Impact of Early Life Shocks on Human Capital Formation: Evidence from El Niño Floods in Ecuador *

Maria Rosales-Rueda

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Abstract

This paper investigates the persistent effect of negative shocks early in life on children's human capital, and explores whether the timing of exposure matters differentially by type of skills. As a source of exogenous variation, I exploit the geographic intensity of severe floods during the 1997-1998 El Niño phenomenon in Ecuador. Children exposed in utero, especially during the third trimester, are shorter in stature five and seven years later. Children affected by the floods in the first trimester of pregnancy score lower on cognitive tests. Also, the paper explores potential mechanisms by studying health at birth and family inputs (income, consumption, and breastfeeding).

Keywords: Early-life shocks, human capital formation, health at birth, family inputs

JEL codes: J13, Q54, I20, O12

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1 Introduction

A growing body of research argues that adverse experiences in utero and during early childhood have lasting effects on later in life human capital outcomes such as health and education. This interest has been inspired by the modern literatures in epidemiology and economics, which demonstrate that genetics do not exclusively explain the evolution of health, cognitive and socio-emotional skills. In contrast, family investments and environments play a major role in determining skill development and subsequent inequalities (Almond and Currie, 2011; Barker, 1995; Cunha and Heckman, 2007; Gluckman and Hanson, 2005; Heckman, 2007). This paper investigates the consequences of disruptions to early-life environments on children's human capital formation.

Because differences in early environments may be confounded with family unobserved characteristics, an increasing number of studies rely on natural experiments as sources of exogenous variation in early childhood conditions to identify their causal impact on later outcomes. Such adverse circumstances include[1] pandemics (Almond, 2006 [U.S.]; Kelly, 2011 [U.K.]); famines (Almond et al., 2010 [China]; Meng and Qian, 2009 [China]; Dercon and Porter, 2010 [Ethiopia]; Scholte et al., 2012 [Netherlands]); armed conflicts (Akresh et al., 2012 [Nigeria]; Camacho, 2008 [Colombia]; Leon, 2012 [Peru]); radioactive emissions (Almond et al., 2009 [Sweden]; Black et al., 2013 [Norway]); and extreme weather shocks (Currie and Rossin-Slater, 2013 [U.S.]; Ugaz and Zanolini, 2011 [Philippines]; Rabassa et al., 2012 [Nigeria], Shah and Steinberg, 2012 [India]; Aguilar and Vicarelli, 2012 [Mexico]). While this literature initially focused on long-term health outcomes, more recently, it has considered the effect of negative shocks on educational and labor outcomes. However, evidence of the effects of early-life shocks on children's human capital, and in particular on cognitive skills, is still growing.

The empirical evidence suggests that experiences during early childhood can have long-lasting effects on later outcomes. However, some open questions remain. First, there is still little evidence about the timing of exposure or whether events at certain periods matter more than others. A second related question is whether the timing of exposure matters differentially by type of skills. For instance, is formation of cognitive skills more vulnerable to shocks in certain periods compared to health skills? Third, most of the previous literature looks at the effects of negative shocks on long-term outcomes and rarely has explored potential mechanisms, making it difficult to inform remediating policies. I address these questions in this paper. In particular, I use the geographic intensity of extreme floods during the

[1] The following studies are examples in the literature. For a more complete overview see Almond and Currie (2011), and Currie and Vogl (2012)

1997-1998 El Niño phenomenon in Ecuador as a source of exogenous variation in children's exposure to a negative shock at different periods early in life.

Extreme weather events are a relevant type of shock because recent trends in global climate change suggest that they may become more frequent and their intensity less predictable (Cai et al., 2014; Kovats et al., 2003). Also, weather shocks are perhaps one of the most frequent adverse conditions faced by households in developing countries (Currie and Vogl, 2012). Income losses, consumption fluctuations, and infectious diseases are among the consequences of weather shocks (Baez et al., 2010). These changes can disrupt development before birth and during early childhood, both of which are critical periods for future human capital development. Because income constrained households fail to protect consumption of food, health, and education, uninsured extreme weather shocks can have considerable and lasting effects on children's human capital (Baez et al., 2010). Most of the research in developing countries has emphasized the effects of weather shocks on nutritional and health outcomes, while the evidence on cognitive and educational outcomes is still limited.[2]

Theoretically, the persistent consequences of negative shocks early in life on later childhood and beyond can be explained by the dynamic nature of human capital formation. First, skills are self-productive, which means that the level of future skills depends on the level of past skills (Cunha and Heckman, 2007). This concept implies that if a negative shock occurs at an influential stage of human capital formation, it will not only affect child's skills in that period, but it will also reduce future accumulation of skills. Second, human capital investments can exacerbate or compensate for early life shocks (Almond and Mazumder, 2013). One reason is that the productivity of future human capital investments depends on the level of past skills. This implies that a negative shock to past skills decreases the productivity of future investments. Another reason is that parental preferences in the form of aversion to inequality influence their human capital investments in children and can motivate them to compensate an early life shock through more investments. Overall, the persistent consequences of early life shocks are the result of the effects of skill's self-productivity and investment responses.

To investigate the effects of early life exposure to severe floods on later child development

[2]Regarding health outcomes, some studies have found full or partial recovery in terms of weight loss (Foster, 1995), but not in terms of height, especially among poor households (Del Ninno and Lundberg, 2005). Indeed, a large body of evidence demonstrates persistent effects of exposure to natural disasters during pregnancy and early years on height in late childhood and adolescence (Aguilar and Vicarelli, 2012; Alderman et al., 2006; Hoddinott and Kinsey, 2001; Porter et al., 2008; Ugaz and Zanolini, 2011). Regarding lasting effects of natural disasters on cognitive test scores, Shah and Steinberg (2012) provide evidence that exposure to droughts in utero reduced test scores among school-aged children in India, both in math and reading. Aguilar and Vicarelli (2012) studied the medium-term effects of the El Niño phenomenon in Mexico on children's outcomes (four to five years later). They estimated that children exposed to the shock early in life scored 11-12 percent lower than same-aged children not exposed to the shock.

and whether the timing of exposure matters, I combine rainfall data with a dataset[3] that collected children's health and cognitive outcomes five and seven years after the 1997-98 El Niño disaster. I identify exposure to severe floods using two sources of variation. First, I exploit timing of birth variation since the sampled children were born between 1997 (during the shock) and 2002 (four years later). Second, I rely on geographic variation in the exposure to the floods since the sample includes villages on the coast (more affected) and in the highlands (less affected). I find that children who were in utero during the El Niño 1997-98 are shorter in stature, tend to be more anemic, and score lower on vocabulary tests five and seven years after the shock. Average effect sizes fall between 0.1 and 0.14 standard deviations. Furthermore, I provide suggestive evidence that the negative effect on height comes from exposure during the third trimester in utero, while the deficit in cognition comes from exposure during the first trimester. These timing of exposure results are in line with the medical literature on sensitive periods for growth and brain development (Altshuler, 2003; Harding and Alan, 2001). Also, I perform several robustness and placebo checks that validate these results.

To explore potential mechanisms behind these persistent effects, I look at the impact of El Niño floods on inputs to human capital production: birth endowments and family inputs (income, consumption, and breastfeeding). I match rainfall data with two Ecuadorian household surveys: the Reproductive and Health Surveys (RHS) and the Living Standard Measurement Studies (LSMS) surveys. Both surveys were collected prior to the 1997-98 El Niño shock and afterward. I find that children exposed to El Niño floods, especially in the third trimester of pregnancy, are more likely to be born with low birth weight. However, I do not find effects of exposure to the shock on the likelihood of premature birth. This pattern of results provides suggestive evidence that the increase in low birth weight may be driven by intrauterine growth restriction, which is largely determined by poor maternal nutrition (Kramer, 1987). Regarding family inputs, I show that households affected by El Niño 1997-98 suffered a decline in income, total consumption, and food consumption. Also, I show that exposure to El Niño floods decreased the duration of exclusive breastfeeding, but increased the duration of total breastfeeding (breast milk combined with formula or other food).

All results are robust to a variety of specifications and falsification tests that rule out the presence of confounding factors or omitted trends. Moreover, I show that exposure to the shock is not confounded with changes in the socio-demographic composition of families living (giving birth) in villages more affected by the shock. Finally, I directly examine selection

[3]This dataset corresponds to the survey collected to evaluate the Bono de Desarrollo Humano, a cash transfer program launched in 2004

concerns related to endogenous fertility, migration and infant mortality, and find that they do not drive the results. All of these tests provide support for the validity of my identification strategy.

My study builds on and contributes to both the early influences literature and the climate change literature in health and economics. First, this paper goes beyond analyzing the impact of early life shocks on later outcomes, and contributes to understanding how different inputs to the production of human capital respond to negative early childhood influences. This type of evidence is still rare in the context of developing countries. Second, this analysis explores the timing of exposure to the shock within the prenatal period, and provides additional evidence of sensitive periods in the evolution of health and cognitive skills. Third, my findings highlight relevant implications for developing policies that improve the coping mechanisms against negative shocks that affect family income, maternal nutrition, stress and health. Those policies should target disadvantaged families with children and pregnant women in order to prevent the negative consequences on children's human capital, which may not be apparent in the aftermath of the shock but in hidden future damages.

The remainder of the paper is organized as follows. Section 2 presents a theoretical framework to conceptualize the persistent effects of early life shocks. Section 3 describes the 1997-1998 El Niño shock and outlines the sources of data. Section 4 discusses the empirical strategy and my findings regarding the lasting effects on children's health and cognitive outcomes. Section 5 presents the results of birth endowment responses, while the evidence on family input responses is presented in Section 6. Section 7 discusses some robustness checks and selection concerns. Section 8 presents further discussion and conclusions.

2 Conceptual framework

This section discusses how the evidence of lasting effects of early life shocks can be interpreted using the dynamic model of human capabilities formation developed by Heckman (2007), Cunha and Heckman (2007), and Cunha et al. (2010). In contrast to the traditional static model, the life-cycle perspective is key to understanding the persistence of a negative shock early in life into later childhood and beyond. In this framework, the notion that "skills beget skills" interacts with family and environmental influences to explain the importance of early disadvantage. The model shows that an early life shock can affect later outcomes through two main mechanisms: the self-productivity of human capital and investment responses. First, the stock of future skills is directly affected by the stock of past skills, an effect known as "self-productivity" (Cunha and Heckman, 2007). If a shock occurs at an influential stage of human capital formation, it directly affects the skill endowment itself, and damages can persist. Second, human capital investments can reinforce or compensate for early life shocks (Almond and Mazumder, 2013). One reason is that the level of skill determines the productivity of future investments, a feature known as "dynamic complementarity" (Cunha and Heckman, 2007), which could lead to investment responses that reinforce early disadvantage. Another reason is that parental preferences, in the form of aversion to inequality, could influence parents' human capital investments and motivate them to compensate for an early life shock through more investments. Overall, the persistent consequences of early life shocks are the result of the effects of skill's self-productivity and investment responses.[4]

In the model developed by Heckman and coauthors, capabilities, captured in the vector θ, are multidimensional and can be cognitive (C), socio-emotional (SE), or health-related (H) skills.[5] Because parents care about the quality of their children's human capital, they make investments that can take the form of goods such as food, books, clothing, and toys, and time such as breastfeeding, cognitive and emotional stimulation, etc. For simplicity, both types of investments are captured in the vector I. Investments interact with the previous stock of a child's skills (θ_t), parental endowments (θ_P), and environmental shocks (π) in the production of further skills (θ_{t+1}).

To better illustrate the effects of in utero exposure to negative shocks, I assume two periods of childhood: birth/infancy ($t = 0$) and childhood ($t = 1$). The production of skills at birth (θ_0) is:

$$\theta_0 = f_{-1}(\theta_{-1}, I_{-1}, \theta_P, \pi_{-1}) \tag{1}$$

where I_{-1} captures prenatal investments, θ_{-1} denotes a vector of genetic endowments at conception, and π_{-1} corresponds to shocks during pregnancy. However, investment decisions are endogenous and also affected by environmental shocks:

$$I_{-1} = q(\theta_{-1}, \theta_P, \pi_{-1}) \tag{2}$$

Similarly, the production of skills during early childhood (θ_1) and investments (I_0) are:

$$\theta_1 = f_0(\theta_0, I_0, \theta_P, \pi_0), \text{ and } \quad I_0 = q(\theta_0, \theta_P, \pi_0) \tag{3}$$

where I_0 corresponds to investments during birth/infancy, and π_0 captures shocks to environments during infancy. To examine the effects of a negative shock, this paper uses

[4] Another related reason that can explain investment responses is the magnitude of the elasticity of substitution between the early-life shock(or early investments) and future investments (Almond and Mazumder, 2013).

[5] In this paper, I focus only on health and cognitive skills.

exposure to severe floods during 1997-98 in Ecuador, known as the "El Niño phenomenon." This shock caused income losses, consumption fluctuations, infectious diseases, family stress, among other negative consequences that will be described below, which disrupted early life environments.

Effects of in utero shocks on skills at birth

We can use this framework to show how experiencing a negative shock in utero π_{-1} affects skills at birth and in later years. First, the total effect on a child's skills at birth (t=0) can be decomposed as follows:

$$\frac{d\theta_0}{d\pi_{-1}} = \underbrace{\frac{\partial\theta_0}{\partial\pi_{-1}}}_{\text{Biological}} + \underbrace{\frac{\partial\theta_0}{\partial I_{-1}}\frac{\partial I_{-1}}{\partial\pi_{-1}}}_{\text{Investment Channel}} \tag{4}$$

The first term on the right-hand side captures the biological effect of in utero exposure to a shock on birth endowments, which is expected to be negative. Seminal work in epidemiology has established that due to disruptions in the prenatal environment, the fetus adapts to increase the likelihood of survival (Barker, 1995; Gluckman and Hanson, 2005). These adaptations may be irreversible if shocks are intense, causing damages that manifest later in life.

The second term captures the investment responses to the shock, and its sign is ambiguous. Experiencing a negative shock like El Niño floods can alter prenatal investments in several ways. First, severe floods increase infectious diseases and parental stress, which can impact maternal physical and mental health that further affect fetal development. Additionally, weather shocks can cause agricultural losses, disruptions in food supply, and damages to infrastructure, which affect household income and maternal nutrition, all of which can negatively influence prenatal investments. Moreover, these direct or local consequences can lead to indirect and general equilibrium effects such as changes in commodity prices and real wages, which are accompanied by competing income and substitution effects. On the one hand, if wages decrease, the income effect implies tighter budget constraints and fewer resources to invest prenatally (both time and goods). On the other hand, a decline in wages implies a decrease in the opportunity cost of time, which could induce mothers to substitute their time away from labor activities and to increase time investments like attending prenatal health care. Overall, the second term on the right-hand side, the investment channel, combines the impacts from both local and general equilibrium effects and its sign is ambiguous, which also makes the total effect of a negative shock in utero on a child's skills at birth ambiguous.[6]

Effects of in utero shocks on future skills

Furthermore, exposure to shocks early in life can have lasting effects on children's future skills. Equation 5 shows the total effect of in utero exposure (t=-1) to a negative shock on a child's skills in the future period (t=1, early childhood):

$$\frac{d\theta_1}{d\pi_{-1}} = \underbrace{\frac{\partial\theta_1}{\partial\theta_0}\frac{d\theta_0}{d\pi_{-1}}}_{\text{Skills' Self-Productivity}} + \underbrace{\frac{\partial\theta_1}{\partial I_0}\frac{\partial I_0}{\partial\theta_0}\frac{d\theta_0}{d\pi_{-1}}}_{\text{Investment Channel}} \tag{5}$$

The total effect of suffering a shock in utero on later skills combines two effects. The first term captures the fact that skills are self-productive across periods: the prior stock of skills influences skills attained in the next period (Heckman, 2007). The second term captures the relationship between parental investment responses to a negative shock and *previous* skills. Parental investments could reinforce or compensate for the negative shock to skills, which again makes this term ambiguous. Therefore, the total effect of in utero exposure to adverse events on later human capital is ambiguous, and it is composed of the biological/self-productivity channel plus the parental investment responses.

Since the effects of early life shocks on child's skills are theoretically ambiguous, this paper uses exposure to severe floods in Ecuador to evaluate these effects empirically. Ideally, one would like to decompose the total effect on the two channels: the biological or self-productivity channel and the investment responses channel. However, this requires access to rich longitudinal data on children exposed to a shock that include both investments and child's skills from birth through later periods. I am unable to perform such analysis because that data are rare in developing countries. In this paper, I estimate reduced form net effects of exposure to severe floods early in life on children's cognitive and health skills five and seven years later. These estimates combine both type of channels, as well as the effects from exposure to both local and general equilibrium consequences from El Niño phenomenon. Moreover, using secondary data, I analyze the effects on some family inputs/investments - family income, consumption and breastfeeding -, which allows me to gain a better understanding of potential intermediate pathways. This analysis offers a more complete picture

[6] Previous studies have found mixed evidence about the responses of infant health to aggregate income shocks. For instance, Bhalotra (2010) and Cutler et al. (2002) find that infant mortality is countercyclical, while Miller and Urdinola (2010) report procyclical mortality. Miller and Urdinola find that one of the mechanisms is that time intensive health investments increase during economic downturns in Colombia. In this paper, I do not find evidence of neonatal and infant mortality responses (Appendix A.6) nor I find evidence that prenatal health investments like attendance and number of prenatal care visits responded to the El Niño 97-98 in Ecuador (Table 6).

of the lasting effect of exposure to shocks early in life that goes beyond the medium-term effects, evidence that is still rare in developing countries.

3 Background and data

3.1 El Niño 1997-1998 in Ecuador

El Niño is a recurrent climate event that causes weather disasters from heavy rainfall, severe flooding, and landslides on the west coast of South America to extreme droughts in Indonesia. Because the cycle of this event is irregular and varies in length from two to seven years, the exact timing and intensity of each occurrence remain uncertain (Kovats et al., 2003).

The El Niño event of 1997-98 in Ecuador was extremely severe. In fact, it was the greatest in magnitude compared to the previous twenty-eight events during the twentieth century (Garibay et al., 2010). The event was exceptionally intense and long, lasting nineteen months from February 1997 through August 1998 (CAF, 2000), with precipitation recorded at more than five times normal levels (see Figure 1). Furthermore, local and international media documented that the strength and timing of the floods were unpredictable (The Economist, 1998). The total social and economic losses were \$2.8 billion (13% of Ecuador's GDP in 1996), with agriculture and infrastructure sectors suffering most of the negative consequences (ECLAC, 1998).

Losses in the agricultural sector accounted for approximately 6% of the GDP.[7] Around 30% of the total area of crops under cultivation in the country were damaged or lost. Not only could some of the cultivated area not be harvested, but the next planting season was also altered. The most affected crops were rice, corn, sugar cane, coffee, and cocoa (CAF, 2000). Geographically, the losses in the agricultural sector were concentrated in the coastal states, matching the regions most affected by extreme precipitation (See Figure 2).

Costs of damages in the infrastructure and transportation sectors corresponded to 3.7% of the GDP, since damages to roads and bridges led to an increase in transportation costs. Housing, health centers, and schools were also severely affected by the floods and landslides. These local negative consequences to the agriculture and infrastructure sectors generated some general equilibrium effects such as changes in relative prices of food and real wages.

Floods also damaged sanitation, drinking water, and sewerage infrastructures. Water contamination increased the risk of people contracting diarrhea, cholera, malaria, dengue fever, and other infectious diseases. Indeed, malaria cases increased from 102.5 cases per

[7] Agriculture represented 14% of Ecuador's GDP between 1997-2000.

100,000 people in 1996 to 351.1 per 100,000 in 1998 (PAHO, 2000).

This paper investigates the medium and short-term effects of El Niño 1997-98 on children's human capital formation. Since the social and economic losses of this shock were very large, disaster relief resources may prioritize remediation of the immediate damages. However, investigating whether exposure to severe weather shocks has lasting damages on children is highly relevant since they may constitute a "hidden" cost of natural disasters and a future toll to economic growth. Children bear a sizable proportion of the consequences from weather disasters. Compared with adults, they are more vulnerable to the direct and indirect consequences of severe weather events but often are left out of discussions. According to the World Health Organization, children suffer around 80% of the health damages from climate change. Also, Save the Children estimates that the number of children affected by natural disasters will increase from 66.5 million per year in late 1990's to 175 million per year in the next decade (Baker and Kyazze, 2008; Currie and Deschnes, 2016). Therefore, improving policies to help families cope with the challenges of climate change is relevant both in the short and long-run.[8]

3.2 Data

Rainfall data and exposure to El Niño

El Niño 1997-1998 lasted approximately nineteen months, from February 1997 to August 1998 (CAF (2000); and, Ecuador Meteorological Department). To measure geographic exposure to this shock and the intensity of the floods, I use rainfall data from 244 weather stations across Ecuador. Using monthly precipitation data, I measure excess rainfall for each month during the shock (m) and weather station (s) as the deviation of the observed precipitation in that month from the long-term mean (1971-2000) divided by the historical monthly standard deviation[9]:

$$sd\_excess\_rainfall_{m,y,s} = \frac{(P_{m,y,s} - \overline{P_{m,s}})}{\sigma_{m,s}} \tag{6}$$

where $P_{m,y,s}$ is the observed precipitation for a given month m in year y at weather station s. $\overline{P_{m,s}}$ is the long-term mean (1971-2000) for month m at location s, and $\sigma_{m,s}$ is the corresponding standard deviation. This index is known in the climatology literature as precipitation anomalies or Standardized Precipitation Index. According to climatologists, when analyzing

[8]Disaster mitigation strategies and policies face the challenge that the costs and benefits of their implementation are not evenly distributed overtime (Oppenheimer and Anttila-Hughes, 2016)

[9]Results are robust to using as reference the mean precipitation during previous El Niño phenomena to capture a more unexpected dimension of the 1997-98 shock.

extreme precipitation events, excess rainfall measures should be expressed in terms of standard deviations to provide more information about the magnitude of the anomaly after the influence of normal dispersion has been removed (The International Research Institute for Climate and Society, (IRI)).

Because the child and family data are geographically identified at the village level, the monthly excess of rainfall indicators are matched to the villages using the closest weather station to the center of each village following Maccini and Yang (2009).[10] At the village level (v), I calculate exposure to El Niño 1997-98 as the number of months between February 1997 and August 1998 during which the observed excess of rainfall exceeded one historical standard deviation (Guerreiro et al., 2008; Seiler et al., 2002; Zeballos, 2004):[11]

$$nino\_shock_v = \sum_{m=jan97}^{Aug98} 1\{sd\_excess\_rainfall_{v,m} \geq 1sd\} \tag{7}$$

However, the findings from this paper are robust to alternative measures of the El Niño shock, such as using a 1.5 cut-off or summing up the excess of rainfall z-scores.[12]

Figure 3 shows the geographic variation in the intensity of El Niño shock among villages in Ecuador using the measure of floods explained above. The geographic variation from this measure closely matched the geographic pattern from agricultural losses displayed in Figure 2, as well as government descriptive reports about the regions more affected by floods during El Niño 97-98. It is clear that the villages most affected by the floods were located in the coastal region, while those situated in the highlands were less affected. For example, on the coast, villages experienced between three and seventeen months of floods. In the highlands, villages either did not suffer from severe floods or experienced very few.

Child data

To analyze the medium-term effects of early life exposure to severe floods on children human capital, this paper uses data from a longitudinal survey that were collected to evaluate Ecuador's cash transfer (CT) program (Bono de Desarrollo Humano (BDH)). The first wave was collected in 2003-04 and it sampled 7,989 children from newborns to age six who were born to 5,056 families. To be eligible to receive the transfer, families have to be in the first two quintiles of a poverty index constructed from a proxy means test. Also, because the

[10] The median distance to the center of a village is around 10 Km, and the percentile 95 is 50 Km.

[11] Zeballos (2004) described that strong El Niño events in Ecuador, like the one in 1997-1998, can be characterized by precipitation anomalies greater than one. Also, conversations with experts at the Ecuador's National Institute of Meteorology and Hydrology (INAMHI) supported the use of this threshold

[12] See Appendix A.1.

goal of the evaluation study was to investigate the effects of the program on the health of young children, families in the sample have at least one child under the age of six and no children ages six or above.[13] The sampled households live in six different states: El Oro, Los Rios, and Esmeraldas, located in the coastal region, and Pichincha, Loja and Azuay, located in the highlands. These states were selected because roll-out of the CT program had not started at that time (Paxson and Schady, 2010).[14] A second wave was collected in 2005-06 with a 7% attrition rate.

The sample of families in this survey is not nationally representative of Ecuador because it consists of households that were eligible to receive the cash transfer. Therefore, this sample corresponds to a low socio-economic status population. Table 1 presents means of selected characteristics for households in this sample as well as for households in a national representative sample, the Reproductive and Health Survey. Compared to national averages, households in the Ecuador cash transfer evaluation survey tend to be more disadvantaged. The fraction of mothers with more than primary education and that are married or cohabiting is lower. Houses have fewer rooms and are less likely to have running water and indoor flush toilets. Also, the families sampled are "younger" because, as mentioned before, the sample excluded families with children older than age 6.[15] It is important to acknowledge that the medium-term effects analyzed in this paper focus on children from low SES families who may lack adequate coping mechanisms to respond to the shock compared to better off households. However, from a policy perspective, this population is particularly interesting since they are more vulnerable to the threats from weather disasters and governments can consider improving safety net programs, access to adequate sanitation among other policies to help them buffer shocks.

The CT surveys collected children's health and cognitive outcomes, as well as rich information on families' socio-demographic characteristics, such us maternal and paternal education, and household size. The health outcomes considered in this paper include height and anemia. Height z-scores were age and sex adjusted using the Center for Disease Control (CDC) growth charts. Anemia status was computed using elevation adjusted hemoglobin levels. The cognitive outcome analyzed is the Peabody Picture Vocabulary Test (PPVT). Scores were standardized using norms published by test developers. The normed sample is composed of Mexican and Puerto Rican children. All three outcomes were collected in both

[13] According to Paxson and Schady (2010), the evaluation study "excluded BDH-eligible families with older children because, in the event that the program became conditional, the conditionality would work differently for families with school-aged children than for families with (only) younger children".

[14] Within those states, 118 villages were selected: 39 control villages and 79 treatment villages. Families in treatment villages were eligible to receive the program at the end of 2004

[15] This explains why the average age of the mothers is lower in this sample compared to national averages.

waves (Paxson and Schady, 2007).

Because the PPVT was collected for children aged three and above, the sample used in this analysis includes children born between 1997 and 2002.[16] The bottom panel in Table 1 shows the descriptive statistics at baseline (2003-04) for the sample of children analyzed in this paper. Children's average height is one standard deviation below the reference population. Children's mean PPVT score is slightly below the normed sample.

Birth outcomes data

Information on birth outcomes comes from the 1994 and 1999 Reproductive and Health Surveys (RHS). The RHS collects data on mothers' fertility histories, health, family planning and sexual behaviors; and on children's health at birth. The surveys are based on a nationally representative sample of women of reproductive ages (15-49 years old) from around 20,000 households. Descriptive statistics for the sample of households in 1994 are shown in Table B.2. This dataset provides measures before and after the 1997-98 El Niño, allowing for analysis of the impact of this extreme weather shock on children's birth endowments.

Household data

To explore households' responses to El Niño 1997-98, this study uses repeated cross-section data from Ecuador Living Standards Measurement Study (LSMS) household surveys for the years 1995, 1998, and 1999. The descriptive statistics for the sample of households in 1995 are displayed in Table B.1. These surveys are nationally representative and sample approximately 5,000 households each year. The outcomes analyzed in this paper correspond to household income, and total and food consumption (proxied by expenditures). Additionally, this paper explores the effect of El Niño floods on investments in children in the form of food consumption and breastfeeding, information that is also gathered in this survey. Also, I perform the analysis of health at birth and households' responses on families from low socio-economic status given that the child data on medium-term outcomes focus on these families.

[16]The baseline survey was collected between October 2003 and March 2004. Given that the survey target children less than age 6, the older children in the sample are born at the end of 1997. Also, children born in 2003 and afterwards did not have PPVT measures in any survey wave.

4 Lasting effects of the 1997-98 El Niño on children's human capital

4.1 Empirical strategy

To investigate the lasting effect of a negative shock early in life on children's cognition and health, I use exposure to extreme floods during the 1997-1998 El Niño in Ecuador as a natural experiment. Children's human capital outcomes were collected in 2003 and 2005 (five and seven years after the shock) through the survey designed to evaluate a cash transfer (CT) program in Ecuador. To identify exposure to El Niño floods, I exploit two sources of variation. First, I use cohort variation, given that the dataset sampled three sets of children: those who were alive during El Niño (born in 1997-98[17]); those who were in utero (born in 1998-1999); and those children who were born up to four years after the shock (born in 2002). Second, I exploit geographic variation, since these data contain information regarding families located on the coast (more affected by El Niño) and in the highlands (less affected). Therefore, to identify the impact of the 1997-98 El Niño shock, the empirical strategy uses cohort variation in child outcomes in villages more affected by El Niño compared to others less affected. I estimate the following model:

$$Y_{i,v,t,w} = \delta_1 nino\_utero_{i,v,t} + \delta_2 nino\_age01_{i,v,t} + X_{i,v,t,w}\beta + \theta_t + \eta_v + \omega_w + \varepsilon_{i,v,t,w} \qquad (8)$$

where t indexes cohort of birth, v villages, i children, and w survey round (2003 and 2005). Y corresponds to health and cognitive outcomes. $X_{i,v,t,w}$ is a vector of child and family socio-demographic characteristics.[18] The cohort fixed effects, θ_t, capture any shock common to all children born in the same cohort.[19] Similarly, village fixed effects, η_v, control for time-invariant characteristics of all children in the same village.[20] ω_w is a survey-wave fixed effect to control for variables common to all children surveyed in a specific wave. Finally, $\varepsilon_{i,v,t,w}$ is a random error term.

The variable $nino\_utero_{i,v,t}$ measures the number of months of floods during El Niño 1997-

[17]Some of the children born in 1998 are also exposed to the shock in utero.

[18]Specifically, child's gender, first born, month of birth and age in months (at the time of the survey) dummies, mother's and father's education, father at home, maternal age, maternal marital status, number of children less than age 14 at home, urban, SES quintile, and inflation at the state-year of birth.

[19]For instance, a financial crisis affecting all the children born in a given period would be absorbed by these fixed effects (such as the dollarization at the end of 1999, see Hidrobo (2014) who studies the effect of this financial crisis on children). Cohort fixed effects, θ_t, are defined as quarter-by-year of birth in order to be more refined that just year of birth

[20]The assignment of villages to treatment and control for the evaluation of the cash transfer program is absorbed by these fixed effects

98 experienced by child i in utero, which depends on the village, month and year of birth.[21] Recall that floods are defined as the monthly excess of rainfall greater than one historical standard deviation during the 1997-98 El Niño. The coefficient δ_1 measures the effect of in utero exposure to an additional month of El Niño floods on later human capital outcomes. Similarly, $nino\_age01$ indicates the total months of floods during El Niño experienced during the first year of life.[22] δ_2 captures the impact of exposure to an extra month of El Niño floods during infancy. To address potential spatial and time correlation, I cluster standard errors at the village level.[23]

The main identifying assumption required to consistently estimate the causal impact of early life exposure to El Niño floods on children's later outcomes is the independence between the error term and the measures of exposure, after controlling for village and cohort fixed effects, and for children's socio-demographic characteristics. Selection problems not controlled by these fixed effects could contaminate the results. For instance, if villages more affected by El Niño 1997-98 had differential growth in cognitive and health outcomes compared to villages less affected, this could violate the identification assumption. I cannot compare the pre-shock trends because of the absence of child outcomes' data before El Niño 1997-98. However, household income data are available in two Living Standard Measurement Study (LSMS) surveys prior to El Niño 1997-98. Using income data from 1994 and 1995 LSMS surveys, Table B.6 tests for pre-El Niño 1997-98 trends. There is no statistically significant association between the intensity of El Niño floods and household income trends prior to the shock.

Another potential threat to the identification assumption is that exposure to El Niño floods may be confounded with similar unobserved influences that vary across villages and over time. Thus, one may be concerned that early life exposure to El Niño floods is mistakenly capturing changes in the socio-demographic composition of families giving birth in villages more affected instead of exposure to the shock itself. To check for this potential selection problem, Table 2 presents the relationship between family socio-demographic characteristics and exposure to El Niño floods. Results show no significant differences in most family

[21] It is important to acknowledge that because there is no information on village of birth in the child dataset, I use village of residence. Data from the 1998 and 1999 LSMS indicate that migration due to climate events is very low (3% of the families that migrate reported as the reason either weather or to improve income sources). In addition, in section 7 using information on maternal migration in the Reproductive and Health Survey, I show that it is very unlikely that the results are contaminated by endogenous migration since I did not find evidence of migration responses to exposure to the 1997-1998 floods.

[22] I chose the period from age 0 to 1 because the oldest children in the sample were born in 1997, thus children in the sample were not exposed to El Niño at older ages.

[23] The village level is similar to a municipality. Inference is robust to estimating standard errors using Conley's spatial correction method. See Conley standard errors in brackets in the main tables and discussed in Appendix A.3.

characteristics except for father's education.[24] In addition, in the next subsection, I present evidence from falsification tests that suggests that the results are not driven by unobserved omitted variables or trends.

4.2 Results

Table 3 presents the results of the medium-term effects of exposure to the 1997-98 El Niño floods on children's human capital. The estimates in the first column suggest that one additional month of in utero exposure to the 1997-98 El Niño floods decreased height-for-age by 0.034 standard deviations (SDs) on average. Conditional on being exposed to El Niño floods, average exposure during pregnancy was three months. At this level of exposure, children's height-for-age decreased by 0.1 SDs[25] five and seven years after the shock. Additionally, exposure to the floods during the first year of life negatively affected height, however the point estimate is not statistically significant.

Regarding the medium-term effects on the likelihood of being anemic, I find that in utero exposure to El Niño floods increased the probability of having anemia five and seven years later by 0.02 per month of exposure. This implies that children who experienced three months of floods in utero were 6 percentage points more likely to be anemic.

Regarding the impact of the shock on later cognitive development, column 3 shows the estimates for the Peabody Picture Vocabulary Test (PPVT). Exposure to severe floods in utero affects later cognitive performance. Results suggest that one month of exposure to the 1997-98 floods during pregnancy decreased cognitive scores by 0.046 SDs on average. This implies that children exposed to three months of floods in utero scored 0.14 SDs lower on the cognitive tests between five and seven years after the shock.[26]

A placebo test One concern is that the negative effects of early life exposure to El Niño on children's medium-term outcomes may be confounded with a trend or omitted variables. To verify that this is not the case, I performed a set of placebo regressions using the sample of children born between 2000 and 2002. This exercise replicates the geographic intensity of El Niño 1997-1998 on a different period, 2000-2001, and calculates the corresponding exposure in utero and age 0 to 1. Because those children are part of the comparison group, this placebo

[24] Other related concerns are endogenous fertility and migration responses, which could contaminate both treatment and comparison groups. I explore these concerns directly in section 7, but I do not find evidence of endogenous fertility and migration responses to the intensity of El Niño floods.

[25] Approximately between 0.465cm-0.6cm for children age 5 and 7.

[26] These calculations at the mean exposure assume that the effect of being expose to El niño floods during pregnancy is linear. I examine the presence of non-linearities and the results are summarized in Figure B.1. I find little evidence of non-linearities since the estimates and confidence intervals increase fairly monotonically with exposure.

regression helps to validate that there are not differential trends between places more and less affected by the floods for children that were not exposed to the shock, which is key for the identification strategy. If my results are spurious and driven by a trend or an omitted variable, one would expect statistically significant estimates in these placebo regressions. As shown in columns 4-6 in Table 3, there is no evidence of such an effect.

Timing of exposure to weather shocks in utero

Furthermore, I investigate whether the effects of exposure to extreme floods vary by trimester of gestation. According to the medical literature about sensitive periods of prenatal development, the brain is very susceptible to changes in the prenatal environment during the first trimester of pregnancy (particularly during the embryonic period). The reason is that during this stage the formation of the brain develops most rapidly. In contrast, the third trimester of pregnancy is a sensitive period for fetal growth as the fetus grows dramatically both in size and mass (Altshuler, 2003; Harding and Alan, 2001). The model estimated to analyze timing of exposure is:

$$\begin{aligned} Y_{i,v,t,w} &= \delta_1 nino\_1tri_{i,v,t} + \delta_2 nino\_2tri_{i,v,t} + \delta_3 nino\_3tri_{i,v,t} + \delta_4 nino\_age01_{i,v,t} \\ &\quad + X_{i,v,t,w}\beta + \theta_t + \eta_v + \omega_w + \varepsilon_{i,v,t,w} \end{aligned} \tag{9}$$

where $nino\_1tri_{i,v,t}$ measures the number of months of floods during the 1997-98 El Niño experienced by child i during his first trimester in utero. $nino\_2tri_{i,v,t}$ and $nino\_3tri_{i,v,t}$ are defined similarly.

Results suggest that the negative effects on height-for-age are stronger for exposure to floods in the third trimester in utero (Table 4). Children who were exposed to one month of floods during the last trimester are 0.09 SDs shorter in stature. In contrast, the deficit on cognitive scores is stronger for exposure during the first trimester in utero. Children who experienced one month of floods during the first trimester scored 0.115 SDs lower on vocabulary tests. These findings about the timing of exposure are consistent with the medical literature about important periods for fetus growth and brain development. One concern is that inference about timing of exposure by trimester and age 0-1 should adjust for the fact that a significant coefficient could appear among many estimates. Appendix Table B.3 Panel A. presents the adjusted p-values for multiple hypothesis testing; inference is robust to this correction.[27] Additionally, the F-test on the joint importance of all the exposure measures

[27] Appendix Table B.3 presents the adjusted p-values for multiple hypothesis testing using the Holm-Bonferroni approach. The result that the first trimester is more sensitive to exposure to floods for the deterioration of cognitive development is robust to this adjustment. In contrast, the result for the deterioration of height is more imprecise and its p-value is 0.158.

is significant at the 5 percent level (bottom of Table 4). However, the test of the equality of coefficients is not rejected at conventional significance levels.[28]

Heterogeneous Effects If more disadvantaged families fail to adequately cope with a negative shock early in life, it is plausible that the negative impacts of exposure to extreme floods on later human capital are stronger for less educated families. To explore this, I interact the measure of exposure to El Niño floods with mother's years of schooling. Results presented in Table 5 (columns 1 and 2) show that the interaction term is positive and statistically significant for vocabulary performance, which suggests that the negative impact of exposure to El Niño during the first trimester of pregnancy is attenuated if the mother is more educated.

Similarly, one may expect the effects of exposure to El Niño floods to be larger for rural families since agriculture was the sector most severely affected by the shock. As a check, I interact the exposure to El Niño floods with a dummy variable for rural households. Table 5 shows that the negative effects on vocabulary are stronger for children in rural families (the coefficient of the interaction is also negative for height but not statistically significant see columns 3-4).[29]

Magnitudes Overall, I provide evidence of the persistent effects of early life exposure to severe floods on later human capital development. On average, children who were in utero during El Niño 1997-98 are 0.1 SDs shorter and score 0.14 SDs lower on cognitive tests than their peers who were born in less affected areas or were born after the shock. To give a sense of the magnitude of these effects, I compare them with the effects of positive early childhood interventions (ECIs) in developing countries. Also, such a comparison indicates whether the persistent consequences of negative shocks can be offset by interventions. Nores and Barnett (2010)[30] summarized the impacts from ECIs conducted in developing countries on several domains, including cognition and health, and report larger effects. Average effect sizes on cognition were around 0.3 SDs both in short-term and long-term outcomes. Average effect sizes on health were around 0.36 SDs in short-term outcomes and 0.15 SDs in long-term outcomes.

[28] Appendix Table B.3 Panel B presents separate tests for different pairs of coefficients. When testing the equality of the coefficients separately for the case of cognition, we can see that the p-values are not huge but around 0.15 when comparing first trimester with each second and third trimester.

[29] These specifications include interactions with exposure in the trimester of pregnancy that is most vulnerable given the specific outcome (first trimester for cognitive scores and third trimester for height for age). However, point estimates from fully interacted measures of exposure are similar while the standard errors increase more than 50%.

[30] This study reviews 30 non-US early childhood interventions with a quasi-experimental or random assignment design. They use meta-analytical techniques and calculate Cohen-D effect sizes.

5 Impact of the 1997-98 El Niño on birth endowments

From a policy perspective, evidence of the long-term effects of exposure to weather shocks early in life says little about the extent to which these consequences can be mitigated. Therefore, in the next sections, I explore potential mechanisms by looking at birth endowments and family input responses to weather shocks. However, since the child dataset was collected five and seven years after the 1997-98 El Niño and cannot be used for this analysis, I rely on secondary data from household surveys collected before and after the shock.

Birth endowments are considered a key input to the production of future human capital (Heckman, 2008). Birth weight is often used in the economic literature as a proxy for health endowments at birth that may reflect prenatal inputs (Bharadwaj et al., 2010; Rosenzweig and Zhang, 2009). Furthermore, birth weight strongly predicts adult outcomes such as educational attainment and earnings (Behrman and Rosenzweig, 2004; Black et al., 2007; Currie and Hyson, 1999).

In this section, I investigate the impact of in utero exposure to the 1997-98 El Niño on health at birth. I estimate equation 8 using data from the 1994 and 1999 Reproductive and Health Surveys (RHS), which collect self-reported health at birth information for children below age five born to women in fertile ages (15-49). To minimize contamination from recall error, I restrict the sample to children less than age two in each wave. As before, the empirical strategy exploits time variation on month and year of birth as well as geographic variation on village of birth.

As mentioned before, one potential threat to the validity of the identifying assumption is that the socio-demographic composition of mothers giving birth is correlated with the timing and intensity of exposure to El Niño floods. To informally test this concern in the RHS data, I regress a rich set of measures of maternal socio-demographic characteristics in 1994 and 1999 on exposure to the 1997-98 El Niño during pregnancy and infancy, controlling for village and survey-year fixed effects. Thus, this exercise examines whether the observed socio-demographic characteristics of mothers giving birth before and/or in less affected areas are different from those exposed to El Niño 1997-98. The estimated coefficients, presented in Table B.4, show no statistically significant relationships (except for marital status).

5.1 Results

Table 6 shows estimates of the impact of in utero exposure to the 1997-98 El Niño on health at birth. Results suggest that exposure to extreme floods during pregnancy increased the likelihood of low birth weight by 0.8 percentage points per month of exposure (column 2). This effect is not driven by preterm births since the results are robust to their exclusion (column 4).[31] This result implies that children exposed to three months of floods were 2.4 percentage points more likely to be born with low birth weight (a 15% increase on an average incidence of 15.8%).[32] Column 3 shows no effect of in utero exposure to El Niño on the probability of preterm birth.[33]

Low birth weight: understanding the channels

Some patterns of the results provide suggestive evidence, although not exhaustive, that deterioration of maternal nutrition during pregnancy could have played a role behind the effects of El Niño on health at birth. Low birth weight is determined by lower gestational length or intrauterine growth restriction (IUGR) (Amarante et al., 2016; Bozzoli and Quintana-Domeque, 2014; Kramer, 1987). According to the medical literature, IUGR depends on poor maternal nutrition, health and smoking. However, the determinants of prematurity are less known with maternal stress playing an important role. For the case of El Niño 97-98 floods, I found suggestive evidence that the increase in the incidence of low birth weight could be driven by IUGR and not by gestational length. Exposure to El Niño did not change the likelihood of premature births. The point estimate is close to zero and not statistically significant (the effect is 0.0005 per one month of exposure, see Table 6).

Timing of exposure to weather shocks in utero Next, I examine whether the effects of exposure to extreme weather shocks very by trimester of pregnancy. According to previous literature, birth outcomes are most sensitive to maternal stress during the first trimester of pregnancy (Bozzoli and Quintana-Domeque, 2010; Camacho, 2008; Currie and Rossin-Slater, 2013; Mulder et al., 2002). In contrast, nutritional deficits impact birth weight mostly in the third trimester of pregnancy (Kramer, 1987; Stein et al., 2000). Table 7 presents the estimates disentangling the timing of in utero exposure. Results show that the increase in low birth weight is stronger for exposure to the shock during the third trimester in utero compared to other trimesters.[34]. Exposure to floods during the third trimester increases the probability of low birth weight by 2 percentage points. This suggests that the increase in the likelihood of low birth weight during El Niño may be explained by maternal nutritional deprivation.

[31] The in utero exposure variable is calculated assuming a gestation length of nine months. Thus, one may be worried that these exposure variables are misleading for children who did not complete full term, which could contaminate the evidence provided. However, column 4 shows that this is not the case.

[32] I examine the presence of non-linearities in the effect and the results are summarized in Figure B.2. I find little evidence of non-linearities since the estimates and confidence intervals increase monotonically with exposure.

[33] Preterm is defined as gestational age less than nine months.

[34] The inference results are robust to adjustments for multiple hypothesis testing (see Appendix Table B.3 Panel A). Also, Panel B shows that the effect of third trimester on low birth weight is statistically different from the effect of first trimester, but not for the case of second trimester.

The estimates are robust to the exclusion of preterm babies. Regarding the probability of preterm birth, there is no significant evidence of effects by trimester of exposure. Moreover, these results are in line with the estimates on height, which are also larger for exposure in the third trimester in utero. Other studies in economics have found a similar pattern of evidence in terms of mechanisms underlying effects on birth weight related to maternal nutrition. For example, studies of the effects of the Dutch famine (Stein et al., 2000), food stamps program in the US (Almond et al., 2011) and cash transfers in Uruguay (Amarante et al., 2016) have found effects on the likelihood of low birth weight but not on preterm birth. Stein et al. (2000) and Almond et al. (2011) also studied timing of exposure and found evidence that birth weight is generally more responsive to maternal nutrition changes during the third trimester. Unfortunately, I did not find data on direct measures of maternal nutrition such as pregnancy weight gain, which could have allowed me to strengthen the evidence provided.

To reconcile this analysis on health at birth based on nationally representative data with the previous analysis on children human capital outcomes based on a sample of disadvantaged children, I explore the impacts of El Niño floods by socio-economic status (SES). I construct an index of SES using information on quality of the housing, household density, access to utilities, mother's education, and assets. As mentioned above, families eligible for the cash transfer program belong to the bottom two quintiles of a similar poverty index constructed by the government from a proxy means test.[35] Table 8 presents the estimation of the model for households on the bottom two quintiles, and for comparison, it also reports the results for the top two quintiles. The negative effect of exposure to extreme floods in the third trimester is larger for children in more disadvantaged families. Indeed, for these children the likelihood of low birth weight increased by 3.1 percentage points.

Health behaviors during pregnancy As mentioned in section 2, El Niño floods' consequences on damages to infrastructure and general equilibrium effects on commodity prices could affect prenatal investments like prenatal care utilization. The income and substitution effects predict opposite responses. As shown in Table 6 columns 5 - 7, The effects on use of prenatal care, number of visits, timing of the first visit, and likelihood of receiving a tetanus vaccination are small and not statistically significant. This provides suggestive evidence that the effects of El Niño on children are not likely explained by a lack of health-care access during pregnancy.

[35] The index I constructed is similar but not the same due to availability of information in the RHS surveys. Also, I constructed the index using principal components analysis.

A placebo test Negative shocks after birth should not have a causal impact on birth outcomes. The last column in Table 7 presents a "placebo test" that estimates the impact of El Niño floods that occurred after birth on the probability of low birth weight. If the estimated effects of in utero exposure to the 1997-98 El Niño on health at birth were biased by the presence of omitted variables or a trend, then these placebo regressions may show significant effects as well. I find no impact of extreme floods during the first year of life on the likelihood of low birth weight, which helps to validate the results shown above.[36]

In sum, these patterns of results on low birth weight suggest that maternal malnutrition could have played a role behind the negative effects of El Niño on children's human capital. Additionally, declines in prenatal health care utilization do not seem to drive the effects.

6 Effects of El Niño on family inputs

As a further step, I investigate the impact of Niño on other inputs to skill formation that could have potentially been affected by the direct and/or indirect consequences of the shock. In particular, I explore effects on household income, consumption and breastfeeding. Because the child dataset was collected several years later and did not gather this information, this section uses the Living Standard Measurement Study (LSMS) surveys, which have the advantage of having been collected before (1995), during (1998), and after (1999) the shock.[37]

6.1 Household income and consumption

Parental income is an important source of investment in children and maternal prenatal health and nutrition. Using different methods including natural experiments, numerous studies have shown an association between family income (especially in early life) and health at birth and child skill development (Amarante et al. (2016); Caucutt and Lochner (2012); Dahl and Lochner (2012); Duncan and Brooks-Gunn (1997); Duncan et al. (2011); Hoynes et al. (2015); Levy and Duncan (2000); among others).

[36] I perform an additional placebo test where I include exposure six months pre-conception, as an alternative way to check if there are spurious differential trends between children in places more and less affected to the El Niño. Those tables are in the additional robustness check in Appendix A.6. They show no impact of these prior exposures and no change in the magnitude of the effects in utero.

[37] There is another LSMS survey in 1994, which was the first one of that kind in Ecuador. The consumption section in that survey was improved/enriched in the following waves, and the sample size also increased. Therefore, that survey was not used for this analysis of family inputs since it is not comparable for most of the outcomes. Additionally, regarding the specific data collection frame, the 1995 survey was collected between August and November, the 1998 data between February and May and the 1999 data between October 1998 and September 1999.

To estimate the effects of El Niño on family income, I use a difference-in-difference approach. I exploit two sources of variation: time (before and after the shock) and geographic variation:

$$m_{h,v,t} = \alpha + \delta_{1998} nino\_floods_v * d\_year98_{h,v} + \delta_{1999} nino\_floods_v * d\_year99_{h,v} + \\ + X_{h,v,t}\beta + \theta_t + \eta_v + \varepsilon_{h,v,t} \quad (10)$$

where h indexes households, v villages, and t survey years. m captures the different household inputs such as household income or consumption. The model controls for households' socio-demographic characteristics (X),[38] survey year fixed effects (θ_t), and villages fixed effects (η_v). The variable $nino\_floods$ indicates the total months of floods during the 1997-98 El Niño experienced by village v. Standard errors are clustered at the village level.

δ_{1998} and δ_{1999} are the parameters of interest, capturing the effects of El Niño floods on household outcomes. These parameters are identified under the assumption that household income and consumption trends would be the same in regions more affected and less affected in the absence of the El Niño shock. I find no evidence of different pre-shock trends in income (Table B.6).[39] Also, Table B.5 shows no evidence that potential sorting may contaminate the estimated effects.

Results

Exposure to El Niño resulted in household income losses (see columns 1-3 of Table 9). The results suggest that labor income fell by 1.1% in 1998 and by 1.8% in 1999 for each additional month of floods during El Niño 1997-98. Similarly, total household income (labor plus non-labor income[40]) decreased by 1.6% in 1998 and by 2.1% in 1999. This implies that at the mean level of household exposure to El Niño phenomenon 1997-1998 (seven months), total income fell by 10.9% in 1998 and by 14.7% in 1999.[41]

The reduction in income could translate into a decline in consumption if households were not able to cope with it. I explore household consumption responses in columns 4-5

[38] $X_{h,v,t}$ includes age, gender, marital status and education of the household head, family size, SES, number of members age 14 and older, and trimester of survey.

[39] I could only perform the pre-shock trends test for household income because other variables like consumption and breastfeeding were not comparable between the 1994 and 1995 LSMS surveys. The reason is that the 1994 LSMS was the first survey of this kind in Ecuador, and there were some sampling problems that were corrected in 1995 and thereafter.

[40] Non-labor income includes remittances, transfers, interest earned, and rents.

[41] These calculations at the mean exposure assume that the effect of being expose to El Niño floods is linear. I examine the presence of non-linearities and the results are summarized in Figure B.3. I find that estimates increase monotonically with exposure.

of Table 9.[42] Total consumption declined by 1.1% in 1998 and by 2.12% in 1999 for each additional month of floods during El Niño. This implies that at the mean level of exposure, household total expenditures declined by 7.94% in 1998 and by 14.85% in 1999. These results suggest that Ecuadorian households were not able to smooth their consumption in the aftermath of the 1997-98 floods, since the declines in consumption mirror the negative effects on household income. Moreover, food expenditures decreased in 1999, but not in 1998.[43] Food consumption decreased by 1.92% in 1999 for each additional month of floods. At the mean level of exposure, average household food expenditures decreased by 13.42% in 1999. Overall, the decline on household income and consumption could have contributed to poor maternal and child nutrition during and in the aftermath of the shock.

To examine the effects on family inputs on a sample similar to the one represented in the dataset that collected child cognitive and health outcomes, Table 10 shows the results separately for the bottom and top two SES quintiles.[44] The negative effects of exposure to El Niño on both household income and consumption are stronger for households in the bottom two quintiles. This is expected since those families are more likely to be rural and depend on agricultural activities, which were the economic sectors most affected by the shock. Also, these families tend to be more vulnerable, lacking mechanisms to cope with the negative consequences of extreme floods.

6.2 Investments in children

The disruption in early environment caused by a negative shock can change parental investments, which in turn affects later skills. This section explores the effects of exposure to severe floods early in life on investments in children. Two dimensions of investments are analyzed: child food consumption and breastfeeding. In the LSMS surveys, mothers reported children's food consumption in terms of servings of meat, milk, eggs, fruits and vegetables, and grains per week. Additionally, mothers were asked about duration of both exclusive breastfeeding and total breastfeeding (breast milk combined with formula, food, or other supplements).

[42] Total household consumption corresponds to expenditures on food and other household goods, education, durable goods, housing, electricity, clothing, transportation. According to the Ecuador Bureau of Statistics, health expenditures were not included because the questions about it were not homogeneous across surveys.

[43] Since the proxy for consumption analyzed here corresponds to expenditures, they combine the quantity and price effect. Thus, finding no effect of the shock on food consumption in 1998 may not be the result of consumption smoothing. Because of the scarcity of some food items and increases in prices, quantities consumed in 1998 could have gone down but the overall effect of expenditure could be zero because it was offset by the increase in prices.

[44] The SES index was constructed using information from housing quality, population density, access to water and sanitation, household head education, and assets.

Children's food consumption

Following the analysis above on family consumption, Panel A in Table 11 shows that children's consumption of meat, fruits and vegetables, and grains declined during El Niño. Since the dependent variable is a count variable, food servings per week, I use a negative binomial count model instead of OLS to account for over-dispersion. Table 11 presents the corresponding marginal effects of the interaction between the dummy for 1998 and the measure of El Niño floods (with year 1995 as the baseline category). Results indicate that in 1998, the average number of servings of meat per week declined by 0.14 for each additional month of floods during El Niño. Similarly, servings of fruit and vegetables decreased by 0.26 servings per week, and those of grains fell by 0.49 servings per week for each additional month of exposure.[45] Overall, although information on food consumption by pregnant women was not provided, this result suggests that declines in children's food intake could have reinforced in utero and early life exposure to the shock.

Panel B in Table 11 displays the results separately by socio-economic status. The point estimates of the effects of exposure to El Niño on child consumption of meat and fruits and vegetables are larger for households in the bottom two quintiles.

Breastfeeding

Breastfeeding is considered a key determinant of children's health and human capital. Very few studies have look at the relationship between exclusive breastfeeding and later child outcomes. Using a randomized control trial intervention in Belarus that promoted exclusive breastfeeding, Kramer et al. (2008) show that exclusive breastfeeding is associated with better child cognitive development. Most of the studies focus on total breastfeeding duration (duration of breastfeeding of any kind, exclusive or non-exclusive) and find a positive relationship with health and educational outcomes (Anderson et al., 1999; Belfield and Kelly, 2010; Rees and Sabia, 2009; Umapathi, 2009; Victora et al., 2015).

Extreme weather shocks in the form of floods could affect breastfeeding practices in several ways. The floods may directly affect maternal health through contaminated water, infectious diseases, and dehydration, which in turn would decrease the amount of milk produced by the mother, leading to a decline in breastfeeding duration. Furthermore, because breastfeeding is a time-consuming activity, the income/wage reduction could affect the mother's time allocation through income and substitution effects that operate in opposite directions. The income effect implies that mothers afford less time for breastfeeding. But

[45] The analysis on child food consumption could not use the survey data from 1999 because of a change on these questions. It did not ask in terms of number of servings as before but instead in terms of number of days.

the substitution effect makes breastfeeding cheaper since the opportunity cost of time is lower. Therefore, the overall direction of the effect of extreme floods on breastfeeding is ambiguous.[46]

I look at duration of both exclusive breastfeeding and total breastfeeding. This information is asked in the three repeated cross-section LSMS surveys in 1995, 1998, and 1999. I focus on children less than age two at the time of the survey. To address right-censoring on the duration of breastfeeding, because some children have not been weaned, I estimate an OLS version of equation (10) that includes age (in months) fixed effects (Jayachandran and Kuziemko, 2011):

$$\begin{aligned} months\_bf_{i,v,a,t} &= \alpha + \delta_{1998} nino\_floods_v * d\_year98_{i,v,t} + \delta_{1999} nino\_floods_v * d\_year99_{i,v,t} + \\ &\quad + X_{i,v,t}\beta + \lambda_a + \theta_t + \eta_v + \varepsilon_{i,v,t} \end{aligned} \tag{11}$$

where, i denotes children, v villages, a age in months, and t survey year. Results are shown in Panel A Table 12. For each additional month of exposure to El Niño floods, average exclusive breastfeeding declined by -0.06 months for children aged newborn to age two in 1998. Estimates are robust to using a proportional hazard model as an alternative way to account for censoring (column 2).

Regarding total breastfeeding, results show that exposure to the 1997-98 El Niño increased the duration of total breastfeeding. According to the OLS estimates (column 3, Panel A), a one-month increase in exposure to El Niño is associated with a 0.09 and 0.14 month increase in total breastfeeding duration for children newborn to age two in 1998 and 1999. These effects are robust to estimating a hazard model (column 4, Panel A). These results may suggest that exclusive breastfeeding and total breastfeeding could be substitutes in the aftermath of a weather shock. Exclusive breastfeeding depends largely on maternal health status and on maternal time availability (the mother has to be available every three to four hours to breastfeed the child). The negative consequences of the floods could deteriorate the mother's health or require that mothers go back to work, leading to a decrease in duration of exclusive breastfeeding.[47] However, breastfeeding could also be used to protect the child against contaminated water, factors that could explain an increase in the duration of total breastfeeding.

To better understand the breastfeeding responses, Panel B in Table 12 shows estimates

[46] Thai and Myrskylä (2012) study the effect of rainfall on breastfeeding in rural Vietnam. They hypothesize that positive rainfall shocks are a proxy for positive transitory income shocks leading to an increase in the opportunity cost of time. However, they mention that they exclude extreme shocks like floods (pg 11), which are the focus of this paper.

[47] Table B.7 in the appendix looks at the labor participation responses for women in households with children (in the LSMS data there is no identifier for the mother of the children)

by socio-economic status. Results suggest that the negative responses in terms of exclusive breastfeeding and the positive responses for total breastfeeding are stronger for low-SES families (point estimates are larger). Moreover, I estimate the effects of the shock on exclusive breastfeeding by sanitation conditions of the household since mothers and children living in households with unimproved sanitation facilities are more vulnerable to the consequences of the floods. I find that the decrease in the duration of exclusive breastfeeding is larger for children in dwellings with bad access to sanitation (Appendix table B.8).

7 Robustness checks and Selection issues

7.1 Robustness checks

Appendix A presents additional checks to confirm that the results are robust to different specifications and not subject to omitted factors or measurement error. First, I explore the robustness to alternative definitions of El Niño 1997-98 shock. In particular, I use a 1.5 standard deviations cut-off (instead of one) to define a flood month, or a simple summation of the z-scores of excess precipitation. Tables A.1 - A.3 show that the evidence is robust to these alternative specifications.

Second, one may be concerned that the results on children's human capital are driven by different cohort trends in places that were more affected to the El Niño relative to those less affected. Therefore, I estimate specifications that add geographic-specific linear trends at the state, district, and village level separately.[48] Table A.4 shows that the results are robust and similar to the ones presented above.[49]

Third, another concern is the issue of spatial correlation since areas with high exposure to El Niño 1997-98 floods are clustered along the coastal region and less affected areas are located along the highlands (see Figure 3). To account for this issue, Table A.5 presents coefficients of specifications of the effects on in utero and infancy exposure on children's outcomes that include region-cohort fixed effects,[50] which only use the variation within those two regions. The coefficients and statistical significance are similar to the main results. An alternative approach to account for the spatial correlation is through the computation of the

[48] A caveat from this type of specification is that although it allows for different trends for each geographic level, it also imposes the variation to be used as deviation of a specific functional form of the trends.

[49] In particular, the point estimates for height are remarkably similar across specifications. For cognition (PPVT), when adding village-specific linear trends, the point estimates somewhat decrease, and are noisier. However, it can not be rejected that they are the same to the main specification.

[50] To differentiate the two regions (coast versus highlands) I separate those places with less than 3 months of floods from those with 3 or more. I added region*cohort fixed effects and the results are robust. I also separate the two regions by less than 4 months of floods versus those with 4 or more and the results are very similar.

standard errors. The main Tables (3, 4, 7, and 9) show in brackets standard errors computed following Conley's spatial error correction method and confirm that inference is robust (see Appendix A.3 for details).

Fourth, another potential issue is measurement error since rainfall measures for villages far from the weather stations could be more noisy and less accurate. Tables A.6-A.7 restrict the sample to children and households in villages within 10km of the weather station (the median distance). Results are robust and similar to full sample estimates, which suggests that potential mis-measurement of rainfall should not pose serious concern in the main analysis.[51]

Lastly, the analysis of health at birth and family inputs uses the Reproductive and Health Survey and the Living Standards Measurement Study, which are household surveys with complex designs. The standard errors estimated in the paper are clustered at a larger geographic level than the primary sample unit, thus they are more conservative. Regarding sampling weights, Tables A.10 and A.11 present the results from weighted regressions, which are similar to the unweighted estimates.

7.2 Sources of selection

One may be concerned that exposure to the shock affected families' fertility and migration decisions, which in turn could contaminate the evidence regarding the impact of early life shocks on child development. That is, one may be worried that the estimates presented are not a causal effect but are confounded with selection issues. In this section, I directly explore these potential sources of selection bias using the data from the Reproductive and Health Survey (RHS).[52]

Another potential selection concern is that exposure to the shock could affect children's likelihood of survival. If extreme floods increase neonatal and infant mortality, selection to survival could bias the results downwards. Results that explore the effects of El Niño floods on infant mortality are presented in Appendix A.6 and show no evidence of changes in children's likelihood of survival.

[51] Another related problem is that clustering standard errors at the village level takes into account that rainfall is the same for all individuals in a village. The rainfall data varies however by weather station and not by village. Thus, as a robustness check Tables A.8- A.9 present estimates when SE are clustered at the weather station level.

[52] In this analysis I use the RHS data because it contains information for the three dimensions of selection: fertility, migration and infant mortality.

Fertility

Women may change their fertility decisions in response to extreme floods, which could contaminate the estimates of early life shocks on later outcomes. Because exposure to extreme floods combines both an income effect and a change in the opportunity cost of time, it is ambiguous whether more advantaged or more disadvantaged families would delay fertility. If more advantaged families delay pregnancies after the El Niño flood, the comparison group is negatively selected, and estimates of in utero exposure to shocks may be a lower bound. In contrast, if less advantaged families delay their fertility, the comparison group is positively selected, and this may bias the results upward. Additionally, because of the long duration of El Niño 1997-98, fertility responses could also contaminate the composition of the treated children born towards the end of the shock.

Using information on women's fertility histories from the 1994 and 1999 RHS, I test whether exposure to the 1997-98 El Niño floods has an effect on short-term fertility behavior by looking at women's pregnancy status at the time of the survey,[53] as well as on whether they had given birth in the twelve months prior.[54] I estimate a difference-in-difference model similar to the one depicted in equation 10 and interact the measure of exposure to the shock with maternal socio-demographic characteristics to explore evidence of endogenous fertility responses. Table A.14 shows that exposure to El Niño floods did not affect the pregnancy status of women in 1999 (columns 1 and 2) or in the twelve months before (columns 3 and 4). Also, I do not find differential responses by several socio-demographic characteristics such as maternal education, age, SES, etc. (except marital status).

Additionally, the analysis for medium-term effects on children's health and cognitive development uses children born in 2002 or earlier as part of the comparison group. Thus, I also checked for impacts of exposure to El Niño on medium-term fertility behavior. Using data on women's fertility history from the 2004 RHS, I looked at the effects of exposure to the 1997-98 El Niño on childbearing between 2000 and 2002. Table A.14 columns 5 and 6 show that there is no evidence that women living in villages more affected by the 1997-98 El Niño changed their fertility behaviors in the medium-term (3-5 years after the shock), nor that there were differential responses by socio-demographic characteristics of women.

Migration

Any analysis that addresses the impact of negative shocks on households should be concerned with selection issues related to endogenous migration. One may be worried that

[53]Women pregnant in the 1999 survey would have conceived at the end of the El Niño or after.

[54]Giving birth 12 months prior to the 1999 survey captures pregnancy status during the shock.

exposure to the shock influenced family migration decisions, and that these responses may differ by family characteristics. If more advantaged families moved from more affected villages to less affected places, then exposure to the 1997-98 El Niño floods could be confounded with family SES.

The surveys asked mothers whether they were living in their current residence five years previously. Thus, if a mother moved just before, during, or after the 1997-98 El Niño, she would respond “No” in the 1999 wave, indicating that she had migrated. I use this information to assess whether there are differences in the probability of migration between villages more affected by El Niño and villages less affected. I examine migration responses, looking at both responses in terms of a trend (using the 1994 and 1999 data), and the relationship between migration and varying degrees of exposure to the floods (using 1999 data only). The outcome of interest is a dummy variable equal to 1 if a woman migrated between the time of the survey and five years ago. Both sets of results are shown in Table A.15.

I find no statistically significant relationship between the likelihood of migrating and exposure to El Niño floods either in trends or in levels. Additionally, when interacting exposure with family characteristics, there is no strong evidence of endogenous mobility responses (see columns 2 and 4).

8 Discussion and Conclusion

A growing literature has demonstrated that shocks in utero and early in life can have lasting effects not only on later health but also on human capital formation. However, most of this literature has looked separately at the impacts of shocks on later human capital outcomes and intermediate inputs. In this paper, I study both human capital inputs and outputs under the same type of negative shock in a developing country setting. I exploit the geographic intensity of extreme floods during the 1997-1998 El Niño phenomenon in Ecuador as a source of exogenous variation in children’s exposure to a negative shock at different periods early in life.

I combine detailed rainfall data with a rich dataset collected five and seven years after the disaster, which compiled children’s health and cognitive outcomes. I find that children exposed to severe floods during El Niño are 0.1 SDs shorter in stature, and score 0.14 SDs lower on cognitive tests. The timing of exposure results are in line with the medical literature findings on sensitive periods for body growth and brain development. The negative effect on height-for-age are stronger for exposure in the third trimester, while the deficit in cognition are larger from exposure in the first trimester in utero.

I explore potential channels behind these lasting effects on children's human capital. I find suggestive evidence that increases in the likelihood of low birth weight, deterioration of family resources, and family investments may explain the negative, persistent impact of exposure to severe floods in utero. Children exposed to El Niño floods, especially in the third trimester of pregnancy, are more likely to be born with low birth weight. I find suggestive evidence that this effect is due to intrauterine growth restriction, which is mainly determined by poor maternal nutrition. In contrast, there is no evidence of changes in the likelihood of premature births. Also, lack of access to prenatal health care utilization does not seem to explain the findings.

On the family inputs side, I show that households affected by El Niño 1997-98 suffered a decline in income, total consumption, and food consumption. Additionally, exposure to El Niño floods decreased the duration of exclusive breastfeeding, but increased the duration of total breastfeeding (breast milk combined with formula or other foods). I do not find evidence that endogenous fertility or migration responses confounded the estimated effects.

Some "back-of-the envelope" calculations may be helpful to put the estimated magnitudes into perspective. For instance, one could translate the decline in cognitive development into potential wage losses. The literature in developing countries documents the relationship between wages and IQ measures such as WISC (Wechsler Intelligence Scale for Children). Thus, for this calculation, I consider the Peabody Picture Vocabulary test (PPVT) as a proxy for IQ.[55] Alderman and Behrman (2006) document that a 0.5 SD decrease in IQ is associated to a 5%-12% decline in wages. Thus, a "back-of-the envelope" calculation suggests that the observed reduction in IQ due to in utero exposure to El Niño (0.14 SDs) could translate into a decline in wages between 1.4% and 3.36%. These effects are smaller than those found by Almond (2006) for in utero exposure to the Spanish flu pandemic in the U.S. (5%-6% reduction in wages). However, this computation just considers the effects on wages through IQ, but ignores potential effects that operate through other channels, such as height and physical health, which are also affected by El Niño.

The evidence presented in this paper has important implications for policies that aim to mitigate damages from weather shocks. First, policies such as social protection and safety nets should improve the coping mechanisms against negative shocks that affect income, maternal nutrition and health, especially in disadvantaged families with children and pregnant women. Second, in terms of timing, safety net policies should target pregnant women not just before they give birth, but also early in their pregnancies to prevent the negative consequences on children's health and cognitive skills.

[55] PPVT developers document that correlations between PPVT and several cognitive ability tests (including WISC) ranged from 0.62 to 0.91 (Dunn and Dunn, 1997).

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Figures and Tables

Figure 1: Excess of rainfall during el Niño 97-98 in selected weather stations in Ecuador

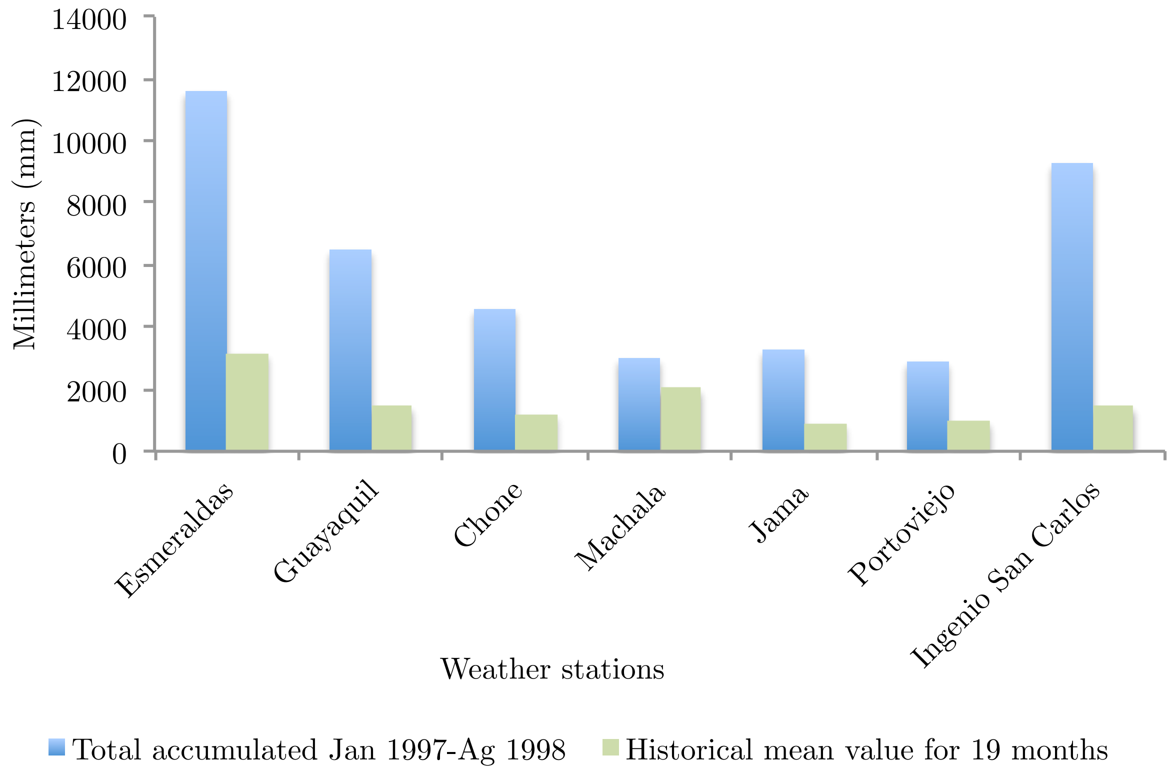


Figure 2: Agricultural losses during el Niño 97-98 by states in Ecuador

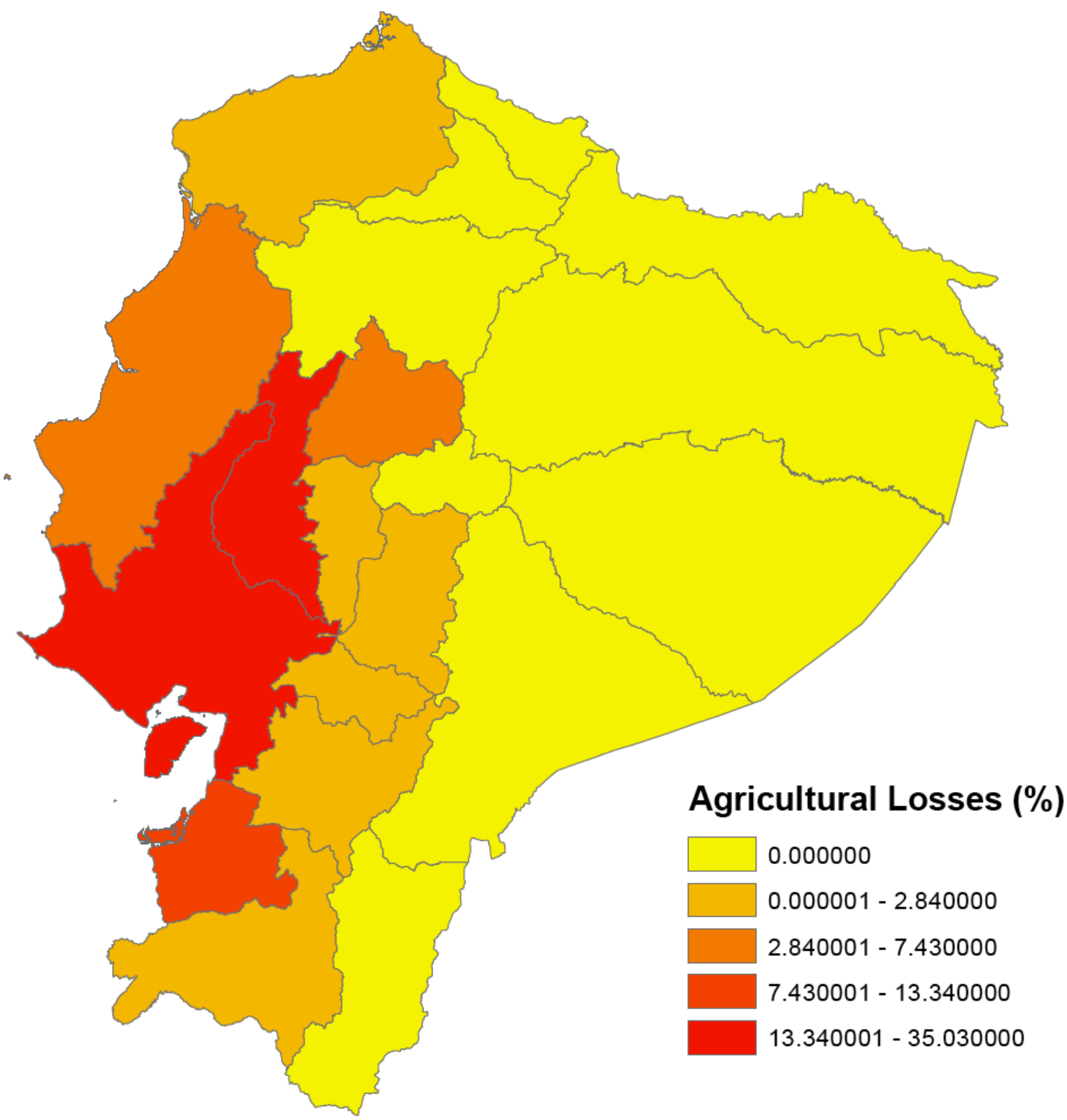
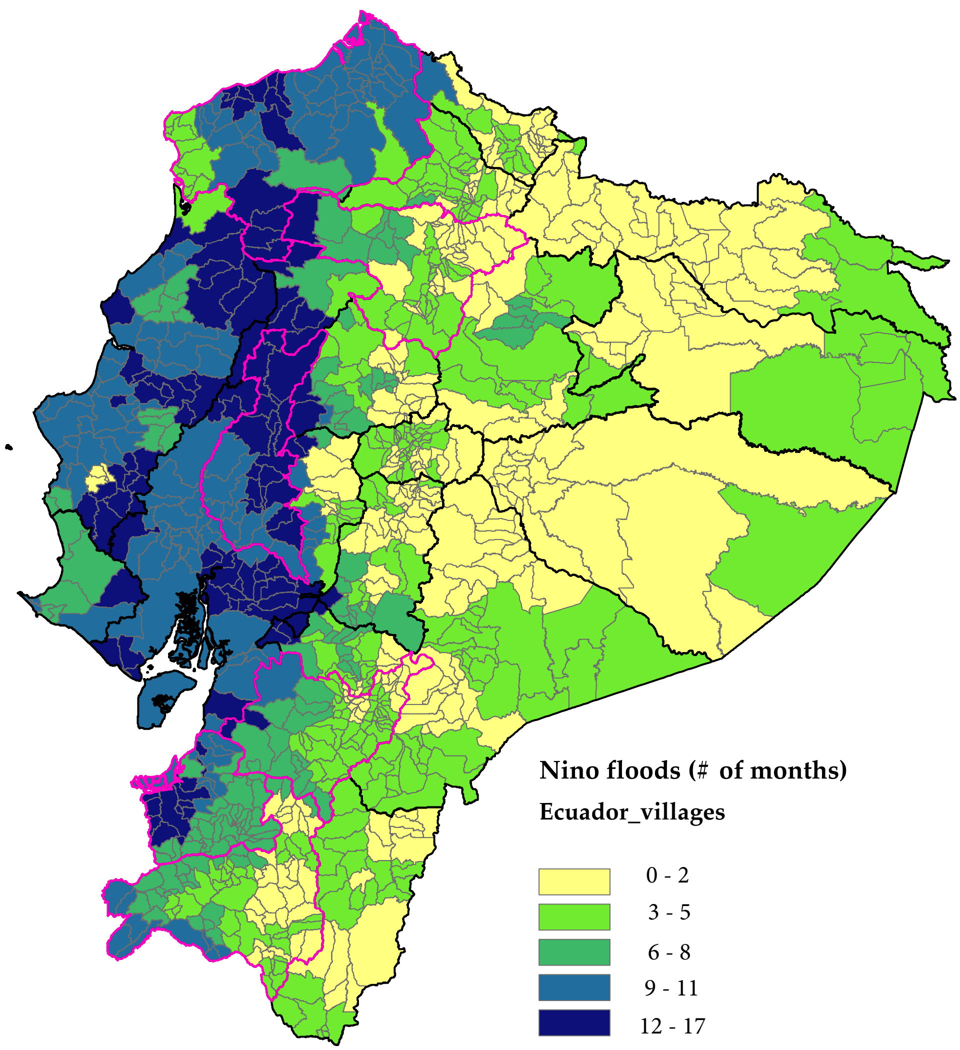


Figure 3: Prevalence of floods during el Niño 97-98 by Ecuadorian villages



Notes: Number of months of floods correspond to monthly excess of rainfall (observed rain deviations from historical mean) greater that one historical standard deviation. The six states selected in fuchsia correspond to the states sampled in the children dataset.

Table 1: Summary statistics - Ecuador's cash transfer evaluation survey - 2003/04

	(1)	(2)	(3)	(4)
	Ecuador Children's data 2003-04 (from cash transfer evaluation survey)		Reproductive and health Survey 2004 (females with preschool children)	RHS 2004 - All Ecuador
	Mean	N	Mean	Mean
Mother Characteristics				
More than primary school	0.480	6553	0.535	0.602
Married or cohabiting	0.783	6553	0.832	0.592
Age	24.737	6548	28.903	29.499
Household characterisitics				
Family size	4.817	6553	5.575	5.290
Number of rooms	2.149	6534	2.790	3.219
Piped water	0.730	6553	0.783	0.816
Flush toilets	0.522	6553	0.602	0.659
Children Characteristics				
If male	0.509	6489		
Age in months	39.866	6489		
If first born	0.742	6553		
if exposed to El Nino in Utero and 0-1	0.087	6147		
Height for age (z score)	-1.190	6147		
Standarized PPVT score (SDs)	-0.907	3551		
If anemic	0.579	5827		

Note: The first two columns correspond to the dataset that contains children medium-term outcomes (data from the survey collected to evaluate the cash transfer program in Ecuador). Summary statistics are calculated in the baseline survey (2003-04), and the unit of observation in this table is children, mother or household. The survey sample families with children at most six years old (pres-school age) and that are elegible to receive the cash transfer. The sample used in this paper correspond do children born between 1997/98 and 2002. The PPVT sample size is smaller because the instrument is administered to children older than 3 years. Children born in 2001 and 2002 have PPVT from the follow-uo survey. To compare the demografic characterisitcs to Ecuador's population, the last two columns used data from the Reproductive and Health Survey (RHS) 2004. Column 4 correspond to women in fertile ages in Ecuador. PPVT: Peabody Picture Vocabulary Test. SDs: Standard Deviations.

Table 2: Checking for selection on observables: family characteristics and exposure to the 1997-98 El Niño floods (2003-04 Child data)

	(1)	(2)	(3)	(4)	(5)
	Married or Cohab	Mom edu: more than primary sch	Dad edu: more than primary sch	Dad lives at home	Family size
Nino floods - in utero	0.008	-0.002	0.013*	0.009	-0.016
	(0.008)	(0.008)	(0.007)	(0.009)	(0.036)
Nino floods - age 0-1	0.014	-0.002	0.014	0.020	0.088
	(0.017)	(0.020)	(0.018)	(0.028)	(0.082)
F-test floods=0 (p-val)	0.24	0.97	0.11	0.34	0.56
Observations	6,492	6,492	6,492	6,384	6,492

	(6)	(7)	(8)	(9)
	Number of children less than 5	Number of children less than 14 at home	Mother age less than 21 years	Mother' s cognitive ability (PPVT)
Nino floods - in utero	0.026	0.010	-0.002	-0.001
	(0.020)	(0.023)	(0.007)	(0.023)
Nino floods - age 0-1	0.035	-0.027	0.020	0.023
	(0.039)	(0.055)	(0.016)	(0.062)
F-test floods=0 (p-val)	0.09	0.87	0.47	0.93
Observations	6,492	6,492	6,448	5,700

Note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses clustered at the village level. The units of observation are children in the cash transfer (CT) data at baseline survey in 2003-04. Each column is a separate regression that includes quarter/year of birth, month of birth and village fixed effects. Nino floods - in utero is the number of months of floods experienced in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life.

Table 3: Medium-term effects of exposure to the 97-98 El Niño floods on child's human Capital

	Height-for-age (SD)	Anemic	Cognition (PPVT, SD)	Placebo (simulate the shock for children born in 2000-01) Height-for-age (SD)	Anemic	Cognition (PPVT, SD)
	(1)	(2)	(3)	(4)	(5)	(6)
Nino floods - in utero	-0.034**	0.020**	-0.046**	0.002	0.002	-0.007
	(0.015)	(0.008)	(0.022)	(0.011)	(0.004)	(0.009)
	[0.0126]***	[0.00766]***	[0.0271]*	[0.0118]	[0.00524]	[0.00943]
Nino floods - age 0-1	-0.046	-0.018	-0.026	-0.009	0.004	-0.007
	(0.034)	(0.021)	(0.051)	(0.009)	(0.004)	(0.011)
	[0.0370]	[0.0227]	[0.0403]	[0.00780]	[0.00227]*	[0.0198]
Observations	11,654	10,484	8,809	8,534	7,627	5,659
Y mean	-1.00	0.518	-0.93			
@Avg. exposure in utero (3m)	-0.10	0.060	-0.14			

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Standard errors adjusted for spatial correlation using Conley (1999) in brackets. Medium-term refers to five and seven years after the 1997-98 El Niño. The units of observation are children in the cash transfer (CT) data. Anemic is a dummy variable equal to one if the child was anemic. Anemia is defined using the Center for Disease and Control Guidelines. PPVT is the Peabody Picture Vocabulary Test standardized to mean 0 and SD of 1 in the norming sample. Each column is a separate regression that includes as controls: child's gender, age, and first born; mother's and father's education, father at home, mother's age, number of children less than 14 at home, urban, SES quintile, inflation at the state of birth, and month of birth, cohort, village and survey-wave dummies. Nino floods - in utero is the number of months of floods experienced in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. The table presents estimates from equation 10 explained in the text and correspond to marginal effects per month of exposure to floods. Placebo regression simulate the occurance of the 97-98 El Niño in 2000 and analyze the effects on children born in 2000 and afterwards. SD: standard deviations. Y mean: mean of the dependent variable. Avg. exposure in utero is the average months of floods experienced in utero and is equal to 3 months.

Table 4: Effects of the 97-98 El Niño on child's human capital: exploring timing of exposure

	Height-for-age (SD)	Anemic	PPVT (SD)
	(1)	(2)	(3)
Nino floods - 1st trimester	-0.020	0.019	-0.115***
	(0.039)	(0.018)	(0.044)
	[0.0232]	[0.0154]	[0.0296]***
Nino floods - 2nd trimester	-0.023	0.026	0.019
	(0.043)	(0.029)	(0.067)
	[0.0411]	[0.0193]	[0.0562]
Nino floods - 3rd trimester	-0.087**	0.010	0.016
	(0.042)	(0.030)	(0.074)
	[0.0489]*	[0.0258]	[0.0733]
Nino floods - age 0-1	-0.032	-0.016	-0.066
	(0.036)	(0.022)	(0.055)
	[0.0384]	[0.0265]	[0.0488]
Observations	11,654	10,484	8,809
Joint test, coefficients of trimesters in utero are equal to 0			
p-value	0.046	0.114	0.043
Joint test, coefficients of trimesters in utero are equal			
p-value	0.435	0.944	0.159
Joint test, coefficients of trimesters in utero and age 0-1 are equal to 0			
p-value	0.013	0.201	0.059
Joint test, coefficients of trimesters in utero and age 0-1 are equal			
p-value	0.620	0.532	0.286

Notes: * $p<0.10$,** $p<0.05$, *** $p<0.01$. Robust standard errors in parentheses clustered at the village level. Standard errors adjusted for spatial correlation using Conley (1999) in brackets. Nino floods - 1st trimester is the number of months of floods experienced during the first trimester in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. The table presents marginal effects per month of exposure to floods. See note in table 3 for additional definitions.

Table 5: Heterogeneous effects of exposure to the 97-98 El Niño floods on child's human capital

	Maternal Education		Urban Vs. Rural	
	Height-for-age (SD)	PPVT (SD)	Height-for-age (SD)	PPVT (SD)
	(1)	(2)	(3)	(4)
Nino floods - 1st trimester	-0.020	-0.276***	-0.022	-0.063
	(0.039)	(0.063)	(0.038)	(0.056)
Nino floods - 2nd trimester	-0.022	0.013	-0.025	0.016
	(0.043)	(0.067)	(0.044)	(0.067)
Nino floods - 3rd trimester	-0.023	0.025	-0.052	0.012
	(0.079)	(0.072)	(0.055)	(0.074)
Nino floods - age 0-1	-0.025	-0.068	-0.040	-0.063
	(0.036)	(0.054)	(0.038)	(0.054)
Interactions				
Nino floods - 1st trimesterXrural				-0.095*
				(0.051)
Nino floods - 3rd trimesterXrural			-0.063	
			(0.057)	
Nino - 1st trimesterX Mom years edu		0.022***		
		(0.007)		
Nino - 3rd trimesterXMom years edu	-0.009			
	(0.009)			
Observations	11,601	8,764	11,654	8,809

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The unit of observation are children in the cash transfer (CT) data. Each column is a separate regression that includes as controls: child's gender, age, and first born; mother's and father's education, father at home, mother's age, number of children less than 14 at home, urban, SES quintile, inflation at the state of birth, and month of birth, cohort, village and survey-wave dummies. Nino floods - 1st trimester is the number of months of floods experienced during the first trimester in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. These specifications include interactions with exposure in the trimester of pregnancy most vulnerable given the specific outcome (first trimester for vocabulary and third trimester for height for age). However, point estimates from fully interacted measures of exposure are similar while the standard errors increase more than 50%. The table presents marginal effects per month of exposure to floods. SD: standard deviations.

Table 6: Effects of exposure to the 97-98 El Niño floods on birth outcomes

Birth outcomes

	Weighted at birth	Low birth weight	Preterm birth	Low birth weight (drop preterm)
	(1)	(2)	(3)	(4)
Nino floods - in utero	0.003	0.008**	0.000	0.007*
	(0.004)	(0.004)	(0.002)	(0.004)
Observations	7,087	5,324	7,075	4,981
Y mean	0.751	0.158	0.060	0.130
@Average exposure in utero (3m)		0.024		0.021

Prenatal investments

	If prenatal care	N prenatal care	If 1st visit in 1st trimester	If tetanus vac
	(5)	(6)	(7)	(8)
Nino floods - in utero	0.003	0.025	0.006	-0.003
	(0.004)	(0.033)	(0.004)	(0.004)
Observations	7,107	7,087	7,107	7,088
Y mean	0.777	4.488	0.558	0.587

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are children age 0-2 in the Reproductive and Health Surveys (RHS) 1994 and 1999. Each column is a separate regression that includes as controls: child's gender, birth order, quartert of birth/year dummie; mother's age, marital status, education, if living in urban, ses index, survey year and village fixed effect. Nino floods - in utero is the number of months of floods experienced in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. The table presents marginal effects per month of exposure to floods. N Prenatal care: number of prenatal care controls. If tetanus vac: whether mother recieved a tetanus vaccination. Y mean: Mean of the dependend variable.

Table 7: Effect of the 97-98 El Niño floods on birth outcomes - timing of exposure & placebo

	Weighted at birth	Low birth weight	Preterm birth	Low birth weight (drop preterm)	Placebo: Low birth weight	Placebo: Low birth weight (drop preterm)
	(1)	(2)	(3)	(4)	(5)	(6)
Nino floods - 1st trimester	0.008	0.003	0.003	-0.002		
	(0.009)	(0.009)	(0.005)	(0.008)		
	[0.00765]	[0.00844]	[0.00631]	[0.00766]		
Nino floods - 2nd trimester	0.004	0.001	-0.002	0.003		
	(0.010)	(0.011)	(0.006)	(0.011)		
	[0.0108]	[0.00851]	[0.00636]	[0.00864]		
Nino floods - 3rd trimester	-0.003	0.020*	0.000	0.021**		
	(0.009)	(0.011)	(0.008)	(0.010)		
	[0.00744]	[0.0112]*	[0.00786]	[0.00857]**		
Nino floods - age 0-1					0.002	0.003
					(0.004)	(0.004)
					[0.00332]	[0.00244]
Observations	7,087	5,324	7,075	4,981	5,324	4,981
Joint test, coefficients of trimesters in utero are equal to 0						
p-value	0.655	0.107	0.954	0.077		
Joint test, coefficients of trimesters in utero are equal						
p-value	0.646	0.437	0.871	0.131		

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Standard errors adjusted for spatial correlation using Conley (1999) in brackets. The units of observation are children age 0-2 in the Reproductive and Health Surveys (RHS) 1994 and 1999. Each column is a separate regression with covariates as in Table 7. Nino floods - 1st trimester is the number of months of floods experienced during the first trimester in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. The table presents marginal effects per month of exposure to floods.

Table 8: Heterogeneous effects of El Niño floods on birth outcomes - by SES

	Low SES (quintile 1-2)		High SES (quintile 4-5)	
	Low birth weight	Low birth weight (drop preterm)	Low birth weight	Low birth weight (drop preterm)
Nino floods - 1st trimester	-0.023	-0.015	0.012	-0.000
	(0.015)	(0.015)	(0.016)	(0.013)
Nino floods - 2nd trimester	-0.005	-0.004	0.007	0.016
	(0.018)	(0.018)	(0.017)	(0.016)
Nino floods - 3rd trimester	0.031*	0.037**	0.015	0.008
	(0.018)	(0.018)	(0.016)	(0.016)
Observations	2,538	2,410	1,735	1,588

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The unist of observation are children age 0-2 in the Reproductive and Health Surveys (RHS) 1994 and 1999. Each column is a separate regression with covariates as in Table 7. The subsamples come from a socio-economic status (SES) index based on quality of the housing, household density, access to utilities, mother's education, and assets.

Table 9: Effect of the 97-98 El Niño floods on household monthly income and consumption

	ln hh labor income	ln hh non labor income	ln hh total income	ln_total consumption (monthly)	ln_food consumption (monthly)
	(1)	(2)	(3)	(4)	(5)
Nino_shockX1998	-0.0114**	-0.0009	-0.0156**	-0.0113***	-0.0005
	(0.0058)	(0.0228)	(0.0077)	(0.0040)	(0.0029)
	[0.00533]**	[0.0161]	[0.00670]**	[0.00315]***	[0.00245]
Nino_shockX1999	-0.0181***	-0.0147	-0.0210***	-0.0212***	-0.0192***
	(0.0052)	(0.0230)	(0.0061)	(0.0037)	(0.0050)
	[0.00523]***	[0.0174]	[0.00597]***	[0.00342]***	[0.00368]***
Observations	16,273	8,587	17,068	17,306	17,140
Effect at the mean level of exposure (7 months)					
1998	-8.0%		-10.9%	-7.94%	
1999	-12.7%		-14.7%	-14.85%	-13.42%

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Standard errors adjusted for spatial correlation using Conley (1999) in brackets. The units of observation are families in the Living Standard Measurement Studies (LSMS) surveys 1995, 1998, and 1999. Each column is a separate regression that includes as controls: age, gender, marital status and education of the household head, family size, number of members >=age 14, trimester of survey, years and village dummies. Nino floods is the number of months of floods during el niño experienced by the village of residence. The table presents marginal effects per month of exposure to floods. Dependent variables are the following montly household income: ln hh labor income: log of labor income, ln hh non labor income: log of non-labor income, and ln hh total income: log of total income.

Table 10: Heterogeneous effects of El Niño floods on income and consumption - by SES

	Low SES (quintile 1-2)				
	ln hh labor income	ln hh non labor income	ln hh total income	ln_total consumption (monthly)	ln_food consumption (monthly)
	(1)	(2)	(3)	(4)	(5)
Nino_shockX1998	-0.0135	-0.0215	-0.0191*	-0.0043	0.0081
	(0.0105)	(0.0227)	(0.0108)	(0.0053)	(0.0057)
Nino_shockX1999	-0.0138	-0.0276	-0.0223*	-0.0216***	-0.0246**
	(0.0123)	(0.0280)	(0.0122)	(0.0077)	(0.0100)
Observations	6,601	2,918	6,904	7,053	6,965

	High SES (quintile 4-5)				
	ln hh labor income	ln hh non labor income	ln hh total income	ln_total consumption (monthly)	ln_food consumption (monthly)
Nino_shockX1998	0.0037	0.0235	-0.0006	-0.0049	0.0053
	(0.0065)	(0.0300)	(0.0094)	(0.0050)	(0.0041)
Nino_shockX1999	-0.0096	0.0049	-0.0120*	-0.0107***	-0.0122**
	(0.0070)	(0.0237)	(0.0073)	(0.0038)	(0.0053)
Observations	6,387	3,976	6,741	6,805	6,760

Notes: * p<0.10 ,** p<0.05, *** p<0.01.Robust standard errors in parentheses clustered at the village level. The units of observation are families in the Living Standard Measurement Studies (LSMS) surveys 1995, 1998, and 1999. Each column is a separate regression with covariates as in Table 9. The subsamples come from a socio-economic status (SES) index based on quality of the housing, household density, access to utilities, mother's education, and assets.

Table 11: Effects of exposure to El Niño floods on child food consumption - children less than age 5: all sample and by SES

Panel A: All sample

# servings per week	Meat	Milk	Eggs	Fruits and Veg.	Grains and cereals
Nino_floodsX1998	-0.137***	-0.005	-0.005	-0.256**	-0.490**
	(0.039)	(0.079)	(0.018)	(0.127)	(0.214)
Observations	6,456	6,442	6,505	6,437	6,437
Y mean	5.290	9.551	2.804	11.521	12.781

Panel B: By SES

	Low SES (quintil 1-2)				
Nino_shockX1998	-0.205***	0.009	-0.007	-0.341**	-0.401
	(0.075)	(0.085)	(0.032)	(0.160)	(0.252)
N	3,155	3,159	3,168	3,152	3,145

	High SES (quintil 4-5)				
Nino_shockX1998	-0.002	-0.046	0.005	-0.192	-0.576***
	(0.070)	(0.144)	(0.035)	(0.140)	(0.193)
N	1,892	1,871	1,913	1,872	1,890

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Dependent variables are counts of number of food servings per week. Negative binominal counts model were used. Controls: child's gender, age in months, age in months sqr; age, gender, marital status and education of the household head, family size, number of members >=age 14, trimester of survey, years and village dummies.
Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are children age 0-5 in the Living Standard Measurement Studies (LSMS) surveys 1995, and 1998 (1999 data was not consistent). Each column is a separate regression that includes as controls: child's gender, age in months, age in months sqr; age, gender, marital status and education of the household head, family size, number of members >=age 14, trimester of survey, years and village dummies. Nino floods is the number of months of floods during el niño experienced by the village of residence. The table presents marginal effects per month of exposure to floods. Y mean: mean of dependent variable. The subsamples in panel B come from a socio-economic status (SES) index based on quality of the housing, household density, access to utilities, mother's education, and assets.

Table 12: Effects of exposure to El Niño floods on duration of breastfeeding - children less than age 2 : all sample and by SES

Panel A: All sample

	Exclusive BF (months)		BF in months	
	OLS	Hazard	OLS	Hazard
Nino_floodsX1998	-0.059*	0.032*	0.088*	-0.045**
	(0.032)	(0.018)	(0.053)	(0.018)
Nino_floodsX1999	0.002	0.003	0.136**	-0.054**
	(0.037)	(0.022)	(0.054)	(0.019)
Observations	3,870	3,511	3,866	3,742
Y mean	3.3		8.9	

Panel B : By SES (OLS)

	Exclusive BF (months)		BF in months	
	Low SES (quintil 1-2)	High SES (quintil 4-5)	Low SES (quintil 1-2)	High SES (quintil 4-5)
Nino_floodsX1998	-0.105**	-0.056	0.111	0.022
	(0.049)	(0.050)	(0.077)	(0.106)
Nino_floodsX1999	-0.029	0.060	0.177*	0.092
	(0.070)	(0.042)	(0.105)	(0.058)
Observations	1,949	1,084	1,946	1,083

Notes: * $p<0.10$,** $p<0.05$, *** $p<0.01$. Robust standard errors in parentheses clustered at the village level. The units of observation are children age 0-2 in the Living Standard Measurement Studies (LSMS) surveys 1995, 1998, and 1999. Each column is a separate regression that includes as controls: child's gender, age in months; age, gender, marital status and education of the household head, family size, number of members >=age 14, trimester of survey, years and village dummies. Nino floods is the number of months of floods during el niño experienced by the village of residence. The table presents marginal effects per month of exposure to floods. Dependent variables are duration of exclusive and total breastfeeding in months. The hazard models estimates have the opposite sign because they estimate the conditional probability of stopping exclusive breastfeeding. Y mean: mean of dependent variable. The subsamples in panel B come from a socio-economic status (SES) index based on quality of the housing, household density, access to utilities, mother's education, and assets.

A Appendix: Additional Robustness and Specification tests

A.1 Appendix: Robustness checks: alternative measures of El Niño floods

This appendix shows that the estimates of the effect of exposure to el Niño floods on children's human capital formation presented in the paper are robust to alternative specifications of the shock. Specifically, two measures are used. First, I define a flood month if the standardized monthly rainfall exceeded 1.5 standard deviations (instead of one SDs). Second, the excess of precipitation during El Niño is calculated as the simple summation of the z-scores of excess of precipitation. Results are presented in the following tables and show that the evidence is robust to these alternative specifications.

Table A.1: Alternative excess of rainfall measures: children outcomes

	Height for age_z	If Anemic	PPVT
	coef/se	coef/se	coef/se
	Cut-off: 1.5 sdev		
Nino floods - 1st trimester	-0.035	0.023	-0.096**
	(0.036)	(0.020)	(0.045)
Nino floods - 2nd trimester	-0.001	0.007	0.033
	(0.032)	(0.031)	(0.076)
Nino floods - 3rd trimester	-0.090*	0.019	-0.002
	(0.052)	(0.035)	(0.087)
Nino floods - age 0-1	-0.006	-0.017	-0.061
	(0.047)	(0.025)	(0.057)
Number of observations	11,654	10,484	8,809
	Sum of the z-scores during el niño		
Nino floods - 1st trimester	-0.008	0.009	-0.034**
	(0.013)	(0.007)	(0.015)
Nino floods - 2nd trimester	-0.005	0.006	0.010
	(0.013)	(0.010)	(0.028)
Nino floods - 3rd trimester	-0.031*	0.006	0.024
	(0.019)	(0.013)	(0.026)
Nino floods - age 0-1	-0.015	-0.018	-0.150*
	(0.059)	(0.031)	(0.085)
Number of observations	11,654	10,484	8,809

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Controls: child's gender, age, first born and month of birth; mother's and father's education, father at home, mother's age, number of children less than 14 at home, urban, SES quintile, inflation at the state of birth, and cohort (quarter by year of birth), village and survey-wave dummies

Table A.2: Alternative excess of rainfall measures: birth outcomes

	Weighted at birth	Low birth weight	Preterm birth	Low birth weight (drop preterm)
	<u>Cut-off: 1.5 sdev</u>			
Nino floods - 1st trimester	0.010	0.002	-0.003	-0.001
	(0.009)	(0.010)	(0.005)	(0.009)
Nino floods - 2nd trimester	0.003	0.001	0.001	0.002
	(0.010)	(0.011)	(0.007)	(0.010)
Nino floods - 3rd trimester	-0.005	0.023**	0.003	0.020**
	(0.009)	(0.011)	(0.008)	(0.010)
Number of observations	7,087	5,324	7,075	4,981
	<u>Sum of the z-scores during el niño</u>			
Nino floods - 1st trimester	0.002	0.003	0.002	0.002
	(0.003)	(0.003)	(0.002)	(0.003)
Nino floods - 2nd trimester	0.001	-0.003	-0.004*	-0.001
	(0.003)	(0.003)	(0.002)	(0.003)
Nino floods - 3rd trimester	-0.001	0.009***	0.003	0.007**
	(0.003)	(0.003)	(0.002)	(0.003)
Number of observations	7,087	5,324	7,075	4,981

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Each column is a separate regression with covariates as in Table 7. Data source: Reproductive and Health Survey.

Table A.3: Alternative excess of rainfall measures: Family income and consumption

	ln hh labor income	ln hh non labor income	ln hh total income	ln_total consumption (monthly)	ln_food consumption (monthly)
			Cut-off: 1.5 sdev		
Nino_shockX1998	-0.012**	-0.009	-0.017**	-0.010**	-0.001**
	(0.006)	(0.022)	(0.008)	(0.004)	(0.003)
Nino_shockX1999	-0.015***	-0.018	-0.019***	-0.018***	-0.018***
	(0.005)	(0.021)	(0.006)	(0.003)	(0.004)
N	16,283	8,595	17,079	17,318	17,152
			Sum of the z-scores during el niño		
Nino_shockX1998	-0.003*	-0.001	-0.004**	-0.003***	-0.000
	(0.002)	(0.006)	(0.002)	(0.001)	(0.001)
Nino_shockX1999	-0.005***	-0.005	-0.006***	-0.005***	-0.005***
	(0.001)	(0.006)	(0.002)	(0.001)	(0.001)
N	16,283	8,595	17,079	17,318	17,152

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Controls: age, gender, marital status and education of the household head, family size, number of members >=age 14, trimester of survey, years and village dummies. Data source: Living Standards Measurement Study.

A.2 Appendix: Robustness checks: adding province-specific trends

Another concern might be that the results are driven by different trends in places more affected by the floods relative to those less affected. I estimate specifications that allow for flexible province-specific trends (cubic). Results are presented in this appendix and show that the estimates are robust to including province specific cubic trends. A caveat from this type of specification is that even though it allows for different trends for each province it also imposes the variation to be used as deviation of an specific functional form of the trends.

Table A.4: Adding geographic-specific linear trends

	Height for age_z			
	No trends	State	District	Village
Nino floods - 1st trimester	-0.020	-0.013	-0.011	0.013
	(0.039)	(0.040)	(0.042)	(0.041)
Nino floods - 2nd trimester	-0.023	-0.028	-0.021	-0.014
	(0.043)	(0.042)	(0.041)	(0.040)
Nino floods - 3rd trimester	-0.0874**	-0.0813*	-0.0869**	-0.0870*
	(0.042)	(0.042)	(0.044)	(0.046)
Nino floods - age 0-1	-0.032	-0.027	-0.015	-0.033
	(0.036)	(0.037)	(0.040)	(0.043)
Number of observations	11,654	11,654	11,654	11,654

	PPVT (SD)			
	No trends	State	District	Village
Nino floods - 1st trimester	-0.1146***	-0.0738*	-0.0651*	-0.0632
	(0.044)	(0.040)	(0.037)	(0.039)
Nino floods - 2nd trimester	0.019	0.063	0.069	0.072
	(0.067)	(0.063)	(0.066)	(0.067)
Nino floods - 3rd trimester	0.016	0.027	0.016	0.010
	(0.074)	(0.076)	(0.079)	(0.082)
Nino floods - age 0-1	-0.066	-0.051	-0.042	-0.058
	(0.055)	(0.049)	(0.053)	(0.055)
Number of observations	8,809	8,809	8,809	8,809

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Cotrol covariates described in table 3 in the paper

A.3 Appendix: Correcting for spatial correlation

Table A.5: Adding coast-cohort fixed effects

	Height-for-age (SD)		Anemic		PPVT (SD)	
	(1)	(2)	(3)	(4)	(5)	(6)
Nino floods - in utero	-0.025		0.012		-0.051**	
	(0.018)		(0.009)		(0.023)	
Nino floods - 1st trimester		-0.012		0.008		-0.112**
		(0.043)		(0.017)		(0.047)
Nino floods - 2nd trimester		-0.010		0.013		0.012
		(0.039)		(0.030)		(0.068)
Nino floods - 3rd trimester		-0.088**		0.020		0.000
		(0.043)		(0.033)		(0.089)
Nino floods - age 0-1	-0.050	-0.039	-0.001	-0.004	-0.047	-0.076
	(0.039)	(0.040)	(0.023)	(0.024)	(0.055)	(0.058)
Observations	11,654		10,484		8,809	

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Nino floods - 1st trimester is the number of months of floods experienced during the first trimester in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. The table presents marginal effects per month of exposure to floods. See note in table 3 for additional definitions.

	Weighted at birth		Low birth weight		Preterm birth		Low birth weight (drop preterm)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Nino floods - in utero	0.002		0.012***		0.003		0.009**	
	(0.004)		(0.004)		(0.003)		(0.004)	
Nino floods - 1st trimester		0.002		0.001		0.002		-0.004
		(0.009)		(0.010)		(0.007)		(0.009)
Nino floods - 2nd trimester		0.007		0.005		0.002		0.005
		(0.011)		(0.011)		(0.007)		(0.011)
Nino floods - 3rd trimester		-0.004		0.032***		0.005		0.028***
		(0.010)		(0.011)		(0.008)		(0.010)
Observations		7,085		5,322		7,073		4,979

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are children age 0-2 in the Reproductive and Health Surveys (RHS) 1994 and 1999. See note in table 8 for additional definitions.

Spatial standard errors Also, I adjusted the standard errors for spatial correlation using the Conley s (1999) approach, which allows dependence across individuals based on distance to the weather station. Standard errors are calculated using a kernel weight estimator that weights observations based on both East-West and North-South orientation. Each kernel decline linearly up to a cut-off. I use a 50km cut-off (the percentile 95 distance between the center of a village and the weather station). Standard errors are shown in brackets for the main tables (Tables 3. 4, 7, and 9). It is apparent that Conley standard errors are not consistently larger in all cases: sometimes they are larger and others smaller than the standard errors clustered at the village level. The reason could be that the village level is a fairly large administrative unit (like a municipality) and clustering at this level takes into account the spatial dependence in a large extend.

A.4 Appendix: Measurement error

Table A.6: Restricting the sample to children close to the weather stations

	Height-for-age (SD)		Anemic		PPVT (SD)	
	(1)	(2)	(3)	(4)	(5)	(6)
Nino floods - in utero	-0.046**		0.017		-0.008	
	(0.023)		(0.012)		(0.032)	
Nino floods - 1st trimester		-0.034		0.007		-0.092*
		(0.048)		(0.023)		(0.050)
Nino floods - 2nd trimester		-0.033		0.013		0.070
		(0.053)		(0.038)		(0.094)
Nino floods - 3rd trimester		-0.093**		0.047		0.078
		(0.048)		(0.035)		(0.096)
Nino floods - age 0-1	-0.098**	-0.089*	0.003	-0.003	0.049	0.004
	(0.049)	(0.051)	(0.036)	(0.034)	(0.099)	(0.096)
Observations	7,602		6,848		5,766	

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Nino floods - 1st trimester is the number of months of floods experienced during the first trimester in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. The table presents marginal effects per month of exposure to floods. See note in table 3 for additional definitions.

	Weighted at birth		Low birth weight		Preterm birth		Low birth weight (drop preterm)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Nino floods - in utero	-0.000		0.011*		0.001		0.009	
	(0.005)		(0.006)		(0.003)		(0.006)	
Nino floods - 1st trimester		0.001		-0.004		0.002		-0.010
		(0.012)		(0.012)		(0.008)		(0.011)
Nino floods - 2nd trimester		0.011		0.004		-0.010		0.011
		(0.013)		(0.015)		(0.008)		(0.015)
Nino floods - 3rd trimester		-0.013		0.033***		0.011		0.027**
		(0.012)		(0.013)		(0.009)		(0.013)
Observations	4,589		3,534		4,580		3,296	

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are children age 0-2 in the Reproductive and Health Surveys (RHS) 1994 and 1999. See note in table 8.

Table A.7: Restricting the sample to children close to the weather stations

	ln hh labor income	ln hh non labor income	ln hh total income	ln_total consumption (monthly)	ln_food consumption (monthly)
	(1)	(2)	(3)	(4)	(5)
Nino_shockX1998	-0.015*	0.016	-0.016	-0.0159***	0.0001
	(0.008)	(0.026)	(0.010)	(0.0042)	(0.0050)
Nino_shockX1999	-0.018***	-0.005	-0.019**	-0.0173***	-0.0100*
	(0.007)	(0.033)	(0.008)	(0.0049)	(0.0056)
Observations	9,665	5,280	10,172	10,308	10,216

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are families in the Living Standard Measurement Studies (LSMS) surveys 1995, 1998, and 1999. Each column is a separate regression that includes covariates as noted in table 11. The table presents marginal effects per month of exposure to floods.

Table A.8: Standard errors clustered at the weather station level-

	Height-for-age (SD)		Anemic		PPVT (SD)	
	(1)	(2)	(3)	(4)	(5)	(6)
Nino floods - in utero	-0.034**		0.020**		-0.046**	
	(0.015)		(0.008)		(0.022)	
	[0.015]**		[0.0077]***		[0.023]**	
Nino floods - 1st trimester		-0.020		0.019		-0.115***
		(0.039)		(0.018)		(0.044)
		[0.036]		[0.018]		[0.041]***
Nino floods - 2nd trimester		-0.023		0.026		0.019
		(0.043)		(0.029)		(0.067)
		[0.041]		[0.027]		[0.071]
Nino floods - 3rd trimester		-0.087**		0.010		0.016
		(0.042)		(0.030)		(0.074)
		[0.041]**		[0.025]		[0.081]
Nino floods - age 0-1	-0.046	-0.032	-0.018	-0.016	-0.026	-0.066
	(0.034)	(0.036)	(0.021)	(0.022)	(0.051)	(0.055)
	[0.035]	[0.038]	[0.022]	[0.023]	[0.050]	[0.058]
Observations	11,654		10,484		8,809	

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Standard errors clustered at the weather station in brackets. Nino floods - 1st trimester is the number of months of floods experienced during the first trimester in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. The table presents marginal effects per month of exposure to floods. See note in table 3 for additional definitions.

Table A.9: Standard errors clustered at the weather station level

	Weighted at birth		Low birth weight		Preterm birth		Low birth weight	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Nino floods - in utero	0.003		0.008**		0.000		0.007*	
	(0.004)		(0.004)		(0.002)		(0.004)	
	[0.004]		[0.004]**		[0.002]		[0.003]**	
Nino floods - 1st trimester		0.008		0.003		0.003		-0.002
		(0.009)		(0.009)		(0.005)		(0.008)
		[0.010]		[0.009]		[0.005]		[0.008]
Nino floods - 2nd trimester		0.004		0.001		-0.001		0.003
		(0.010)		(0.011)		(0.006)		(0.011)
		[0.011]		[0.011]		[0.006]		[0.011]
Nino floods - 3rd trimester		-0.003		0.021**		0.000		0.022**
		(0.009)		(0.011)		(0.007)		(0.010)
		[0.009]		[0.011]*		[0.007]		[0.010]**
Observations	7,087		5,324		7,075		4,981	

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are children age 0-2 in the Reproductive and Health Surveys (RHS) 1994 and 1999. See note in table 8.

A.5 Appendix: Robustness checks: sampling weights

Table A.10: Birth outcomes

	Weighted at birth	Low birth weight	Preterm birth	Low birth weight (drop preterm)
Nino floods - 1st trimester	0.012	0.006	0.002	-0.001
	(0.009)	(0.011)	(0.006)	(0.010)
Nino floods - 2nd trimester	0.006	-0.003	-0.003	0.003
	(0.011)	(0.011)	(0.007)	(0.012)
Nino floods - 3rd trimester	-0.005	0.023**	0.000	0.022**
	(0.009)	(0.011)	(0.009)	(0.009)
Number of observations	7,087	5,324	7,075	4,981

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Control covariates described in the paper.

Table A.11: Family income and consumption

	ln hh labor income	ln hh non labor income	ln hh total income	ln_total consumption (monthly)	ln_food consumption (monthly)
	(1)	(2)	(3)	(4)	(5)
Nino_shockX1998	-0.013*	0.004	-0.016*	-0.0111***	-0.0009
	(0.007)	(0.027)	(0.009)	(0.0042)	(0.0032)
Nino_shockX1999	-0.009	0.011	-0.010*	-0.0097**	-0.0126***
	(0.006)	(0.023)	(0.006)	(0.0042)	(0.0044)
Observations	16,283	8,595	17,079	17,318	17,152

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are families in the Living Standard Measurement Studies (LSMS) surveys 1995, 1998, and 1999. Control covariates described in the paper

A.6 Appendix: Additional placebo

Table A.12: Adding exposure pre-conception: Children human capital

	Height-for-age (SD)		Anemic		PPVT (SD)	
	(1)	(2)	(3)	(4)	(5)	(6)
Nino pre-conception (6m)	0.010	0.008	0.006		-0.037	
	(0.016)	(0.017)	(0.007)		(0.022)	
Nino floods - in utero	-0.039**		0.017*		-0.030	
	(0.016)		(0.009)		(0.021)	
Nino floods - 1st trimester		-0.027		0.013		-0.087**
		(0.043)		(0.019)		(0.043)
Nino floods - 2nd trimester		-0.025		0.025		0.024
		(0.039)		(0.029)		(0.069)
Nino floods - 3rd trimester		-0.085**		0.012		0.004
		(0.043)		(0.031)		(0.082)
Nino floods - age 0-1	-0.040	-0.030	-0.015	-0.016	-0.047	-0.072
	(0.036)	(0.037)	(0.022)	(0.023)	(0.049)	(0.054)
Observations	11,654		10,484		8,809	

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. Nino floods - 1st trimester is the number of months of floods experienced during the first trimester in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. Nino pre-conception is the mumber of months of flods experienced 6 months before conception. The table presents marginal effects per month of exposure to floods. See note in table 3 for additional definitions.

Table A.13: health at birth

	Low birth weight		Preterm birth		Low birth weight (drop	
	(1)	(2)	(3)	(4)	(5)	(6)
Nino pre-conception (6m)	0.002	0.006	0.005	0.006	0.000	
	(0.006)	(0.006)	(0.004)	(0.004)	(0.005)	
Nino floods - in utero	0.007**		-0.000		0.007*	
	(0.004)		(0.002)		(0.004)	
Nino floods - 1st trimester		-0.001		-0.001		-0.006
		(0.010)		(0.007)		(0.010)
Nino floods - 2nd trimester		0.001		-0.002		0.002
		(0.011)		(0.006)		(0.011)
Nino floods - 3rd trimester		0.023**		0.002		0.023**
		(0.010)		(0.007)		(0.009)
Observations	5,324		7,075		4,981	

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are children age 0-2 in the Reproductive and Health Surveys (RHS) 1994 and 1999. Nino pre-conception is the mumber of months of flods experienced 6 months before conception. See note in table 7.

A.7 Appendix: Exploring selection concerns

Table A.14: Fertility responses to the 1997-98 El Niño floods

	Using RHS 1994 and 1999				RHS 2004	
	Pregnant at the time of survey (include mom of children born after jul 1994 (comparison) & children born after ago 1999 (conceive at the end of el nino and after)		**Childbirth 12 months before the survey** (include children born between ag1998-ago1999 so were conceive during el nino)		**Childbirth between 2000-2002** caputres medium-term responses	
	(1)	(2)	(3)	(4)	(5)	(6)
Year_1999	-0.0052	-0.0047	-0.0048	-0.0051		
	(0.0071)	(0.0071)	(0.0092)	(0.0093)		
Nino_floodsX1999	0.0007	0.0004	-0.0003	-0.0004	0.0015	0.0029
	(0.0007)	(0.0010)	(0.0009)	(0.0013)	(0.0038)	(0.0049)
<u>Interactions with maternal char.</u>						
Married_cohabitingXshock_99		0.0009		-0.0021**		0.0005
		(0.0009)		(0.0010)		(0.0022)
Age less than 20Xshock_99		0.0013		0.0006		0.0016
		(0.0011)		(0.0015)		(0.0024)
Age more than 45Xshock_99		0.0002		0.0020		-0.0012
		(0.0008)		(0.0014)		(0.0027)
Primary scholing Xshock_99		-0.0004		0.0003		0.0013
		(0.0007)		(0.0009)		(0.0022)
Health insuranceXshock_99		0.0000		0.0011		-0.0007
		(0.0009)		(0.0010)		(0.0027)
Number of childrenXshock_99		-0.0002		0.0003		-0.0004
		(0.0002)		(0.0002)		(0.0006)
Low SES Xshock_99		0.0000		-0.0003		0.0003
		(0.0010)		(0.0010)		(0.0019)
RuralXshock_99		-0.0005		-0.0010		-0.0016
		(0.0009)		(0.0013)		(0.0019)
Observations	27,646	27,646	27,785	27,785	10,757	10,757
Y mean	0.07		0.13		0.30	

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are women age 15 to 49 in the Reproductive and Health Surveys (RHS) 1994 and 1999 (columns 1-4) and in the RHS 2004 (columns 5-6). Each column is a separate regression that includes as controls: survey year dummies, villages dummies, and main effects of the covariates. Nino floods is the number of months of floods experienced in the village of residence during the 1997-98 El Niño. Columns 2 and 4 include triple interactions of the shock, dummy for year 1999 and demografic characteristics are included to explore endogenous responses to the shock. SES: socio-economic status. Column 6 icnlude double interacttions of the shock and socio-demographic characterisitics. Columns 5 and 6 include district dummies instead of villages since the data used there is one cross-section (2004). Char.: chracteristics.

Table A.15: Migration responses to the 1997-98 El Niño floods

	If migrate between survey and 5 years ago			
	Trend (data from 1994 and 1999)		Cross-sect (just 1999 data)	
	(1)	(2)	(3)	(4)
Year_1999	-0.0341***	-0.0352***	Cross-sect	
	(0.0124)	(0.0124)		
Nino_floodsX1999	0.0010	0.0010	-0.0011	-0.0005
	(0.0010)	(0.0015)	(0.0019)	(0.0029)
Interactions with maternal char.				
Married_cohabitingXshock_99		0.0014		-0.0020
		(0.0011)		(0.0016)
Age less than 20Xshock_99		0.0008		-0.0006
		(0.0013)		(0.0020)
Age more than 45Xshock_99		0.0019		-0.0001
		(0.0014)		(0.0019)
Primary scholing Xshock_99		0.0006		0.0008
		(0.0009)		(0.0014)
Health insuranceXshock_99		-0.0013		-0.0020
		(0.0011)		(0.0017)
Number of childrenXshock_99		-0.0003		0.0001
		(0.0002)		(0.0003)
Low SES Xshock_99		0.0002		-0.0011
		(0.0009)		(0.0015)
RuralXshock_99		0.0010		0.0032**
		(0.0014)		(0.0015)
Observations	27,784	27,784	14,208	14,208
Mean	0.080			

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are women age 15 to 49 in the Reproductive and Health Surveys (RHS) 1994 and 1999. Each column is a separate regression that includes as controls: survey year dummies, villages dummies (counties for the cross-section regressions in columns 3-4) , and main effects of the covariates. Nino floods is the number of months of floods experienced in the village of residence during the 1997-98 El Niño. Triple interactions of the shock, dummy for year 1999 and demografic characteristics are included to explore endogenous responses to the shock. SES: socio-economic status. Char.: chracteristics. Cross-sec: cross-section.

Appendix: Infant Mortality responses to the El Niño shock

Another potential issue that could contaminate the estimates of the effect of early-life exposure to extreme weather on later outcomes is that I only observe children who survive and are observed years later. If extreme floods increase neonatal and infant mortality, selection to survival could bias the results. In the development literature, the evidence suggests a negative relationship between income shocks and infant mortality. Bhalotra (2010) find that recessions increase neonatal and infant mortality in rural India while booms decrease it. Similarly, Paxson and Schady (2005) argue that children born during the 1980's macroeconomic crisis in Peru are more likely to die as infants. Therefore, if exposure to extreme weather conditions in Ecuador during El Niño increased infant mortality and those who survived were stronger, then one would expect that my estimations are biased downward. However, the degree of scarring can dominate this selection effect and explains my findings of negative, long-lasting effects of exposure to early-life shocks (Deaton, 2007).

To explore this issue, I exploit the information on birth histories collected by the RHS in 2004 that target females between ages 15 and 49.[56] I restrict the sample to children older than 12 months in 2004 to avoid incomplete exposure to the infant mortality risk. Also, I drop children born before 1985 because of both recall bias and the small number of births occurring prior to 1985 in the sample. I estimate the following model:

$$d_{i,h,v,t} = \alpha + \Sigma_{t=1985}^{2003}\{\delta_t nino\_floods_v * d\_year\_t_{i,h,v,t}\} + X_{i,h,v,t}\beta + \theta_t + \eta_v + \varepsilon_{i,h,v,t}$$

where $d_{i,h,v,t}$ is a dichotomous indicator that captures if child i, born to mother m in year t and village v died by age 12 months. δ_{1997} captures the average effect of exposure to El Niño floods on the likelihood of infant mortality for children born in year 1997[57].

Table A.16 presents the estimated coefficients for the interactions between year of birth and village exposure to El Niño floods (δ_t). There is no evidence of a relationship between infant mortality and early-life exposure to the El Niño phenomenon.

[56] For this analysis I did not use the 1999 RHS because children born in the twelve months prior to the survey would not be fully exposed to the infant mortality risk.

[57] I use a classical DID specification instead of computing exposure to El Niño according to month and year of birth because, as noted by Jayachandran (2009), samples are too small to analyze impacts by month of exposure. Instead, I focus on exposure according to year and place of birth.

Table A.16: The 1997-98 El Niño floods and infant mortality responses

	Neonatal Mortality	Infant Mortality
nino_floodsX1991	-0.00081	0.00174
	(0.00145)	(0.00195)
nino_floodsX1992	-0.00094	0.00039
	(0.00124)	(0.00169)
nino_floodsX1993	0.00014	0.00211
	(0.00125)	(0.00159)
nino_floodsX1994	0.00103	0.00301
	(0.00167)	(0.00207)
nino_floodsX1995	-0.00182	-0.00023
	(0.00121)	(0.00170)
nino_floodsX1996	-0.00037	0.00165
	(0.00120)	(0.00161)
nino_floodsX1997	-0.00028	0.00100
	(0.00127)	(0.00171)
nino_floodsX1998	-0.00094	-0.00065
	(0.00133)	(0.00184)
nino_floodsX1999	-0.00170	-0.00015
	(0.00162)	(0.00185)
nino_floodsX2000	-0.00080	0.00149
	(0.00131)	(0.00190)
nino_floodsX2001	-0.00069	0.00025
	(0.00131)	(0.00165)
nino_floodsX2002	-0.00154	-0.00082
	(0.00134)	(0.00176)
nino_floodsX2003	-0.00046	0.00208
	(0.00129)	(0.00175)
Observations	14,161	14,161
Y Mean	0.0251	0.0404

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are children in the Reproductive and Health Surveys (RHS) 2004. 2004 data was used instead of 1999 because in the later children are not fully expose to infant mortality spell. Each column is a separate regression that includes as controls: child's gender, birth order, quartert of birth/year dummie; mother's age, marital status, education, if living in urban, ses index, survey year and village fixed effects. Nino floods is the number of months of floods experienced in the village of residence during the 1997-98 El Niño. Dependent variables are neonatal mortality (likelihood child died within a month of life) and infant mortality (if child died within a year of life).

B Appendix: Additional Tables and Figures

Table B.1: Summary statistics - Living Standard Measurement Study 1995

	Mean	SD	N
Household head Characteristics			
Age	45.48	15.44	5808
If male	0.82	0.39	5807
Years of schooling	6.82	4.85	5795
Married or cohabiting	0.76	0.43	5805
If Salaried worker	0.48	0.50	5082
Household size	4.64	2.35	5810
Number of member age 14 or above	2.97	1.56	5810
Monthly total income (Ecu pesos 1995)	967589.20	1725923.00	5700
If urban	0.56	0.50	5810

Note: One dollar = 3000 Ecuadorian sucres in 1995. SD: standard deviation. N: number of observations
Source: Living Standard Measurement Study (LSMS) Survey 1995.

Table B.2: Summary statistics - Reproductive and Health Survey 1994

	Mean	SD	N
Mother characteristics			
Any health insurance	0.17	0.37	3620
Age	26.97	6.45	3620
Age less than 20	0.11	0.32	3620
Age more than 45	0.00	0.05	3620
Married or cohab	0.90	0.29	3620
Number of children	3.19	2.33	3620
urban	0.46	0.50	3620
Primary education completed or less	0.59	0.49	3620
Children charaterisitcs			
Male	0.52	0.50	3620
first born	0.28	0.45	3620
if weighted at birth	0.75	0.43	3619
Preterm	0.06	0.24	3613
Low birth weight	0.18	0.38	2714
if prenatal care	0.76	0.42	3619
Number of prenatal controls	4.33	3.64	3607

Note: SD: standard deviation. N: number of observations
Source: Reproductive and Health Survey (RHS) 1994.

Table B.3: Exposure to El Niño 97-98 and timing of exposure: Multiple hypothesis testing correction

Panel A. P-values MHT correction holm-bonferoni

	Height-for-age (SD)	Anemic	PPVT (SD)
	(1)	(2)	(3)
Nino floods - 1st trimester	0.698	1.000	**0.028**
Nino floods - 2nd trimester	1.000	1.000	1.000
Nino floods - 3rd trimester	0.158	0.737	0.849
Nino floods - age 0-1	1.000	0.950	0.669

Panel B : P-values, equality of pair of coefficients

	Height-for-age (SD)		PPVT (SD)
Exp. 3rd trim = Exp. 1st trim	0.2615	1st trim=2nd trim	0.1532
Exp. 3rd trim = Exp. 2nd trim	0.3082	1st trim=3rd trim	0.1817
Exp. 3rd trim = Exp. age 0-1	0.4028	1st trim= Age 0-1	0.4238

Notes: Panel A: P-values for table 4 correcting for mulpliple hypothesis testing using Holm-Bonferroni approach

Panel A. P-values MHT correction holm-bonferoni

	Low birth weight	Low birth weight (drop preterm)
	(1)	(2)
Nino floods - 1st trimester	1.000	1.000
Nino floods - 2nd trimester	0.988	0.898
Nino floods - 3rd trimester	0.142	**0.065**

Panel B : P-values, equality of pair of coefficients

Exp. 3rd trim = Exp. 1st trim	0.242	**0.046**
Exp. 3rd trim = Exp. 2nd trim	0.286	0.2819

Notes: Panel A: P-values for table 8 correcting for mulpliple hypothesis testing using Holm-Bonferroni approach

Table B.4: Maternal characteristics and exposure to the 97-98 El Niño floods using data from RHS 1994 (before) and 1999 (after)

	Married or cohab	Age less than 20	Age more than 45	Health insurance.	Number of children
	(1)	(2)	(3)	(4)	(5)
Nino floods - in utero	0.004	-0.003	0.001	-0.002	-0.022
	(0.003)	(0.003)	(0.000)	(0.003)	(0.020)
Nino floods - age 0-1	-0.006**	0.004	-0.000	0.001	0.007
	(0.003)	(0.003)	(0.001)	(0.003)	(0.019)
F-test floods=0 (p-val)	0.04	(0.271)	(0.181)	(0.620)	(0.516)
Observations	7,129	7,129	7,129	7,129	7,129
	No education	Primary school	High school	College	Low SES
	(6)	(7)	(8)	(9)	(10)
Nino floods - in utero	0.001	-0.002	0.004	-0.003	-0.000
	(0.002)	(0.004)	(0.005)	(0.003)	(0.004)
Nino floods - age 0-1	0.001	0.002	-0.004	0.001	-0.002
	(0.002)	(0.005)	(0.004)	(0.003)	(0.005)
F-test floods=0 (p-val)	(0.916)	(0.769)	(0.546)	(0.652)	(0.860)
Observations	7,129	7,129	7,129	7,129	7,108

note: *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses clustered at the village level. The units of observation are children age 0-2 in the Reproductive and Health Surveys (RHS) 1994 and 1999. Each column is a separate regression that includes quarter/year of birth, month of birth and village fixed effects. Nino floods - in utero is the number of months of floods experienced in utero. Nino floods - age 0-1 is the number of months of floods experienced in the first year of life. Cohab: Cohabiting. Health insurance: if mother had any form of health insurance.

Table B.5: Is there any evidence of household sorting after the 97-98 El Niño?

	Household head (HH) age	HH male	HH married	Household size	HH less than high school	Urban	Low SES
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Nino floodsX1998	0.090	-0.002	-0.001	0.002	0.001	-0.002	-0.000
	(0.071)	(0.002)	(0.002)	(0.010)	(0.003)	(0.005)	(0.003)
Nino floodsX1999	0.118	-0.005**	-0.002	0.011	0.004	-0.004	-0.003
	(0.095)	(0.002)	(0.002)	(0.011)	(0.004)	(0.007)	(0.003)
Observations	17,425	17,424	17,421	17,427	17,422	17,427	17,410

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Robust standard errors in parentheses clustered at the village level. The units of observation are families in the Living Standard Measurement Studies (LSMS) surveys 1995, 1998 and 1999.. Each column is a separate regression that includes village and year fixed effect. Nino floods is the number of months of Nino floods according to the village of residence. Estimates correspond to interaction of shock measure with year dummies with 1995 (before Niño) as the beseline year.

Table B.6: Pre-Niño 1997-98 shock trends in household income

	(1)	(2)	(3)
	ln hh labor income	ln hh non labor income	ln hh total income
Nino_shockX1995	-0.003	0.011	-0.008
	(0.008)	(0.026)	(0.010)
Observations	9,493	3,845	9,933

Notes: * p<0.10 ,** p<0.05, *** p<0.01. Sample includes households in the LSMS 1994 and 1995 surveys. Nino_shock is the number of months of floods during el niño. Dependent variables are the following montly household income: ln hh labor income: log of labor income, ln hh non labor income: log of non-labor income, and ln hh total income: log of total income. Robust standard errors in parentheses clustered at the village level. Regression include village and survey year fixed effects.

Table B.7: Maternal labor responses to the shock

	Mother working
	coef/se
flood_shockX1998	0.005**
	(0.002)
flood_shockX1999	0.007*
	(0.003)
Number of observations	11,706

note: *** p<0.01, ** p<0.05, * p<0.1

Table B.8: Effects of exposure to the 97-98 El Niño floods on breastfeeding by access to sanitation

	Exclusive BF (months)	
	Inadecuate sanitation	inproved sanitation
Nino_floodsX1998	-0.124**	-0.045
	(0.052)	(0.034)
Nino_floodsX1999	-0.033	0.038
	(0.065)	(0.037)
Observations	1,907	2,060

note: *** p<0.01, ** p<0.05, * p<0.1

Robust standard errors in parentheses clustered at the village level. The units of observation are children age 0-2 in the Living Standard Measurement Studies (LSMS) surveys 1995, 1998, and 1999. See covariates included as in table 12. According to the World Health Organization, adequate sanitation facilities are those which separate human excreta from human contact. Thus following their definition, for this exercise, improved sanitation facilities are those dwellings with flush to piped sewer systems or flush to septic tank, while inadequate sanitation are those with pit latrine without slab/open pit, or no facilities.

Figure B.1: Is the effect on child outcomes linear on months exposed to floods?

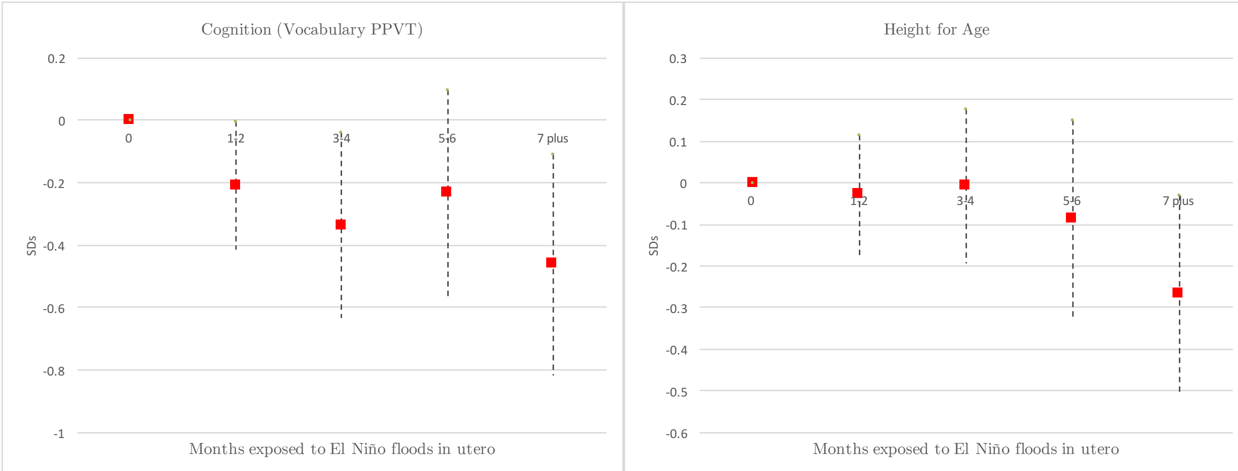


Figure B.2: Is the effect on birth weight linear on months exposed to floods?

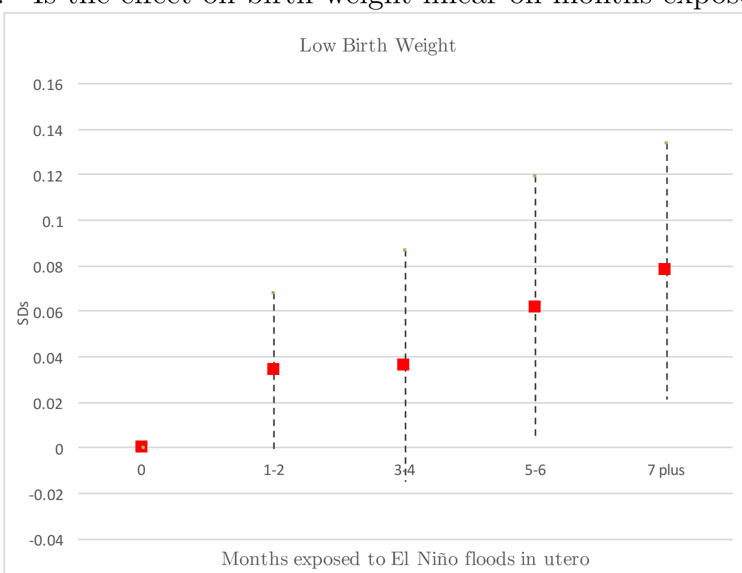


Figure B.3: Is the effect on HH income linear on months exposed to floods?