exploring the effects of early-life health and nutrition interventions on long-term cognitive development in developing countries, which find mixed results. Barham (2012) investigates the effect of a home intervention targeting pre-natal health, child immunization and nutrition in Bangladesh, finding that it increased cognitive functioning of 8-14-year-olds. On the other hand, Walker et al. (2005) find that an early childhood nutritional supplementation program in Jamaica had no significant effects on cognitive skills of 17-18-year-olds.

Huang and Liu (2023) examine the effect of a demand-side intervention in rural China, called the New Cooperative Medical Scheme (NCMS), which expanded health insurance to rural residents in China in order to reduce the risk of catastrophic health spending. While exposure to NCMS during ages 0-5 increased verbal test scores during adolescence (significant only at the 10 percent level), it had no significant effect on mathematics test scores. While insurance against catastrophic health shocks might affect household health outcomes and decision making, the FHP supply-side intervention would have had more direct effects on health by providing a range of preventative and basic healthcare services, free at point of use, and expanding access to healthcare through the use of community healthcare workers.[2]

While several developing countries advocate universal health insurance, most target expansion of health insurance coverage to the uninsured, such as people working in informal

[2] There are also several advantageous features of the FHP policy that help overcome some of the empirical challenges associated with estimating the causal effects of the NCMS. For example, Chen and Jin (2012) show that the beneficial effects of NCMS on child and maternal health and school enrollment of 7-16-year-olds are driven by endogenous introduction and take-up of the NCMS and disappear once selection bias is addressed. Furthermore, several studies find no effects on health and out-of-pocket payments and discuss that the lack of effects can be explained by high copayments, limited financing, low reimbursement rates, and selection (Yi et al. 2009; Lei and Lin, 2009; Chen and Jin, 2012).

sectors and living in rural areas. Such demand-side interventions could fail to improve health outcomes and affect household behavior due to lack of affordability of healthcare services or increases in the prices of healthcare services as a response to the healthcare reform.[3] On the other hand, health interventions with supply-side measures have been shown to increase both healthcare use and health outcomes.[4] Brazil's FHP provides an opportunity to examine the effect of exposure to a public health intervention that integrated supply-side measures in early life on cognitive skills.

Our results contribute to the existing literature by showing that the benefits of a large-scale health intervention extend beyond improving short- and long-run health outcomes to include long-run cognitive skills. The fact that provision of healthcare before childhood can partly explain the differences in cognitive skills later on in life underscores the importance of health interventions to improve early cognitive development. In addition, our findings contribute to the "critical period" literature as early-life (especially in utero) exposure is critical to contributing to later-life cognitive skills. Brazil is a relevant case study to explore the role of health interventions in cognitive skills as 61% (about 75%) of 15-year old students scored at or below the lowest reading (mathematics) proficiency in the 2000 (2003) PISA assessment and 24% of primary school students repeated a grade in 1999 (UNESCO 2014).

The remainder of the paper is organized as follows: Section 2 provides a brief description of the program and the mechanisms through the program affects cognitive skills; Section 3 describes the data; Section 4 presents the empirical strategy; Section 5 presents the results and robustness checks; and Section 6 concludes.

2. Brazil's Family Health Program

2.1 Brief Description of FHP

Brazil's FHP was initiated in 1994 as a federal program by the Brazilian Ministry of Health. Since 1994, FHP has become a nationwide large-scale health intervention, covering about 95% of municipalities by 2012 and serving about 120 million people by 2015.

[3] See Giedion and Diaz (2010) for a review of impact of health insurance on access, use, and health outcomes in low- and middle-income countries.
[4] See Gruber et al. (2014) in Thailand, Miller et al. (2013) in Colombia, Rocha and Soares (2010) in Brazil among many others.

FHP delivers primary healthcare, free at point of use. Preventive and basic healthcare services are provided by multidisciplinary family health teams (FHTs) to defined local populations. Each FHT includes at least one physician, one nurse, one nurse aid, and about six community health workers and may be supported by a dental team. Each FHT is assigned to a pre-determined geographic area, covering up to 1000 households or 3000-4000 people, with no overlap or gap between catchment areas. The teams are responsible for registering every family in their catchment area, provide comprehensive and universal primary care in community health facilities and at home, monitor health status, and deliver public health interventions, such as immunization campaigns (Harris 2012).

CHWs play a key role in the program and each agent is assigned to a maximum of 150 households in geographically delineated micro-areas within the larger catchment area (Harris 2012). CHWs visit each and every household at least once a month, regardless of need, and deliver a package of health-related activities, such as health education and promotion, clinical care, and household data collection (Harris 2012). Thus, CHWs target health problems at the individual level and serve as instruments for public health action and community empowerment (Harris 2012). Moreover, CHWs help physicians understand the needs of the assigned population and identify health problems prior to the need of hospitalization or clinical care. Brazil's FHP has one of the largest CHW networks in the world, including more than 265,000 CHWs that provide services to about 67% of the population (Perry et al. 2014). CHWs are recruited from the community they serve and receive 40 hours of initial training and additional informal, on-the-job training (Grossman-Khan et al. 2018).

FHP is a publicly funded federal program that relies on a decentralized healthcare model, in which municipalities are responsible for the implementation of the program and the overall management of primary care. Several studies have shown that FHP is associated with improvements in health, such as reduced adult and infant mortality, and is a highly cost-effective program. For example, Rocha and Soares (2010) find that infant mortality (mortality rate between ages 1 and 4) is reduced by 6.7 (6.4) percent for municipalities 3 years into the program and 20 (24) percent for municipalities 8 years into the program. They also find that the largest impacts of the program on infants before age 1 are related to a reduction in deaths due to perinatal period conditions, infectious diseases, and respiratory diseases caused by health conditions such as complications during pregnancy and diarrhea. Bhalotra et al. (2019) find that the program is associated with reductions in maternal, fetal, neonatal and post-neonatal mortality and increases in the number of prenatal care visits and share of hospital births.

2.2 How May FHP Affect Cognitive Skills?

FHP could directly or indirectly affect cognitive skills through several channels. FHP might directly affect the cognitive development of children through improved infant and child health as well as maternal health during pregnancy. In particular, several studies have documented that better childhood nutrition and health and parental health are associated with better educational outcomes and cognitive performance (see Miguel (2005) for a review of the literature). In developing countries, there is growing evidence that early childhood nutrition programs might play a substantial role in increasing academic achievement. For example, a home intervention program targeting improvements in health and nutrition of young children in Bangladesh is shown to be related to increases in cognitive functioning (Barham 2012). Maluccio et al. (2009) and Glewwe et al. (2001) show that early childhood nutrition programs increase cognitive skills in Guatemala and Philippines, respectively. FHP could have improved the nutrition of young children by the provision of nutrition advice and postnatal care, including breastfeeding assistance. Moreover, FHP supports immunization programs, which could reduce diseases such as measles which might lead to malnutrition through complications, such as diarrhea (Barham 2012). FHP could also improve child health since community health workers provide healthy pregnancy support to each household such as low-risk pregnancy health education and information on healthy lifestyle during pregnancy (Harris 2012). Better birth outcomes and health improvements in early childhood due to FHP could be directly linked with better cognitive development. In addition, better health after the start of formal schooling resulting in reductions in absence rates due to sickness, grade repetition and dropout rates could further strengthen the link between FHP and cognitive skills.

While the direct channels are related to changes in child health, FHP may also affect test scores indirectly by changing parental behaviors and resources. For example, parents might increase the investment in the human capital of their children as a response to improved child health. Also, reduced child (and adult) morbidity due to FHP could increase household income, which in turn increases parental resources to invest in children. Greater parental investments in education could be monetary as well as non-monetary, such as changes in parental behavior and time inputs related to education. Parental investments both in terms of financial expenditures and parental actions have been shown to be important determinants of cognitive skill development (see Del Bono et al. 2016; Francesconi and Heckman 2016 among others).

3. Data

3.1 Data on Education and FHP

We use national standardized age-appropriate test scores as measures of cognitive skills. In particular, we use biennial test score data from a national exam (Prova Brasil/SAEB) administered to all students in 5th grade attending public schools.[5] The student-level microdata is available for 2007, 2009, 2011, 2013, and 2015 and contains standardized language and mathematics test scores (with the same reference population in all years). The scoring system uses item response theory, where different questions are weighted differently depending on their difficulty and allows comparison of test scores across years.[6] In addition to exam scores, data contain information on various student characteristics, including age, gender, race, and other household and parent characteristics that allow us to study heterogeneity in the treatment effect and explore potential mechanisms.

We merge the student-level microdata to municipality-level data on FHP availability in each year.[7] Using monthly FHP coverage date, the implementation year is defined as the first year the municipality is covered by the policy in December of that year. We also define program intensity as the proportion of the population covered by FHP in a municipality.

3.2 Program Coverage and Descriptive Statistics

Our sample of analysis includes municipalities that adopted the program by 2007 (i.e., by the first year of the national exam) and have information on the full set of municipality-level controls for all 5 years.[8] This provides us a sample of 4,531 municipalities that adopted the

[5] Data available at http://portal.inep.gov.br/basic-education-assessments. Note that all public schools that have a minimum of 20 students enrolled per class are included.
[6] For detailed information on the scale and content of Prova Brasil, see https://download.inep.gov.br/educacao_basica/prova_brasil_saeb/downloads/livretos/livreto_prova_brasil_2009.pdf.
[7] Monthly data on FHP coverage at the municipality level is available at http://dab.saude.gov.br/portaldab/historico_cobertura_sf.php.
[8] About 96% (98%) of all (northern) municipalities in the education data adopted the program by 2007. We exclude municipalities that did not adopt the program since they are potentially different than those that adopted the program. The results are robust to including municipalities that adopted the program by 2015. Results are available upon request.

program over the period between 1998-2007.[9] In the analysis, we include students with non-missing age, gender, race and test scores. We exclude students that report being at the age of 8 at the time of the test year (0.16% of sample) to reduce misreporting bias as it is unlikely that an 8-years-old would be in 5th grade. We further exclude students that are 15 years old and older (1.36% of sample) because we cannot determine the age at exposure to the program as all students older than 14 are grouped together in one age category. Our final sample of analysis includes 8,530,829 students in 4,531 municipalities and 2,748,869 students in 2,013 municipalities in the North and Northeast provinces.[10]

Figure 1 shows the cumulative distribution of municipalities in the sample of analysis by year of program implementation. The program was expanded from few municipalities in 1998 to all municipalities in 2007, with higher adoption rates in earlier years. In particular, 58% of the municipalities adopted the program in 2000 or earlier, 16% in 2001, 9% in 2002, and 5% or less in each of the following years with only 35 municipalities adopting the program in 2007. Figure 1 also shows that northern municipalities adopted the program earlier: 40% of northern municipalities adopted the program before 2000 compared to 36% (32%) in all (other) municipalities. Figure 2 shows the average program intensity since the implementation of the program. On average, the program covers about 75% (58%) of the population within five (one) years of implementation. Program intensity is slightly higher in northern municipalities with 81% (60%) of the population covered by the program within five (one) years of implementation.

Table 1 provides summary statistics of students by exam year, separately for the samples of all and northern municipalities. Demographics of students in all and northern municipalities are similar in each year. Overall, the average age of students is about 11, half are female, and about half identify as mixed race in both samples. While average language and mathematics test scores are lower in northern municipalities than all municipalities in each year, there is an upward trend in test scores over time in both samples. In particular, average language and

[9] It should be noted that we restrict our analysis to urban populations in order to keep sample composition consistent across years. Fewer than 10% of student observations in each year (and fewer than 200 observations in 2007) are from rural areas and excluding students with rural residence only reduces the number of municipalities from 5,545 to 5,529. 4,531 out of 5,529 municipalities have the full set of municipality controls for all 5 years and adopted the program by 2007.

[10] North and North East provinces included the sample of analysis are as follows: Acre, Alagoas, Amazonas, Amapá, Bahia, Ceará, Maranhão, Pará, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, Rondônia, Roraima, Sergipe, Tocantins. It excludes the following provinces: Espírito Santo, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraná, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, São Paulo.

mathematics test scores increase from 2007 to 2015 by approximately 19% and 14% in the two samples, respectively.

4. Empirical specification

4.1 Main Model

Our main empirical specification compares the test scores of students with exposure to FHP at or prior to birth (early exposure hereafter) to those without early exposure. Exploiting variation in the FHP implementation date across municipalities, birth cohort, and test year, we estimate

$$y_{ibjt} = \alpha + \beta FHP_{ibj} + \mu_j + \eta_b + \tau_t + \gamma X_{ibjt} + \theta_s T + \lambda Z_j^{base} \times t + \delta K_{jt} + \epsilon_{ibjt} \quad (1)$$

where y_{ibjt} is the test score of a student i born in year b that lives in municipality j in year t; μ_j are municipality fixed effects; η_b are student year of birth fixed effects, τ_t are test year fixed effects; and X_{ibjt} is a vector of student-level control variables, including age fixed effects, gender and race.

FHP is the measure of early exposure to the program. More specifically, FHP_{ibj} is a dummy variable that takes the value 1 if a student i born in year b lives in a municipality j that adopted the program at or prior to birth and 0 otherwise. We also use an alternative definition of early exposure excluding exposure at birth. The main coefficient of interest, β, is the effect of early exposure to FHP on cognitive skills. The estimated effect is considered an intent-to-treat effect as the whole population in a municipality that adopted the program would not be covered by the program immediately. We cluster the standard errors at the municipality level in all estimations.

The validity of the model relies on the assumption that the timing of program adoption in a municipality is exogenous to the variation in test scores. Municipality fixed effects in equation 1, μ_j, account for any time-invariant differences across municipalities that may have affected the adoption of FHP as well as test scores, while year fixed effects, τ_t, account for any common time trends. Students' year of birth, η_b, and age fixed effects account for cohort differences.[11] Thus,

[11] There is variation in age within a grade because of grade repetition and differences in school starting age.

the effect of early exposure to FHP on cognitive skills is identified from variation within municipalities across birth cohorts.

Previous research has shown that the introduction of the FHP at the municipality level was correlated with political party affiliation of the municipality and initial municipality characteristics, such as household income per capita (Rocha and Soares 2010). We alleviate endogeneity concerns in three ways. First, we control for state-specific linear time trends, $\theta_s T$ that account for state-level time-varying unobservable factors. Second, we control for trends in several municipality characteristics at baseline (2000) that are related to FHP adoption, $Z_j^{base} \times t$, including household income per capita, percent of people living under less than half of the poverty line, proportion of people with eight or more years of schooling, under five mortality rate, neonatal mortality rate, maternal mortality rate, and BCG, DTP, measles and yellow fever vaccination coverage.[12] Finally, because there could be unobservable differences between municipalities that adopted FHP and those that have not adopted FHP which may bias the results, our sample of analysis includes only municipalities that adopted the program.

There could also be time-varying shocks, such as municipality-specific policies that are related to both test scores and the adoption of FHP. For example, a school funding program, FUNDEF, introduced in 1998, redistributed federal education funds to municipalities based on the number of students enrolled and also set limits on spending for teachers (Ferraz et al. 2012; Haddad et al. 2017; Cruz 2018). In order to account for such possibilities, we control for time-varying municipality characteristics, K_{jt}, that may be related to education and the implementation of FHP: log GDP, log of education funds (transferred from the central government for the FUNDEF program), and number of schools and students in 1st to 5th grade.[13]

While there are no other specific programs that were implemented during the same period with the same timing and geographic roll-out of FHP, there are two nationwide policies that are worth mentioning. Bolsa Familia is a national conditional cash transfer program that was introduced by the federal government in 2004. While our model includes year fixed effects and

[12] Data available at http://tabnet.datasus.gov.br/.
[13] Data on municipality-level GDP available at: https://www.ibge.gov.br/estatisticas/economicas/contas-nacionais/9088-produto-interno-bruto-dos-municipios.html?edicao=18760&t=resultados. Data on education funds available at: https://www.tesourotransparente.gov.br/temas/estatisticas-fiscais-e-transparencia/informacoes-e-publicacoes-de-estados-df-e-municipios. Data on number of schools and students are based on authors' calculations using the education census available at: http://inep.gov.br/censo-escolar.

accounts for national trends, we provide robustness checks by excluding test scores from the 2015 data as most students in that survey year were born in 2004 or after and thus could have been affected both by FHP and Bolsa Familia. In addition, a nationwide education reform that lowered the minimum age of entry to primary school from seven to six years old by changing the birth month cut-off took place in 2006. Ryu et al. (2020) show that there was variation in the adoption of the policy across schools, but not municipalities. We still provide robustness checks by controlling for school and month of birth fixed effects to account for potential differences in the student age distribution in the different test years.

The change in sample composition due to reductions in fetal and infant mortality as a consequence of the program could potentially bias the results. If children with poor health survived when they would have died in the absence of the program then the effect of the program on test scores of surviving children would be underestimated. For example, Bhalotra et al. (2019) show that, contrary to expectations, quality of births as measured by birth weight and APGAR scores were not affected by the program, possibly due to the large reduction in fetal mortality. Thus, our results provide lower bounds of the net effect of the program.

While differences in schooling between students that are exposed and not exposed to the program might lead to additional changes in sample composition, Rocha and Soares (2010) find that FHP did not change school enrollment of students at the ages of 10-14. This provides suggestive evidence that the sample composition of 5th graders in our analysis is unlikely to be affected by the program.[14]

Selective fertility could potentially bias the results if it changes the sample composition. For example, if the program reduces unplanned pregnancies then child quality could increase through pre- and post-natal investments that may be unrelated to the program. Such possibilities could lead to an overestimation of the effect of the program on cognitive skills. Bhalotra et al. (2019) find that FHP is associated with reductions in fertility only after 3 years of implementation. Because it takes time for the program to affect fertility, the test scores of students born soon after program implementation are less likely to be affected by selective fertility. We therefore provide robustness checks to test the potential effect of fertility responses

[14] Compulsory education was 8 years until the education reform in 2006 which increased it to 9 years, and about 97% of children between the ages of 6 and 14 attended school in 2006 (Ministry of Education 2014).

by excluding students born more than 3 years after the introduction of the program in their municipality.

Finally, because the program does not cover the whole population in a municipality in its first years of implementation, we examine the effects of the intensity of the program on cognitive skills as a robustness check. In particular, we replace the measure of early exposure to the program in Equation 1 with a measure of program intensity (i.e., the proportion of the population covered by FHP in a municipality) at birth as well as one year prior to birth. The main coefficient of interest would thus be the effect of one percentage change increase in program coverage on cognitive skills.

4.2 Alternative Specification

The main estimation model, Equation 1, identifies the effects of early exposure to the program. Because students are exposed to the program at different ages, we can explore whether the effect of the program extends beyond exposure at and prior to birth. We can explore the relationship between cognitive skills and initial exposure to the program at different ages using an augmented event study model, following several recent studies with similar gradual program rollout (Bailey and Goodman-Bacon 2015; Hoynes et al. 2016; Hjort et al. 2017):

$$y_{ibjt} = \alpha + \beta_k \sum_{k=-5}^{6} FHP_{ibjk} + \mu_j + \eta_b + \tau_t + \gamma X_{ibjt} + \theta_s T + \lambda Z_j^{base} \times t + \delta K_{jt} + \epsilon_{ibjt} \quad (2)$$

where FHP_{ibjk} is a dummy variable that takes value 1 if a student i born in year b that lives in a municipality j is age k at program introduction in that municipality. Students with initial exposure to the program at age 1 are the omitted control group (k=1) and thus the estimated effects, β_k, are relative to the effect of first being exposed to the program at age 1. The lower (k=-5) and upper (k=6) bounds indicate, respectively, exposure to the program for 5 or more years prior to birth and 6 and more years after birth to account for the small number of observations in the tails of the distribution of the age at program introduction. In this specification, we therefore flexibly estimate the effects of initial exposure to the program at birth, prior to birth, and in childhood. Note that negative values of k indicate exposure prior to birth (i.e., FHP was in place in the municipality prior to birth), $k = 0$ indicates exposure at birth, and positive values indicate exposure in childhood (i.e., FHP was implemented in the municipality after birth).

We expect that the longer the program exposure prior to birth, the greater the effects of the program would be because it may take time for the program to be fully implemented within a municipality. We also expect that the program might be less effective if introduced after birth due to administrative delays as well as the presence of sensitive periods of child development. In other words, the effect of the program should decrease as age at program introduction (k) increases.

4.3 Placebo Test

In order to provide further support for the empirical design, we employ a placebo test in which students are randomly assigned to different ages at initial exposure. We estimate the effects in Equation (2) with placebo exposure using a bootstrap procedure that is repeated 500 times and plot the average estimated effects with associated confidence intervals at 95% confidence level. We should not find significant effects employing the placebo test if our main empirical specification provides the true effect of the program. In other words, we should see a flat line when we plot the placebo effects.

5. Results

5.1 Effects of FHP on Cognitive Skills

Table 2 presents the effects of early exposure to FHP on cognitive skills for both all and northern municipalities. While the results suggest small and statistically insignificant effects on test scores in the full sample of municipalities (columns 1 and 2), we find that early exposure to FHP is associated with improvements in cognitive skills in northern municipalities (columns 3 and 4). In particular, early exposure to FHP at or prior to birth is associated with an increase of 0.88 and 1.30 points in language and mathematics test scores, respectively. The results are robust to using an alternative measure of early exposure: exposure prior to birth. Given that an additional year of schooling (200 school days) is associated with about a 20-point increase in both test scores, the estimated effects correspond to 9 and 13 extra days of schooling for language and mathematics test scores, respectively (Ministry of Education 2014). This is consistent with prior research showing that the municipalities in the North and Northeast regions benefitted from the program the most (Rocha and Soares 2010). For the remainder of the analysis we focus on students living in northern municipalities.

To put these effects into perspective, Barham (2012) finds an increase of 0.39sd in the cognitive functioning of 8-14 years old children associated with a health and family planning program designed to improve health and nutrition of young children in Matlab, Bangladesh. Bharadwaj et al. (2013) find an increase of 0.15sd in mathematics test scores of 4th graders associated with a program providing special care for very low birth weight babies in Chile. Standardizing the test scores using the mean and standard deviation of the scores in 2007, our findings correspond to increases of 0.021sd and 0.030sd in language and mathematics test scores, respectively. While the effects appear small, the effects of treatment-on-the-treated are similar to those found previously if we consider that our estimated effects are intent-to-treat effects. In particular, a back-of-the envelope calculation suggests that the effects of treatment-on-the-treated would be 0.123sd (0.03/0.244) and 0.086sd (0.021/0.244) for mathematics and language test scores given that the average program intensity at birth over the sample of northern municipalities is 24.4 percent.[15]

Next, we employ a wide range of robustness checks using our main measure of early exposure at or prior to birth. First, we add additional controls of month of birth and school fixed effects to account for the nationwide education reform in 2006 that may have affected school composition. The results for both language and mathematics test scores in Appendix Table 1 are robust to adding these controls.[16] Second, we exclude students born more than 3 years after the program was first implemented in their municipality (about 20% of the sample) to examine the potential bias due to fertility changes in response to the program. Columns 2 and 5 in Appendix Table 2 present the results for language and mathematics test scores, respectively. The results remain robust, suggesting that there is limited bias due to endogenous fertility changes. Third, we exclude test scores in 2015 to account for possible effect of Bolsa Familia.[17] While the estimated effects for both test scores (columns 3 and 6 in Appendix Table 2) are slightly reduced, they are not significantly different from the main effects (columns 1 and 4).

We also provide robustness checks by exploring the effects of the program intensity on test scores. We use two alternative measures of program intensity (the proportion of the

[15] Moreover, the size of the effects is considerable compared to the effects of cash transfer programs, particularly given that FHP was not directly targeted at improving schooling outcomes. For example, in a meta study, Baird et al. (2015) show that the effects of cash transfer programs on test scores are small ranging between 0.04sd and 0.08sd.
[16] We lose some observations due to missing information on the month of birth or school ID.
[17] World Bank (2001) finds that Bolsa Familia had little effect on students' test scores.

population covered by FHP in a municipality), including program intensity at birth and one year prior to birth. Consistent with our main results, we find that higher program coverage at birth (columns 1 and 4 of Table 3) and one year prior to birth (columns 2 and 5 of Table 3) are associated with higher language and mathematics test scores. More specifically, a 10-percentage points increase in the population covered by FHP at the municipality level at birth (one year prior to birth) is associated with 0.20 (0.22) and 0.12 (0.10) points increase in mathematics and language test scores, respectively. Given that, on average, in northern municipalities, the program intensity at birth (one year prior to birth) is 24.4% (18.9%), the results in columns 4 (5) and 1 (2) suggest that students in municipalities that adopted the program at birth (one year prior to birth) have 0.488 (0.416) and 0.293 (0.189) points higher mathematics and language test scores, respectively, compared to students in municipalities that adopted the program later in their childhood.

Finally, we use an alternative measure of early exposure as a robustness check. We define early exposure as the share of years exposed to the program from conception (one year prior to birth) to age 3 that the program was available in the municipality. Results in columns 3 and 6 of Table 3 confirm the positive effects of early exposure to the program on language and mathematics test scores. Specifically, the estimated estimates suggest that increasing the share from zero (no exposure) to one (full exposure during the period from in utero to age 3) increases the language and mathematics test scores by 1.6 and 1.9 points, respectively.

5.2 Effects Using Alternative Specification

Table 4 presents the effects of exposure to the program at different ages on language and mathematics test scores. Columns 1 and 3 show that students exposed to the program prior to age 1 have higher test scores than those exposed at age 1, while the effects for students exposed to the program in childhood are small and not statistically significant. Because the estimated effects are jointly insignificant for exposure in childhood for both test scores, we also estimate the effects where students exposed to the program after birth is the omitted control group in columns 2 and 4. The results remain robust, suggesting that FHP increases cognitive skills of students exposed to the program at or prior to birth.

Figure 3a and 3b present the results of the event study analysis graphically for language and mathematics test scores, respectively. In each figure, the solid line represents the estimated effects of exposure to the program at different ages relative to the effect of exposure at age 1 and the dashed lines are 95% confidence intervals. The results in these figures, consistent with our hypothesis, show that the effect of FHP decreases as age at initial exposure (k) increases. The results suggest that the largest effects of FHP on cognitive skills are for those students exposed at or prior to birth. The slopes of the solid lines on the right end of both graphs are relatively flat, suggesting trivial effects if exposed after birth. Appendix Figures 1 and 2 present the placebo estimates (solid lines) with their associated confidence intervals (dashed lines) for language and mathematics test scores, respectively. The solid lines are flat for both language and mathematics test scores, confirming the finding of robust effects of FHP on cognitive skills.

5.3 Heterogeneous Effects

We explore whether the effects differ by student's gender and mother's education using our main measure of early exposure to the program at or prior to birth. To this end, we split the sample into subsamples of female and male students and students who have mothers that completed high school education and did not complete high school education.[18] Panels A and B of Table 5 present the results for language and test scores for the whole sample (column 1) and subsamples by gender of the student (columns 2 and 3) and mother's education (columns 4 and 5), respectively. We do not find significant differences in either test score between female and male students. We find that the positive effect of early exposure to the program on language test scores is statistically significant for students who have mothers who did not complete high school, while it is insignificant for students who have mothers who completed high school. While the positive effect on mathematics test scores is slightly higher for students whose mothers did not complete high school than for those whose mothers completed high school, the estimated effects in columns 4 and 5 are not statistically significantly different from each other.

5.4 Mechanisms

In this section, we investigate potential mechanisms through which FHP could affect cognitive skills. While we cannot test all of the hypotheses discussed in Section 2.2 due to data limitations, we examine parental behavior and time investments related to education as indirect mechanisms that drive improvements in cognitive skills. More specifically, we use information

[18] Due to missing information on mother's education (24% of observations), sample size is reduced when we explore heterogeneity by student's mother's education.

on whether parents encourage their children to study, do homework, or read, ask their children about school, and attend parent-teacher meetings (PTA) as measures of non-monetary parental investments in education. We also use information on whether a child ever repeated a grade and dropped out of school as measures of schooling outcomes that could have been affected by improved contemporary child health due to the program. To gain insights into the indirect mechanisms discussed above, we explore the effects of early exposure to FHP on the mechanisms and present the results in Table 6.

The results suggest that parental behavior related to schooling does not play an important role in explaining the link between early exposure to FHP and cognitive skills. In particular, early exposure to the program is not associated with the probability of parents' asking their children about school, encouraging their children to study, do homework, or read, and attending parent-teacher meetings as the estimated effects (columns 1-5) are very small and statistically insignificant. We also find that early exposure to FHP is not associated with grade repetition and school dropout (columns 6-7), suggesting that schooling is not the mechanism underlying the effect of FHP on cognitive skills. Given that these indirect channels cannot explain the link between FHP and cognitive skills, it is more likely that the direct channels of improved infant and child health could explain the link.

6. Conclusion

Universal primary healthcare provision is becoming an increasingly popular policy across many developing countries. Brazil's Family Health Program, launched in 1994, has been considered a leading successful large-scale health intervention that provides prevention and provision of basic health care through the use of professional healthcare teams that directly intervene at the community level. In this paper, we provide evidence on the effect of the program on cognitive skills of fifth-grade students and explore potential mechanisms in which the program affects cognitive skills.

Exploiting variation in the FHP implementation date across municipalities, birth cohort, and test year, we show that initial exposure to the program at or prior to birth is associated with increases in cognitive skills (increases of 0.030sd and 0.021sd in mathematics and language test scores in intent-to-treat effects, respectively) in northern municipalities. Moreover, employing an event-study analysis, we show that while initial exposure at or prior to birth improves cognitive skills, initial exposure after birth (i.e., exposure in childhood) does not. Our results remain robust to employing various specifications and sample restrictions, alternative measures of early exposure and program intensity, and a placebo test. We do not find evidence of heterogeneity by student's gender or parental education.

Investigating a wide range of potential mechanisms does not indicate that the effects are the consequence of educational outcomes (student grade repetition and school drop-out) or parental behavior related to schooling (whether parents encourage their children to study, do homework, or read, ask their children about school, and attend parent-teacher meetings). This suggests that the effects are likely to operate through the direct impact of better infant and child health on child cognitive development.

Our findings indicate that the benefits of a large-scale health intervention can extend beyond improving health outcomes to improving cognitive skills. The findings also suggest that returns to similar health interventions should include the indirect effects on cognitive skills when conducting cost-benefit analysis. Future research may explore heterogeneous effects across different student characteristics and types of families and monetary parental investment in education as a channel to have a thorough understanding of the relationship between the program and cognitive skills.

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Figures

Figure 1: Cumulative Distribution of Program Implementation

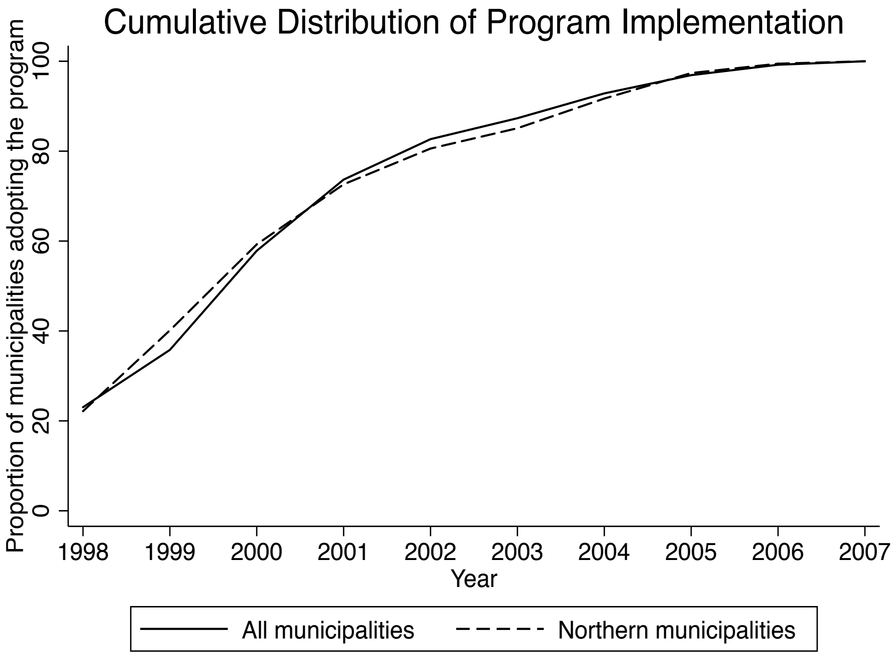


Figure 2: Program Intensity by Time since Implementation

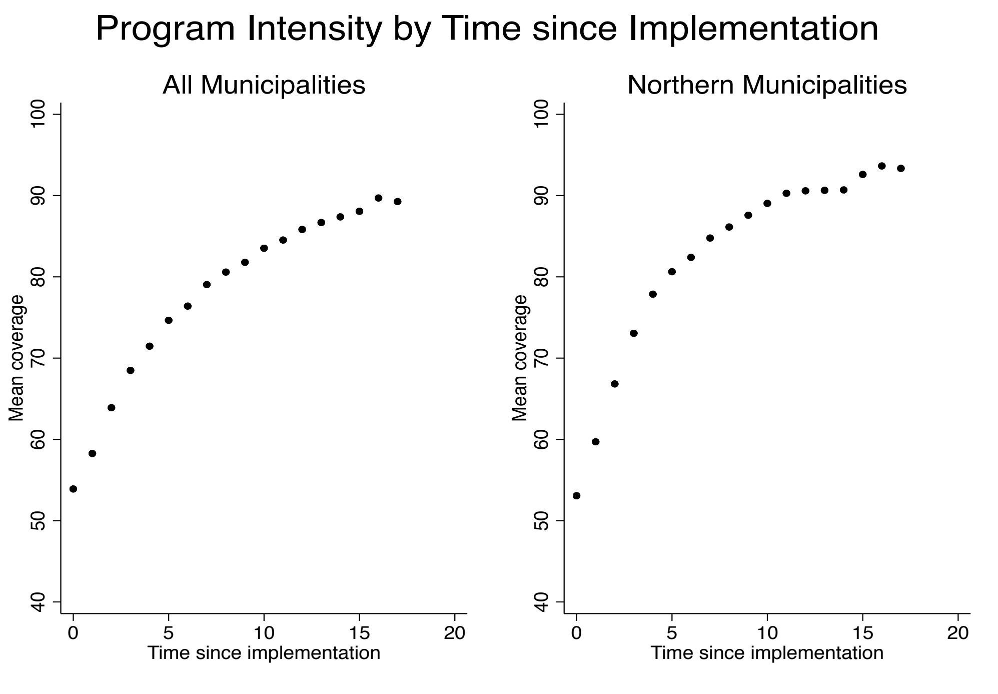
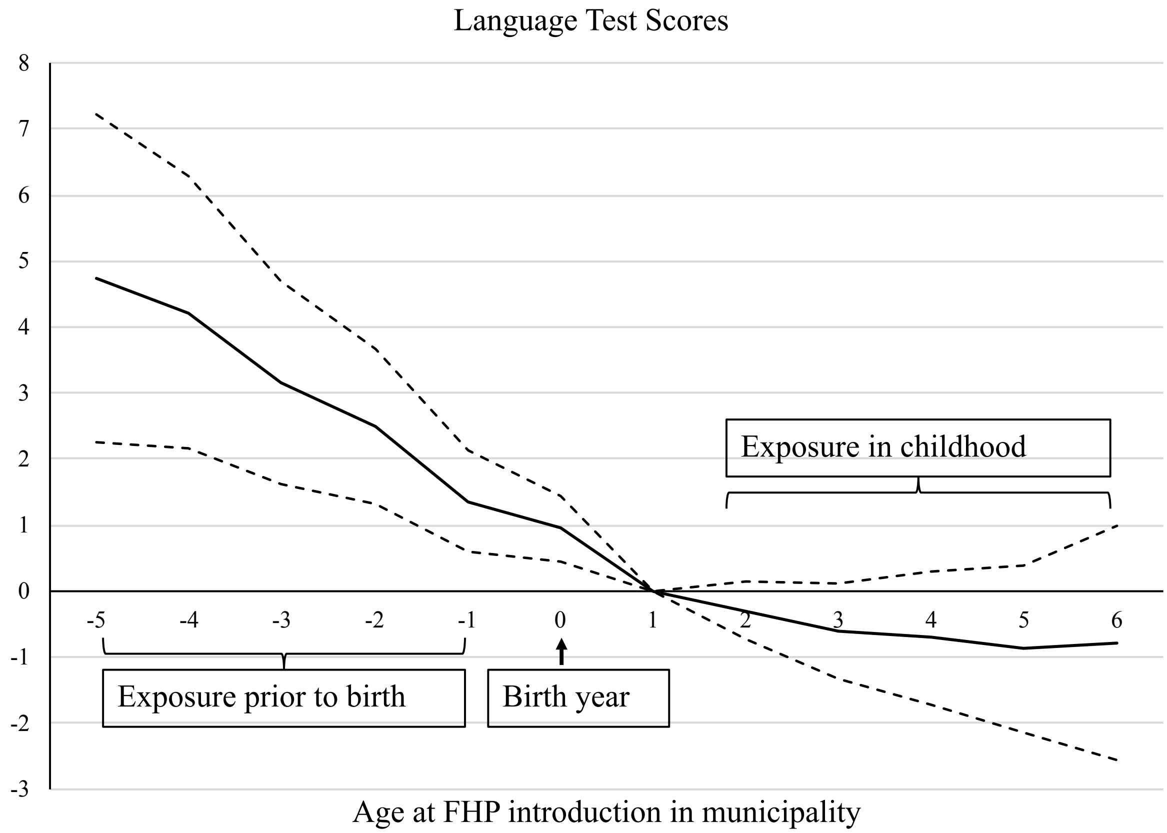
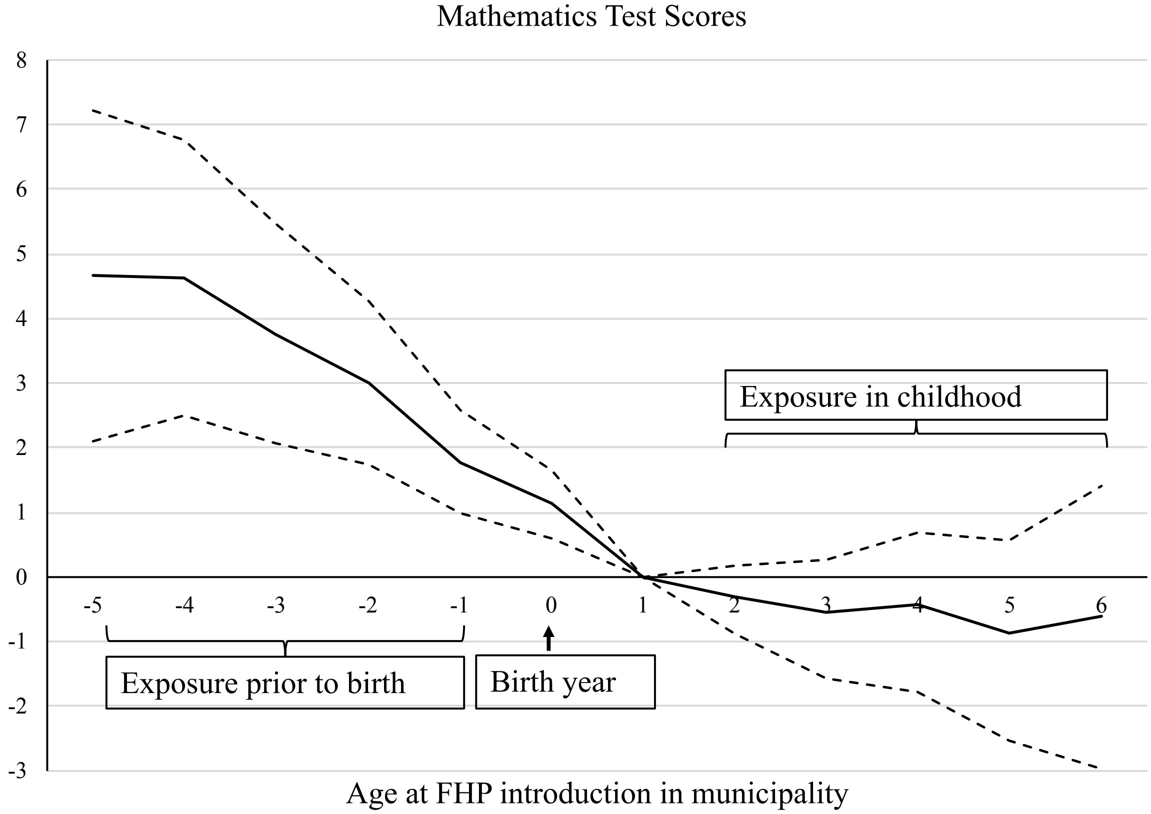


Figure 3a: Event-Study Analysis for Language Test Scores



Notes: Solid line represents the coefficients of initial exposure to the program at different ages on language test scores. The estimates are relative to the effect of initial exposure at age 1. Dashed lines are 95% confidence intervals.

Figure 3b: Event-Study Analysis for Mathematics Test Score



Notes: Solid line represents the coefficients of initial exposure to the program at different ages on mathematics test scores. The estimates are relative to the effect of initial exposure at age 1. Dashed lines are 95% confidence intervals.

Tables

Table 1: Descriptive Statistics

	All municipalities				
	2007	2009	2011	2013	2015
Age	10.69	10.69	10.74	10.82	10.84
Female	0.50	0.50	0.49	0.50	0.50
Race					
Branco (White)	0.35	0.35	0.30	0.30	0.27
Pardo (Mixed)	0.47	0.46	0.45	0.43	0.45
Preto (Black)	0.12	0.12	0.10	0.10	0.09
Amarelo (Asian)	0.03	0.02	0.02	0.02	0.02
Indigenous	0.04	0.04	0.02	0.03	0.03
Not specified	0.00	0.00	0.11	0.12	0.13
Language	176.05	186.45	191.95	198.38	208.90
Mathematics	193.03	206.87	211.01	214.73	220.32
Number of observations	1,796,853	1,872,803	1,775,967	1,476,189	1,609,017
Number of clusters	4,531	4,531	4,531	4,531	4,531

	Northern municipalities				
	2007	2009	2011	2013	2015
Age	11.00	11.00	11.01	11.07	11.03
Female	0.51	0.50	0.50	0.50	0.50
Race					
Branco (White)	0.25	0.25	0.20	0.20	0.18
Pardo (Mixed)	0.52	0.52	0.52	0.48	0.52
Preto (Black)	0.14	0.15	0.11	0.11	0.11
Amarelo (Asian)	0.04	0.03	0.02	0.03	0.03
Indigenous	0.05	0.05	0.03	0.03	0.03
Not specified	0.00	0.00	0.12	0.15	0.14
Language	163.42	171.24	176.8	180.2	193.82
Mathematics	178.67	187.58	192.07	193.78	203.83
Number of observations	584,791	586,880	569,838	465,077	542,283
Number of clusters	2,013	2,013	2,013	2,013	2,013

Table 2: Effect of Early Exposure to FHP on Cognitive Skills

	All Municipalities		Northern Municipalities	
	Language	Mathematics	Language	Mathematics
	(1)	(2)	(3)	(4)
Exposure at or prior to birth	-0.1063	-0.1828	0.8759**	1.2946**
	(0.3700)	(0.4648)	(0.2386)	(0.2723)
Exposure prior to birth	0.2583	0.0844	0.9375**	1.4362**
	(0.2993)	(0.4108)	(0.2482)	(0.2860)
Number of observations	8,530,829	8,530,829	2,748,869	2,748,869
Number of clusters	4,531	4,531	2,013	2,013

Notes:
[1] Each coefficient is from a separate regression model. Each regression controls for gender and race of the student, year of survey fixed effects, municipality fixed effects, age and birth year fixed effects, state trends, trends in baseline municipality characteristics (household income per capita, percent of people living under less than half of the poverty line, proportion of people with eight or more years of schooling, under five mortality rate, neonatal mortality rate, maternal mortality rate, as well BCG, DTP, measles and yellow fever vaccination coverage), time-varying municipality characteristics (log GDP, log of education funds transferred for the FUNDEF program, number of schools and number of students in 1st to 5th grade).
[2] Standard errors in parentheses are clustered at the municipality level.

Table 3: Effects of Program Intensity and Share on Cognitive Skills

	Language			Mathematics		
	(1)	(2)	(3)	(4)	(5)	(6)
Program intensity at birth	0.0119** (0.0049)			0.0204** (0.0066)		
Program intensity one year prior to birth		0.0096* (0.0056)			0.0217** (0.0078)	
FHP share conception-3			1.5780** (0.4276)			1.8711** (0.4776)
Number of observations	2,748,869	2,748,869	2,748,869	2,748,869	2,748,869	2,748,869
Number of clusters	2,013	2,013	2,013	2,013	2,013	2,013

Notes:
[1] Effects are estimated for northern municipalities. Each specification includes the same controls provided in the notes of Table 2.
[2] Standard errors in parentheses are clustered at the municipality level.

Table 4: Effects of Initial Exposure to FHP at Different Ages on Cognitive Skills

	Language		Mathematics	
	(1)	(2)	(3)	(4)
Age at initial exposure k<=-5	4.7405**	4.1387**	4.6629**	4.2527**
	(1.2662)	(0.9741)	(1.3015)	(1.0336)
Age at initial exposure k=-4	4.2266**	3.8133**	4.6215**	4.3541**
	(1.0522)	(0.7850)	(1.0840)	(0.8280)
Age at initial exposure k=-3	3.1607**	2.8679**	3.7651**	3.5870**
	(0.7860)	(0.5909)	(0.8679)	(0.6673)
Age at initial exposure k=-2	2.4935**	2.3206**	3.0051**	2.9170**
	(0.5975)	(0.4578)	(0.6451)	(0.5084)
Age at initial exposure k=-1	1.3632**	1.3028**	1.7792**	1.7751**
	(0.3889)	(0.3140)	(0.4041)	(0.3460)
Age at initial exposure k=0	0.9501**	1.0059**	1.1265**	1.2081**
	(0.2575)	(0.2285)	(0.2688)	(0.2490)
Age at initial exposure k=1	Control Group		Control Group	
Age at initial exposure k=2	-0.2956		-0.3104	
	(0.2214)		(0.2462)	
Age at initial exposure k=3	-0.6201*		-0.532	
	(0.3691)	Control Group	(0.4144)	Control Group
Age at initial exposure k=4	-0.7058		-0.4351	
	(0.5140)		(0.5736)	
Age at initial exposure k=5	-0.8679		-0.8638	
	(0.6467)		(0.7394)	
Age at initial exposure k>=6	-0.7977		-0.593	
	(0.9020)		(1.0232)	
Number of observations	2,748,869	2,748,869	2,748,869	2,748,869
Number of clusters	2,013	2,013	2,013	2,013

Notes:
[1] Effects are estimated for northern municipalities. Each specification includes the same controls provided in the notes of Table 2.
[2] Standard errors in parentheses are clustered at the municipality level.
[3] Omitted control group is students exposed to the program at age 1 in columns 1 and 3, while omitted control group is students exposed to the program after birth in columns 2 and 4.

Table 5: Heterogeneous Effects

	Whole Sample	Gender of the Student		Mother's Education	
		Female	Male	No HS	HS
	(1)	(2)	(3)	(4)	(5)
Panel A: Language					
Early Exposure	0.8759**	0.8044***	0.9470***	0.6997***	0.4479
	(0.2386)	(0.2818)	(0.2411)	(0.2630)	(0.3050)
Panel B: Mathematics					
Early Exposure	1.2946**	1.1190***	1.4621***	1.2159***	0.9210***
	(0.2723)	(0.2878)	(0.3051)	(0.2791)	(0.3434)
Number of observations	2,748,869	1,372,517	1,376,352	1,531,725	551,941
Number of clusters	2,013	2,013	2,013	2,013	2,013

Notes:

[1] Effects are estimated for northern municipalities. Each specification includes the same controls provided in the notes of Table 2.

[2] Standard errors in parentheses are clustered at the municipality level.

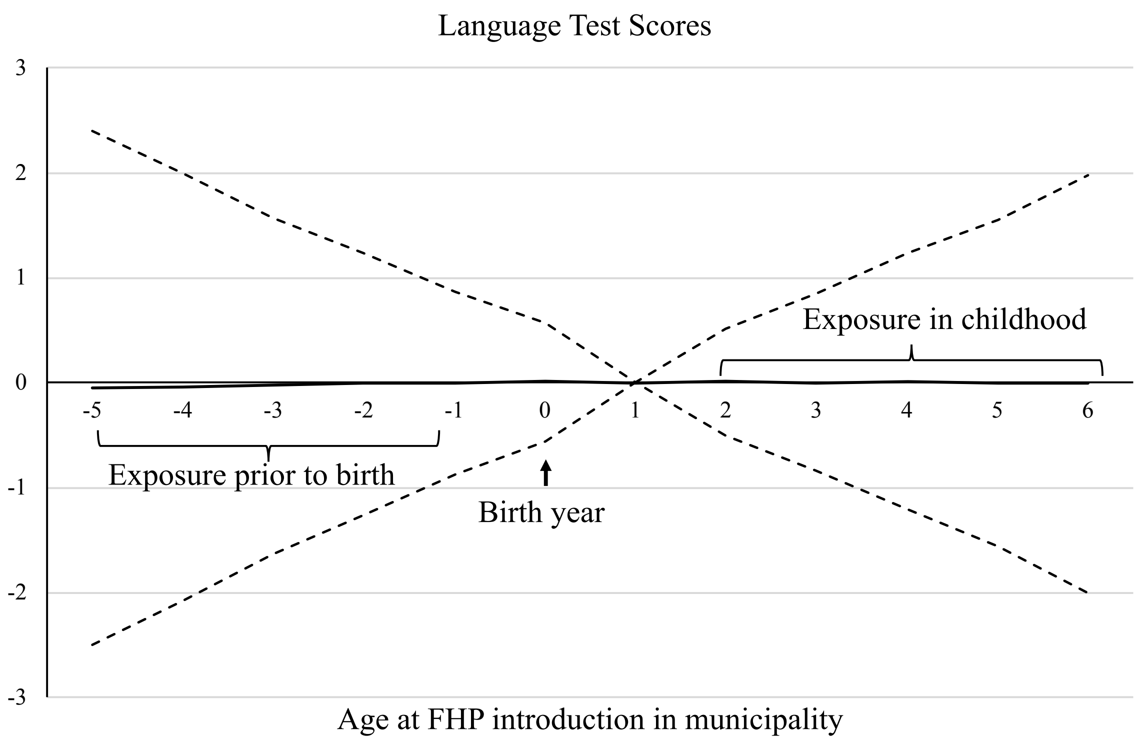
Table 6: Effects of Early Exposure to FHP on Schooling and Parental Behavior Related to Education

	Parents ask about school	Parents always attend PTA	Parents encourage to			Ever repeated grade	Ever dropped out of school
			Study	Do homework	Read		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Early Exposure	0.0003	-0.0014	-0.0007	-0.0003	-0.0003	-0.0036	-0.0001
	(0.0013)	(0.0023)	(0.0007)	(0.0008)	(0.0008)	(0.0046)	(0.0012)
Number of observations	2,638,368	2,608,984	2,515,229	2,648,473	2,566,458	2,595,562	2,628,607
Number of clusters	2,013	2,013	2,013	2,013	2,013	2,013	2,013

Notes:
[1] Effects are estimated for northern municipalities. Each specification includes the same controls provided in the notes of Table 2.
[2] Standard errors in parentheses are clustered at the municipality level.

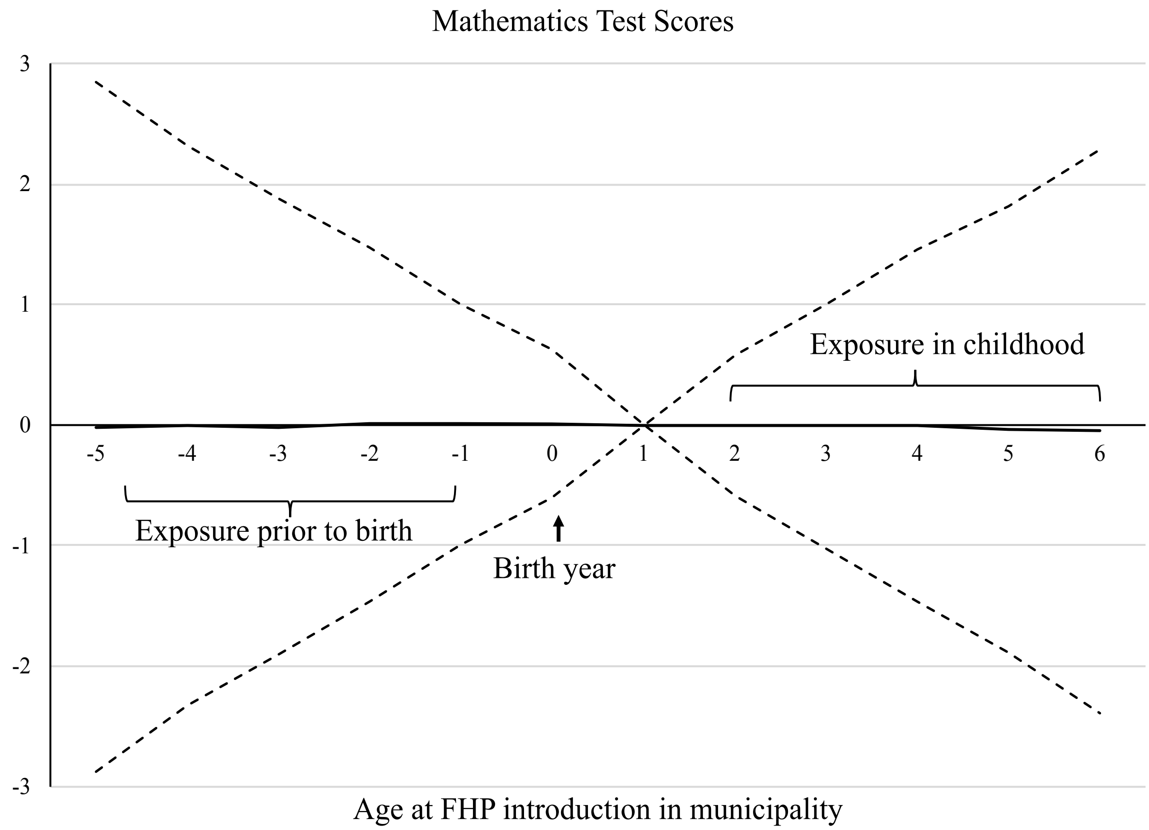
Appendix Figures and Tables

Appendix Figure 1: Placebo Estimates for Language Test Scores



Notes: Solid line represents the coefficients of initial exposure to the program at different ages on language test scores. The estimates are relative to the effect of initial exposure at age 1. Dashed lines are 95% confidence intervals.

Appendix Figure 2: Placebo Estimates for Mathematics Test Scores



Notes: Solid line represents the coefficients of initial exposure to the program at different ages on mathematics test scores. The estimates are relative to the effect of initial exposure at age 1. Dashed lines are 95% confidence intervals.

Appendix Table 1: Sensitivity Analysis with Additional Control Variables

	Language			Mathematics		
	Original Case	Month of birth FE	School and Month FE	Original Case	Month of birth FE	School and Month FE
	(1)	(2)	(3)	(4)	(5)	(6)
Early Exposure	0.8759**	0.8918**	0.7903**	1.2946**	1.3272**	1.2142**
	(0.2386)	(0.2385)	(0.2355)	(0.2723)	(0.2692)	(0.2608)
School FE	No	Yes	Yes	No	Yes	Yes
Month of birth FE	No	No	Yes	No	No	Yes
Number of observations	2,748,869	2,696,884	2,696,877	2,748,869	2,696,884	2,696,877
Number of clusters	2,013	2,013	2,013	2,013	2,013	2,013

Notes:

[1] Effects are estimated for northern municipalities. Each specification includes the same controls provided in the notes of Table 2.

[2] Standard errors, clustered at the municipality level, in parentheses.

Appendix Table 2: Sensitivity Analysis with Different Sample Restrictions

	Language			Mathematics		
	Original Case	Exclude born>3 years after	Exclude 2015	Original Case	Exclude born>3 years after	Exclude 2015
	(1)	(2)	(3)	(4)	(5)	(6)
Early Exposure	0.8759**	0.9973**	0.5467**	1.2946**	1.1954**	0.8998**
	(0.2386)	(0.2429)	(0.2594)	(0.2723)	(0.2807)	(0.3050)
Number of observations	2,748,869	2,171,778	2,206,586	2,748,869	2,171,778	2,206,586
Number of municipalities	2,013	2,013	2,013	2,013	2,013	2,013

Notes:
[1] Effects are estimated for northern municipalities. Each specification includes the same controls provided in the notes of Table 2.
[2] Standard errors, clustered at the municipality level, in parentheses.