Early-Life Shocks and Childhood Social Programs: Evidence of Catch-Up in Brazil

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Abstract

Early-life shocks often produce negative long-run consequences lasting into adulthood, but little is known about how childhood social programs interact with early-life environments. In this paper, we analyze the effect of adverse early-life conditions on child health and evaluate whether access to a conditional cash transfer program is differentially effective among children who experienced adverse early-life events. We use variation in delays in enrollment from the rollout of Brazil's *Bolsa Família* program to analyze the impact of longer duration of benefit receipt alongside variation of in utero rainfall to determine the potential for the program to drive catch-up growth. We find that the duration of Bolsa treatment impacts stunting, obesity, and other health outcomes, with the program being most effective among children whose in utero conditions predisposed them to worse health outcomes. Finally, we find that these effects are driven by children who receive Bolsa before age five. Keywords: early-life; conditional cash transfer programs; human capital; *Bolsa Família*; Brazil; safety nets. JEL codes: I15, J13, O12.

1 Introduction

A growing literature finds that temporary early-life shocks produce negative life-long consequences spanning health, education, and employment (Almond and Currie, 2011; Currie and Vogl, 2013; Almond et al., 2018). With these long-run effects increasingly established in the literature, new research is beginning to investigate whether policy interventions can mitigate these negative effects and, after the shocks occur, allow children to catch-up (Singh et al., 2013; Aguilar and Vicarelli, 2018; Duque et al., 2019; Adhvaryu et al., 2019). In this paper, we ask three main questions. First, do in utero shocks impact health during childhood? Second, how does subsequent access to a conditional cash transfer program interact with early childhood conditions? We investigate whether the intervention mitigates the impact of in utero shocks by helping the most vulnerable children recover or whether it is more effective among relatively less poor children. Third, does the duration and timing of the intervention matter? For many health outcomes, catch-up may only be possible if interventions occur very early in life and persist for a sufficient period of time. To answer these questions, we utilize exogenous variation of in utero rainfall exposure as a measure of early-life shocks and evaluate the impact of Brazil's *Bolsa Família* (Bolsa) program by comparing beneficiaries who registered for the program at the same time but who began receiving benefits at different times. Importantly, we investigate the interaction of these two forces to evaluate the potential of the Bolsa program to enable children who are disadvantaged by adverse in utero conditions to catch up to their peers in terms of health. It is important to investigate whether early-life social programs are more beneficial for children exposed to adverse early-life conditions – thus enabling catch-up from early-life shocks that may be infeasible later in life – or if interventions exacerbate preexisting differences in human capital by being less effective among the more disadvantaged.

We first analyze how early-life endowments impact childhood health outcomes. There is overwhelming evidence that early-life conditions can have persistent effects into adolescence and adulthood (Almond and Currie, 2011; Almond et al., 2018; Glewwe and King, 2001; Akresh et al., 2012; Thai and Falaris, 2014; Leight et al., 2015; Shah and Steinberg, 2017; Aguilar and Vicarelli, 2018; Rosales-Rueda, 2018; Adhvaryu et al., 2019). In this paper, we investigate this topic in Brazil using exposure to exogenous rainfall variation based on historical municipal rainfall data. We focus on conditions in utero, a critical period that can negatively impact individuals into adulthood (Almond, 2006; Nelson, 2010; Akresh et al., 2012; Maccini and Yang, 2009). Our findings are consistent with evidence that short periods of adverse rainfall conditions in critical periods can have long-run impacts (Thai and Falaris, 2014; Leight et al., 2015; Shah and Steinberg, 2017; Aguilar and Vicarelli, 2018; Rosales-Rueda, 2018; Adhvaryu et al., 2019), including evidence from Brazil that rainfall is linked to birth outcomes (Rocha and Soares, 2015) and adult welfare (Fitz and League, 2020). We examine child health outcomes across a range of anthropometric measures, finding that birth-year rainfall one standard deviation lower than normal increases the probability that children are stunted by 1.3 to 5.4 percentage points and lowers adolescent weight across several measures. Given that the overall rate of stunting in our sample is 16%, this is a large effect. This finding supports the existing literature, which finds that in utero rainfall can significantly impact childhood health outcomes, and we leverage this result to investigate the potential of Bolsa to ameliorate these negative effects.

Second, we evaluate whether or not conditional cash transfers enable children to catch-up from negative early-life shocks or, alternatively, whether transfers are more effective among children who experienced better early-life endowments.[1] The potential for catch-up is important for possible equity-efficiency tradeoffs, which might arise if the largest effects occur among the least disadvantaged children. If, instead, the largest gains occur among more disadvantaged children, then a program may be able to promote both equity and efficiency by targeting the least well-off. Given that these benefits might help children recover from shocks with otherwise life-long consequences, the gains might be particularly large. This is an under-explored topic because evaluating the impacts of early-life shocks and childhood policy interventions is challenging and addressing both questions requires exogenous variation for both the shocks and policy interventions (Almond and Mazumder, 2013; Adhvaryu et al., 2019). To answer this question, we use data collected to evaluate Brazil's Bolsa program by exploiting geographic and temporal variation in municipally-determined registration processes and federally-determined budgets. Based on the program's design, implementation, and growth, very similar households can register to be eligible for the program at the same time but face very different delays before beginning to recieve transfers due to the municipality they live in and the federal budget when they register. Our main identification strategy evaluates the impact of the duration of treatment on child health by estimating the effects conditional on when a household registered in a list that makes them eligible to receive Bolsa transfers. This duration analysis compares Bolsa beneficiaries with each other and relies on the assumption that, conditional on the timing of registration and a range of individual, household,

[1] The term catch-up is often used in distinct ways in the health and economics literature. The nutritional literature often interprets catch-up growth as above-average growth rates "following a transient period of growth inhibition" (Boersma and Wit, 1997). However, these studies face challenges in identifying exogenous variation in initial growth inhibition and later causes of catch-up growth. In this paper, we use exogenous rainfall variation to show that negative early life conditions worsen several childhood health outcomes on average and then evaluate the effects of Bolsa. While we don't focus solely on children who are stunted, underweight, or otherwise in poor health, our approach provides exogenous variation in early-life conditions and is consistent with other economic research (Adhvaryu et al., 2019).

and municipal controls, beneficiaries can be reliably compared across different durations of treatment. In the context of potential catch-up from early-life shocks, the duration of treatment is particularly important to explore since short-run shocks with long-run consequences may not be overcome with quick treatments. By providing cash transfers, CCTs can positively impact child health and anthropometric outcomes (Gertler, 2004; Behrman and Hoddinott, 2005; Attanasio et al., 2005). By requiring certain health conditionalities, including prenatal care, regular vaccinations for children 6 and under, and regular health checkups, CCTs may impact health through direct treatments, greater knowledge, or reminders to pursue healthier behaviors. As discussed more below, an effective CCT program is likely to increase child height (Gertler, 2004; Behrman and Hoddinott, 2005) but weight may increase (Fernald et al., 2008a), not be impacted (see Hoddinott and Bassett, 2008), or decrease (Fernald et al., 2008b) depending on the context.

To preview our findings, we uncover evidence of general effects among all children as well as evidence of catch-up based on larger effects among children born in worse in utero conditions. Furthermore, we find that these gains accrue quickly, with catch-up occurring after only one year of transfers. Focusing on height, Bolsa reduces stunting among children born with lower in utero rainfall, bringing the likelihood of stunting in line with children born in normal or more advantageous conditions. This provides evidence of catch-up in height. Among all children, Bolsa reduces severe stunting after about a year of treatment. However, we find important heterogeneity with the effect of Bolsa on height is driven by children receiving Bolsa before age 5, thus highlighting the importance of early access to transfers.

In terms of weight, Bolsa generally reduces the likelihood that children are overweight and obese, which drives down average weights. However, we also observe some evidence of catch-up in weight, with children exposed to worse in utero environments showing large declines in the likelihood of being underweight. We find that, as with height, these gains accrue quickly, but in contrast we find that catch-up in weight can occur among those receiving Bolsa after age five.

Taken as a whole, these results indicate that Bolsa not only leads to positive impacts for children, but that it can allow those exposed to adverse early-life conditions to catch up to others in health capital. The duration and timing of treatment matter, with many effects arising after a year of treatment and catch-up in height occurring for children receiving transfers before age 5 but not after.

In addition to the papers cited above, our results are closely related to two main literatures. The first literature to which our study contributes discusses the efficiency of early-life interventions and the potential for disadvantaged children to catch up to their peers. The economics literature argues that early critical periods exist in which closely related "cognitive, linguistic, social, and emotional" development occurs in ways that affect productivity later in life (Heckman, 2006; Knudsen et al., 2006). As a result, early childhood interventions may have higher returns on investment than those at other ages (Cunha et al., 2006). On the other hand, there is a question as to the relative returns to interventions for children with higher or lower initial endowments of human capital. In particular, if interventions are complementary to children's existing human capital endowments, then investment in all children will exacerbate pre-existing inequalities. Alternatively, interventions may cause relatively disadvantaged children to catch up to their peers if the returns to investment are higher for these children. There is a large medical literature investigating the potential for catch up, with most recent studies finding potential for catch up growth in height (Adair, 1999; Mani, 2012; Lundeen et al., 2014; Hoddinott and Kinsey, 2001). In contrast, there is less consensus on the window during which interventions can lead to catch up growth, with some studies arguing that child growth is largely determined within the first two years of life (Bhutta et al., 2008; Dewey and Huffman, 2009; Victora et al., 2010; Dewey and Adu-Afarwuah, 2008; Dewey and Begum, 2011) while others find evidence of catch-up growth through age five or six (Crookston et al., 2010; Singh et al., 2013; Outes and Porter, 2013). Focusing on child health outcomes resulting from early-life exposure to air pollution, Rosales-Rueda and Triyana (2019) find that children exposed in utero do not catch up in terms of height but those exposed between birth and age two do. Determining the window of opportunity for interventions successfully leading to catch up growth in human capital is essential to crafting policies to target inequalities coming from early-life shocks that have lifelong consequences. If these large, lifelong benefits can be achieved, then programs can become both more efficient and more equitable. Our paper weighs in on this question by examining the differential effects of a conditional cash transfer for children exposed to beneficial or adverse in utero conditions and who benefitted from the policy intervention at different ages and for different durations.

Additionally, our paper is most closely related to three recent papers that investigate the mechanisms through which catch-up occurs and the types of programs that cause catch-up. Like them, we use exogenous variation in early-life rainfall alongside a careful evaluation of a conditional cash transfer program. Two of these studies evaluate Mexico's *Progresa/Oportunidades* program (utilizing the randomized rollout of the program) alongside earlier weather shocks, including the 1999 El Niño floods (Aguilar and Vicarelli, 2018) or a comparison of children born in municipalities with normal or abnormal rainfall years (Adhvaryu et al., 2019). Aguilar and Vicarelli (2018) find that exposure to floods negatively impacted health (including height and weight) as well as a range of cognitive development test scores, however they find no mitigation from CCT receipt. Adhvaryu et al. (2019) similarly find negative effects of birth-year rainfall shocks on later educational and employment outcomes. In contrast, however, they find that Progresa mitigates these negative effects and can fully mitigate the effects after a few years in the program. In Colombia, Duque et al. (2019) find that CCTs are most effective among young children, but that they are also most effective among children who experience more normal early-life rainfall conditions. Thus, this growing literature presents several contrasting findings that we seek to inform with evidence from Brazil and investigations into how the effects of conditional cash transfers evolve through time and across different ages. Unlike prior studies, we are able to evaluate a broader range of treatment durations. By evaluating Progresa, both Adhvaryu et al. (2019) and Aguilar and Vicarelli (2018) rely on comparisons of random short and long treatments that differ by two years. Because the program we study was rolled out more slowly, we are able to precisely compare the effect of durations of treatment from zero through six years. Furthermore, we are able to evaluate the health of children across a broader age range than previous studies, examining the effects for children from the critical ages of 0-10 years. Besides studying the potential for catch-up in a new context (that of the world's largest CCT program), our more flexible measure of treatment and broader range of beneficiaries allow us provide insights into how social programs can best drive catch-up growth. We find that gains from treatment accrue relatively quickly, with longer durations of treatment being less effective, and we find that early intervention is important, with the program being most effective when initiated before age five.

Our findings are important for social policy in several ways. First, we provide further evidence that early-life conditions can cause negative medium-run effects, here evaluated through age 10. Second, we contribute to a small but growing literature on the potential for social programs to facilitate catch-up and enable children to overcome negative early-life conditions. We find that conditional cash transfers during childhood can improve health outcomes and enable catch-up among children who experienced early-life conditions that predisposed them to worse health. Given the significance of long-run negative effects that can persist to adulthood, these benefits are potentially extremely cost effective. Because Bolsa causes larger effects among more disadvantaged children when delivered at young ages, targeting the program toward the more disadvantaged improves both equity and efficiency, with larger effects of the program among more disadvantaged children. Third, our analysis contributes to the literature by additionally evaluating how the duration of treatment influences childhood health across distinct early-life endowments. In several cases, we find that benefits become significant after only a year in the program and that early access is particularly important for enabling children's heights to recover from adverse in utero conditions.

2 Bolsa Família Background

Brazil created its national conditional cash transfer program in 2001 (named *Bolsa Escola*) and in 2003 rebranded it as *Bolsa Família* while expanding it and combining it with smaller cash transfer programs.[2] While the details of Bolsa have changed over time, the central pillars of the program are a conditional cash transfer to poor households with children (requiring regular school attendance and health check-ups for children under seven years of age) and an unconditional cash transfer to households living in extreme poverty. Importantly, the program has rapidly expanded over time, growing so that by 2007 Bolsa provided payments to over 11 million families, more than double the number of beneficiaries of Mexico's *Progresa/Oportunidades* program (Glewwe and Kassouf, 2012). In 2009 at the time of our study, Bolsa payments ranged from R$20 to R$182 per month, depending on the level of poverty and the age and number of children in the household.[3] Given that the maximum per capita monthly household income for eligible households was only R$120, these transfers represent a substantial boost to household income.

The receipt of conditional Bolsa transfers is contingent on the entire family meeting both health and educational conditionalities. For education, school-age children must attend 85% of school days (80% for 16 and 17 years after 2008). In terms of health, all children from birth through age seven must attend regular health check-ups and receive vaccinations while pregnant and breastfeeding women must attend pre and post-natal check-ups and attend health and nutritional information sessions. As with most CCT programs, payments are targeted to female heads of household. Based on this design, Bolsa may improve child health through increased consumption, more frequent doctor visits, vaccinations, improved pre-natal care, or greater maternal health knowledge.

To become eligible for Bolsa, households self-report income while registering in the *Cadastro Único* (Single

[2] In 2001, President Cardoso introduced a national conditional cash transfer for school-aged children named *Bolsa Escola* (the School Grant) and a transfer to low-income families with children under six or pregnant mothers (*Bolsa Alimentação,* or the Food Grant). After taking office in 2003, President Lula expanded funding for these and other programs while rebranding them as *Bolsa Família* in October 2003. Because beneficiaries were smoothly integrated from these predecessor programs into *Bolsa Família* and because the rules remained similar, we utilize transfers under predecessor programs in our analysis and treat these programs as a single "Bolsa" program. For simplicity, we simply refer to all programs as Bolsa, as is commonly done elsewhere (Hall, 2006; Glewwe and Kassouf, 2012).

[3] Bolsa provided payments for children under eighteen using three transfer components. First, households classified as living in extreme poverty (monthly per capita income less than R$60) receive the Basic Benefit of R$62 per month, regardless of the number of children. Households living in poverty (monthly per capita income less than R$120) are eligible for two additional benefits. The Variable Benefit provides a payment of R$20 per child age fifteen and under, for up to three children, and the Variable Youth Benefit provides a payment of R$30 per child age sixteen and seventeen, for up to two children.

Registry, or Cadastro) that oversees all government transfer programs. Because households self-select into registering in the Cadastro, the timing of Cadastro registration is crucial for understanding the unobservable selection of program beneficiaries. In particular, our identification strategy relies on comparing beneficiaries from households that register at the same time but are ultimately enrolled in the program at different times because of adminstrative bottlenecks and limited funding. These exogenous delays between Cadatro registration and Bolsa enrollment allow us to identify the effect of longer periods of time benefitting from the program by controlling for households' self-selected timing of registration.

Delays between Cadastro registration and Bolsa enrollment come from the decentralized design and rapid expansion of the Bolsa program. Bolsa has a highly decentralized structure that should improve the targeting of poor households but means that the exact implementation depends on the municipality. While Bolsa is a national program (with the national government determining budgets for Bolsa in each municipality and providing the payments directly to households through debit cards), considerable variation across municipalities in beneficiary enrollment arose from the very start of the program. Here, we highlight three features of the program that contributed to delays in program enrollment.

First, beneficiary selection varied widely across municipalities. In a study of 261 municipalities, de Janvry et al. (2005) find "considerable confusion over the municipality's role in beneficiary selection and consequently much heterogeneity in implementation across municipalities." They find this was especially true under the earlier *Bolsa Escola* program (when municipalities selected beneficiaries) and that confusion declined somewhat under *Bolsa Família* (when households were selected at the national level). Furthermore, municipalities often took time to reach all communities and coverage by municipality varied considerably. In fact, Glewwe and Kassouf (2012) note that while most municipalities implemented Bolsa in 2001, many did even begin implementation until the next year. This geographic variation in program implementation is largely unexplained by political factors (Fried, 2012), and "is – and will continue to be – a fact of life in Brazil's decentralized context" (Lindert et al., 2007).

Second, the national Ministry of Social Development (MDS) determines the total budget for each municipality based on national surveys and local poverty maps. In cases where this budget is sufficient to fund all households registered in the Cadastro in a given municipality, all eligible households are enrolled in Bolsa and receive transfers. However, de Janvry et al. (2005) find that the local budget is almost never sufficient to cover all households registered in the Cadastro.[4] In these cases, the MDS chooses households from the

[4] They write that: "In our sample more than 97 percent of the municipalities had qualified children who were rationed out of the program. For these municipalities, an estimated 49 percent of eligible household

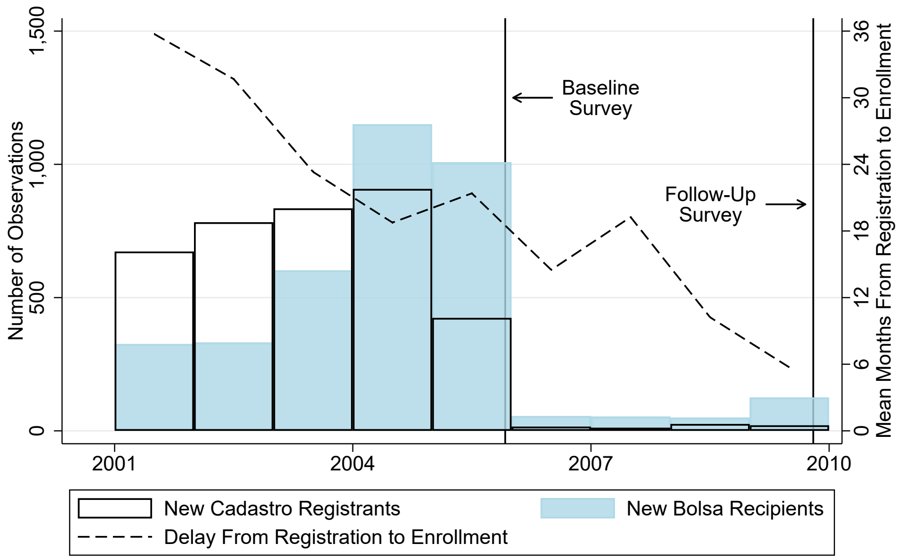
Cadastro list based on per capita incomes and the number of children under the age of 17 (de Brauw et al., 2014). As a result, we control for proxies of household wealth and family structure as explained below. Nonetheless, variation in the budget shortfalls across municipalities lead to differences in the lag time between Cadastro registration and program enrollment for observably similar households that selected into registration at the same time.

Third, the federally determined funding for Bolsa expanded considerably from 2001 through 2009. Given the budget constraints limiting the number of beneficiaries, total funding for the program is an important determinant in clearing the backlog of households registered in the Cadastro and eligible for Bolsa yet waiting to be enrolled in the program. While spending for Bolsa was initially R$1.5 billion in 2001 (Hall, 2006), funding for Bolsa quickly expanded, allowing the program to expand coverage from 3.6 million families in 2003 to over 11 million families by 2006 (Skoufias et al., 2017). This pattern is borne out in our data, as shown in Figure 1. Here, we report a histogram of the year of Cadastro registration and the first year of Bolsa receipt along with the mean delay between the two for those registered in that year. We base this on the children used in our final analysis and also note the timing of the baseline (late 2005) and follow-up survey (late 2009). Comparing the timing of Cadastro registration and the start of transfer payments, we note that Cadastro registration initially surpassed Bolsa receipt, consistent with the evidence that budgets were insufficient during Bolsa's early years. Similar to de Janvry et al. (2005), we find that under half of all registered individuals receive Bolsa from 2001-2003. As Bolsa funding surged in 2004 and 2005, the backlog began to be reduces as more individuals began receiving benefits than newly registered in the Cadastro. While continuing to add households that registered in the Cadastro more recently, benefits caught up to the backlog in Cadastro registration and the mean delay between a household registering in the Cadastro and enrolling in the Bolsa program fell from almost 3 years to less than 6 months.

As a result of this program design and implementation, we evaluate the duration of treatment as exogenous conditional on our set of individual, household, and municipality controls. Crucially, to control for self-selection into the program and isolate variation coming from exogenous delays in benefit receipt, we condition on a household's year of Cadastro registration. Because the funding levels were initially insufficient for the vast majority of municipalities, the initial receipt of transfers differs based on municipal budgets relative to eligible households as well as the municipality-specific processes for selecting transfer beneficiaries. Thus, two otherwise similar households that both register in the Cadastro might not both receive transfers – or might receive transfers at different times – due simply to their municipality and its funding relative to

were left out of the program" (p. 18).

Figure 1: Timeline of Bolsa Program and Surveys



Notes: Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The vertical lines denote the baseline AIBF survey in October 2005 and the follow-up survey in October 2009.

demand. Eventually, the total funding levels for Bolsa increased considerably and the corresponding increase in the number of total beneficiaries provides further variation in the start of Bolsa transfers in our sample. Thus, otherwise similar households can experience very different delays between registration and enrollment because of their municipal budget levels and the growth in the overall budget throughout our period of study.

Our identifications of the effect of Bolsa is similar to previous studies. First, de Brauw et al. (2014, 2015a, and 2015b) restrict their study to households enrolled in the Cadastro and use the 2005 data as a baseline to estimate household-level propensity scores measuring the likelihood of being treated. Then, they estimate single differences based on the 2009 survey using propensity score weighting to improve the comparison of treated and untreated households. This approach assumes that, conditional on registration into the Cadastro and controlling for a range of household and municipal-level observable variables, Bolsa treatment is exogenous. In de Brauw et al.'s (2014) first treatment variable, they exclude any households that received transfers through Bolsa or its predecessor programs at the time of the 2005 survey. In their second treatment indicator, they include households that received benefits in 2005. Our duration of treatment analysis can be seen as an extension of these approaches to a continuous version. We restrict our analysis to households registered in the Cadastro and assume that, conditional on our household and municipal controls, the duration of treatment is exogenous across treated households, rather than in comparison with a control group that did not receive Bolsa. In some sense, this identification can be seen as an improvement because rather than only using households registered in the Cadastro by 2005 but still not receiving treatment in 2009, we control for Cadastro registration more flexibly and can compare households who got treatment at various times despite simulteneous Cadastro registration. Although there are similar criteria across all municipalities (based on income levels and the number and ages of children), the possible variation across municipalities leads us to include municipal-level controls that may correlate with Bolsa transfers (de Brauw et al., 2015b). Second, Glewwe and Kassouf (2012) argue that the existence of Bolsa in a given school is exogenous to educational outcomes, conditional on location and year fixed effects, state time trends, and other controls based on observable child and school characteristics. They note that their "approach can be viewed as a natural experiment; Bolsa dramatically expanded in 2001, but it did not reach all municipios at the same time." Our approach effectively combines these approaches through a duration of treatment analysis.

3 Data and Descriptive Statistics

3.1 Rainfall Data

In order to assess the differential impact of Bolsa on children based on their health outcomes, we use birth-year rainfall as a proxy for early-life conditions that affect adolescent health. Rainfall data comes from the Terrestrial Air Temperature and Precipitation: 1900-2014 Gridded Monthly Time Series, Version 4.01 (Willmott and Matsuura, 2015). This dataset provides monthly average temperature and monthly total precipitation for 0.5 degree by 0.5 degree squares worldwide, centered on the 0.25 and 0.75 degree nodes. The data is created using spatial interpolation of the weather stations within the square surrounding each node, with an average of 20 stations per node. We match rainfall data to municipalities by locating each municipality's centroid within the grid of 0.5 degree nodes. The rainfall data for the four nodes surrounding the municipality are then averaged, weighting each node by its linear distance from the municipality's centroid.[5]

[5]If the municipality is located at the exact same latitude (longitude) as the nearest nodes, then a weighted average of the nodes directly to the east and west (north and south) is used. If, as is the case for a select number of municipalities, the centroid is at the same geographic coordinate as a node, then the data of that node is used exclusively. Because the weather dataset was created using weather stations, there is only data for nodes above land. This means that for many municipalities, especially those along the coast, there is not data for all four nodes surrounding the municipality. In the case that data for one or two of the surrounding nodes is missing, a weighted average of the remaining nodes is used. In the case that three of the surrounding

We then create annual rainfall measures for each month of birth by adding up the total amount of rainfall in each municipality during previous 12 months. In particular, we calculate the "rainfall deviation" as the natural logarithm of a given year's rainfall minus the natural logarithm of the average annual rainfall in the municipality in which an individual resides at the time of the survey (using all years since 1980). As a difference of natural logs, the deviation in rainfall is interpreted as the percentage deviation from the average annual rainfall in a given municipality. This variable is commonly used in rainfall studies and captures deviations from the local long-run mean (Maccini and Yang, 2009; Björkman-Nyqvist, 2013; Rocha and Soares, 2015). It is most appropriate when the relationship between rainfall deviations and the outcome of interest is monotonic. The relationship between rainfall and agricultural yields is complex, with greater rainfall potentially increasing yields in one region but not another (Galindo, 2009; Skoufias and Vinha, 2013). Given the geographic spread of our sample throughout all five macroregions of Brazil (as shown in Appendix Figure A1), we focus on this common, easily interpretable measure.

The precise functional form of the relationship between rainfall and adolescent outcomes is not the focus of this paper – we are more interested in rainfall as an exogenous shock to early-life endowments. Because of this, it is not important that we perfectly capture the relationship between early-life rainfall and adolescent outcomes but rather that we use a measure that is a good approximation of the shocks to early-life conditions that rainfall variation represents. In this spirit, we first note that rainfall deviations is the preferred method in other studies of Brazil, including Rocha and Soares (2015) and Fitz and League (2020). Furthermore, existing studies have linked positive rainfall deviations to increased agricultural output, a key indicator of economic conditions (Assunção and Feres, 2009; Mueller and Osgood, 2009; Fitz and League, 2021). We further find evidence of this monotonic relationship between rainfall and agricultural output during our sample period, as shown in Appendix A. Beyond agricultural effects, extreme rainfall events can also significantly impact urban labor outcomes, as found in Latin American cities (Desbureaux and Rodella, 2019). Furthermore, Damania et al. (2020) find that higher rainfall is significantly related to higher GDP growth among all income categories except for high income and that agriculture is the primary but not the only channel through which rainfall impacts GDP growth, with significant effects holding in areas even with little cropland. We interpret these results as evidence that our measure of higher local rainfall deviations positively impacts local wages and living standards, and that this result holds even in an upper-middle income country like Brazil and even in areas with less agriculture.

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nodes were missing, the data from the remaining node was used exclusively.

In our analysis, we focus on rainfall in the year before birth so as to capture in utero shocks.[6] Additionally, we create an indicator variable measuring whether or not an individual is born during the rainy season. To determine the rainy season in a given municipality, we calculate the block of four-consecutive months with the highest average rainfall for each state or municipality. The dry season is the eight months that are not a part of the rainy season.[7]

As shown in the summary statistics in Table 1, the average rainfall deviation in the year of birth (including the month of birth and the previous 11 months) is slightly positive. The standard deviation is 0.20, so when discussing the magnitudes of results below, we focus on a 20%, or roughly one standard deviation, increase in rainfall.

3.2 Bolsa Data

To assess the potential for interventions to undo the earlier deleterious effects of early-life shocks, we analyze Brazil's Bolsa program. We use the *Avaliação de Impacto do Programa Bolsa Família* (AIBF) data collected in 2005 and 2009 to evaluate this program. The 2005 baseline survey interviewed 15,426 households before the 2009 follow-up survey reached 11,433 of those households. The 2005 baseline survey specifically targeted households that were already receiving Bolsa transfers, households that were registered in the Cadastro (and thus selected into being eligible) but not receiving Bolsa transfers, and households that were not registered in the Cadastro (and thus ineligible). Both surveys included a range of information including household demographics, assets, labor activity, consumption, anthropometry, and Bolsa transfers. While households can be matched between the 2005 and 2009 surveys, individuals within households cannot be reliably matched (de Brauw et al., 2015b). As a result, we do not use individual fixed effects and instead rely on a series of individual and household controls, as explained more below.

[6] Our empirical analysis uses rainfall during the year of birth to capture the effects of in utero shocks. While there are various ways of measuring critical periods around one's birth, we define the birth year as the birth month and 11 months prior, as done in Rocha and Soares (2015) who find that shocks during this period significantly impact health at birth in semiarid regions of Northeast Brazil. Other approaches are used in related papers. Adhvaryu et al. (2019) define birth year as the calendar year of birth and in a robustness check as the six months before and after birth. Similarly, Aguilar and Vicarelli (2018) treat birth year as equivalent to calendar year. Shah and Steinberg (2017) do not explicitly say how they define a year, possibly using a calendar year. Another approach defines the birth year as the season an individual is born in and the following season (Maccini and Yang, 2009). We evaluate alternative rainfall measures in Appendix A and find evidence that our rainfall measure best captures early-life conditions and that our results are robust to alternative rainfall measures.

[7] The four-month rainy season is appropriate for many regions of Brazil, as found in other rainfall studies in Brazil (Rocha and Soares, 2015; Fitz and League, 2020).

Table 1: Summary Statistics

	2005 Survey Wave			2009 Survey Wave		
	Mean	St. Dev.	Obs.	Mean	St. Dev.	Obs.
Treatment Variables						
Birth Year Rainfall Deviation	0.10	0.19	2,306	0.11	0.20	1,392
Years of Bolsa Receipt	19.94	14.30	2,306	42.34	27.29	1,392
Years Registered	3.19	1.25	2,306	6.71	1.70	1,392
Outcome Variables - Height						
Height-for-Age Z-Score	-0.64	1.31	2,047	-0.22	1.35	1,130
Stunted	0.16	0.36	2,132	0.09	0.29	1,190
Moderately Stunted	0.10	0.30	2,132	0.05	0.21	1,190
Severely Stunted	0.06	0.23	2,132	0.05	0.21	1,190
Outcomes Variables - Weight						
Weight-for-Age Z-Score	-0.19	1.29	1,874	0.03	1.33	1,071
Weight-for-Height Z-Score	0.18	1.47	1,198	0.00	1.44	559
Underweight	0.04	0.20	1,905	0.04	0.19	1,102
Overweight	0.16	0.37	1,905	0.20	0.40	1,102
Obese	0.08	0.28	1,905	0.11	0.31	1,102
Individual Characteristics						
Age	5.57	3.05	2,306	6.17	2.86	1,392
Female	0.49	0.50	2,306	0.52	0.50	1,391
White	0.31	0.46	2,306	0.29	0.45	1,369
Black	0.09	0.29	2,306	0.12	0.32	1,369
Born in Rainy Season	0.33	0.47	2,306	0.34	0.47	1,392
Household Characteristics						
Head of Household is Female	0.36	0.48	2,306	0.45	0.50	1,349
Head of Household Age	39.16	12.13	2,306	39.96	11.73	1,342
Head of Household is Literate	0.84	0.37	2,306	0.84	0.36	1,349
Household Members	5.67	2.07	2,306	6.17	2.19	1,392
Household Members under Age 6	1.47	1.09	2,306	0.93	0.90	1,392
Household Members under Age 15	3.11	1.43	2,306	3.02	1.42	1,392
Household Owns Home	0.58	0.49	2,306	0.56	0.50	1,383
Rooms in Home	4.52	1.60	2,306	4.83	1.49	1,295
Piped Water in Home	0.80	0.40	2,306	0.84	0.37	1,392
Rural	0.14	0.35	2,306	0.18	0.38	1,392

Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Birth year rainfall deviation is the difference in the natural logarithm of total rainfall in the individual's municipality of birth in the 12 months prior to birth and natural logarithm of the long-run municipal average annual rainfall. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively. Age and age of household head are measured in years.

3.2.1 Outcomes

We focus on children ages 10 and under, since this captures much of the period during which children might catch up. We explore several health outcomes focused on height and weight. Anthropometric data was collected for all individuals in 2005 but only up through age 10 in 2009. Thus, for consistency we evaluate whether children age 10 and younger are stunted, underweight, and overweight as well as height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) z-scores.

These are important outcomes for evaluating the effects of both early-life conditions as well as early-childhood social programs. Height-for-age is a common measure of long-run health and nutritional investments, though the first years of life are particularly important for determining one's height. While one's weight can fluctuate in the short-run due to, for example, food consumption and disease, it is also influenced by in-utero conditions, potentially at both extremes. First, worse in utero conditions can cause low birth weights, which can cause subnormal growth (for both height and weight) in addition to negative health and cognitive outcomes (Hack et al., 1995).[8] Second, the Barker hypothesis argues that worse in utero conditions increase the probability that individuals experience cardiovascular and diabetic diseases, which can increase obesity in childhood and adulthood (Barker, 1990). As a result, we use weight-for-height and weight-for-age as measures of short-run health and nutritional investments that is more likely to change at any age, but that may still reflect persistent effects of early-life health. While several CCT studies find positive impacts on child health and anthropometric outcomes (Gertler, 2004; Behrman and Hoddinott, 2005; Attanasio et al., 2005), it has proven difficult to identify the specific mechanisms by which these programs work (Gaarder et al., 2010). There are several ways through which CCTs may impact health. First, higher incomes enable households to afford more food, better quality food, and more health services.[9] Second health conditionalities, which include prenatal care, regular vaccinations for children 6 and under, and regular health checkups, can improve health outcomes directly (such as vaccines reducing illness) or indirectly (by, for example, increasing maternal health knowledge in ways that drive healthier household choices relating to food, nutrition, and health).[10] In

[8]For example, Rosenzweig and Zhang (2013) find that birth weight corresponds positively with weight-for-height among children and young adults. Linnemayr and Alderman (2011) find that better maternal nutrition increases weight-for-age of toddlers. Ludwig et al. (2013) find that greater maternal weight gain during pregnancy corresponds to higher childhood weights and obesity.

[9]Bolsa increases food expenditures, including on meat and dairy but also on unhealthy foods like sugar and soft drinks (de Bem Lignani et al., 2011). Drawing on results from several CCTs, Leroy et al. (2009) suggest that programs with larger transfers had larger increases in growth.

[10]Consistent with these conditionalities, Bolsa increases the likelihood that children receive health check-ups, growth monitoring, and vaccinations (Shei et al., 2014). These may directly improve health outcomes, but the effectiveness depends on the quality of services provided and low-quality services may diminish the

some cases (such as height) these effects can work in the same direction, but for outcomes such as weight it is possible that they work in opposing directions. Higher incomes enable households to consume more food, which may increase weight among beneficiaries. However, CCT programs that require regular health checkups also provide more opportunities for doctors to provide feedback on overall recipient health, which might help drive beneficiaries toward healthier weights and avoid potential increases in obesity. Thus, we might predict that CCTs with health conditionalities condense the distribution of weights, producing fewer underweight or overweight individuals, while producing small or no effect in measures of average weight.[11] This ambiguity makes it essential that we study the extremes of the weight distribution rather than only the average.

To that end, we classify individuals as underweight, overweight, or obese if an individual's WAZ is more than two standard deviations below, more than one standard deviation above, or more than two standard deviations above the CDC growth standards median, respectively.[12] Similarly, we classify individuals as stunted if their HAZ is less than two standard deviations below the CDC growth standards median.[13] Consistent with guidelines from the WHO (1995) and commonly used for CDC growth standards, we define outliers to be HAZ scores below -5 and above 3, WAZ scores below -5 or above 5, and WHZ scores below -4 or above 5.

As seen in Table 1, we see some evidence of improving health from 2005 to 2009, with each z-score increasing. Approximately 16% of children were stunted in 2005 but only 9% in the 2009 survey. Obesity is much more prevalent in our sample, with only 4% of children are underweight but 16-20% being overweight. Given the prevalence of obesity in our sample, a higher WAZ may not be an unambiguous improvement in health. Thus we are careful to disentangle the effects that rainfall and Bolsa may have on different parts of the bodyweight distribution.

effect of this channel (Gaarder et al., 2010; Shei et al., 2014).

[11]Some studies find reductions in weight outcomes (Fernald et al., 2008b), others find no effect (including studies reviewed by Hoddinott and Bassett, 2008), and some find increases (Fernald et al., 2008a). Based on their review of the literature, Gaarder et al. (2010) find a reduced likelihood of being underweight in Nicaragua, but not in Mexico, Honduras, or Colombia (except for older children in rural areas), despite clear reductions in stunting in each of these studies. Fernald et al. (2008b) control for conditionalities and compare different transfer amounts in Mexico, finding that increasing the size of the cash transfer causes higher height-for-age z-scores, reduced stunting, lower BMI, and reduces likelihood of being overweight.

[12]Note that the "overweight" and "obese" categories are not exclusive. That is, an obese child is also defined as being overweight.

[13]We also define moderate stunting (between -2 and -3) and severe stunting (below -3).

3.2.2 Duration of Treatment and Registration

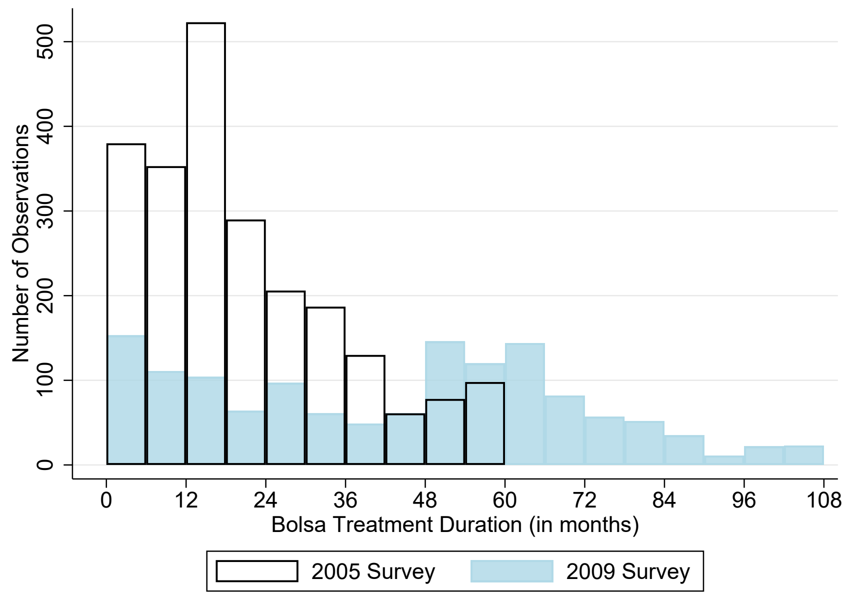
Our duration of treatment approach analyzes the impact of the duration of Bolsa treatment. Because Bolsa integrated several distinct programs and participants receive different monthly transfers based on which of these sub-programs they quality for, we use the start date for any predecessor program or Bolsa in our treatment duration variable. For example, a household that started receiving *Bolsa Escola* in February 2002 that then transitioned into *Bolsa Familia* in 2003 is considered as having started Bolsa in February 2002. Because transfers are paid to the mother of the household rather than individuals, we use the earliest date that a member of the household starts receiving a transfer to construct a household-level measure. We also adjust infeasible start dates (those before a program began) to the earliest feasible date, although our findings are robust to dropping these misreported dates. Given this household duration of treatment measure, we construct individual duration of treatment variables as either (a) the household duration for all children born before the initial receipt date or (b) the child's age (in months) for all children in treated households born after the initial receipt date. Since households must choose to enroll in the Cadastro in order to become eligible for Bolsa, it is possible that households differ based on whether and when they initially register. Thus we control for the number of years that a household has been enrolled in the Cadastro.[14] In this way, our identification comes from the delay between a household's registration in the Cadastro and eventual enrollment in the program.

Focusing on individuals within the age-range of our analysis, Figure 2 presents a histogram of the Bolsa treatment duration (in months). The duration of treatment extends from 1 (0 is excluded) to 104 months overall, including a range of 0 to 56 months in 2005 and 0 to 104 months in 2009. Individuals appearing in 2005 often receive 48 additional months of treatment by 2009 and new beneficiaries appear across a range of durations, thus providing considerable variation across the full range of durations. In addition to attrition, many children who appear in the 2005 data are older than 10 years old by 2009 and, as a result, no longer appear in our analysis.

We see that much of the variation in the timing of first Bolsa receipt comes before 2005, during the rollout of Bolsa predecessor programs and the initial increase in funding for *Bolsa Família*. Because of this, we perform a robustness check in Appendix C using only data from the 2005 survey wave, finding that our results are

[14]While we are able to measure the Bolsa treatment duration in months, the year of Cadastro registration is much more commonly reported than the month, leading us to control for the year that a household registered in years to maximize our sample size. A more complete description of the creation of the construction of our Bolsa start date, duration of program receipt, and registration duration variables is provided in Appendix B.

Figure 2: Bolsa Treatment Duration Histogram



Notes: Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The x-axis denotes the number of months at the time of the survey since the individual began receiving Bolsa transfers.

largely unchanged. In our main analysis, we keep both survey years in order to assess the effectiveness of longer durations of treatment as well as exploit the additional variation that comes from observing the same households and individuals at different treatment durations.

Given that we are comparing individuals that enroll in Bolsa at different times conditional on when their household registers for the Cadastro, it is important that there is balance in individual characteristics across those exposed to long delays between registration and enrollment and those who begin receiving benefits earlier. Table 2 shows the results of regressing the delay between Cadastro registration and the Bolsa enrollment date on individual characteristics. We see that the most important predictor for the delay the individual faces is the year in which the household registered, with those registering later facing shorter wait times. This is consistent with the decline in enrollment delay seen in Figure 1 and is explained by the fact that its expansion enabled Bolsa to clear a backlog of potential beneficiaries and absorb new ones. As described in our empirical strategy below, we include a range of municipal controls that may help explain differences in Bolsa's rollout in different regions as well as household controls that may relate to the receipt of Bolsa. Other than registration year, only three of the fourteen variables are significant. One significant predictor is the age of the child, with older children facing shorter delays. Part of this is mechanical, as

Table 2: Predictors of Delay Between Cadastro Registration and Bolsa Enrollment

	(1) Enrollment Delay	(2) Enrollment Delay	(3) Enrollment Delay
Age	-1.919***	-1.926***	-1.865***
	(0.109)	(0.109)	(0.110)
Female	-0.848	-0.838	-1.061*
	(0.556)	(0.555)	(0.549)
White	0.261	0.342	0.381
	(0.646)	(0.666)	(0.726)
Black	-0.198	-0.373	0.520
	(0.926)	(0.942)	(0.991)
Born in Rainy Season	-1.360**	-1.346**	-1.564***
	(0.585)	(0.584)	(0.572)
Head of Household is Female	0.735	0.450	-0.00800
	(0.580)	(0.591)	(0.652)
Head of Household Age	-0.0377	-0.0457	-0.0487
	(0.0276)	(0.0278)	(0.0304)
Head of Household is Literate	1.358*	0.821	0.251
	(0.803)	(0.822)	(0.919)
Household Members (#)	0.297	0.229	0.137
	(0.257)	(0.258)	(0.285)
Household Members under Age 6 (#)	0.0973	0.124	0.211
	(0.353)	(0.356)	(0.373)
Household Members under Age 15 (#)	-0.338	-0.269	-0.0186
	(0.363)	(0.364)	(0.395)
Household Owns Home	-0.295	-0.105	0.0707
	(0.590)	(0.600)	(0.639)
Rooms in Home (#)	0.349*	0.557***	0.664***
	(0.190)	(0.196)	(0.227)
Piped Water in Home	-0.179	-0.544	-0.524
	(0.719)	(0.768)	(0.865)
Registration in 2002	-5.301***	-5.482***	-6.012***
	(1.069)	(1.072)	(1.145)
Registration in 2003	-12.53***	-12.71***	-12.58***
	(1.026)	(1.031)	(1.115)
Registration in 2004	-17.73***	-18.12***	-18.33***
	(1.001)	(1.012)	(1.128)
Registration in 2005	-20.38***	-20.54***	-21.52***
	(1.211)	(1.203)	(1.346)
Registration in 2006	-39.74***	-39.77***	-39.25***
	(3.033)	(3.127)	(3.897)
Registration in 2007	-31.10***	-30.70***	-31.73***
	(3.616)	(3.815)	(4.177)
Registration in 2008	-42.06***	-42.28***	-43.48***
	(1.737)	(1.706)	(2.339)
Registration in 2009	-48.98***	-49.60***	-51.84***
	(1.934)	(1.951)	(2.199)
Municipality Controls	0	1	0
Municipality FE	0	0	1
Survey Year FE	1	1	1
Dep. Var. Mean	25.32	25.32	25.32
R^2	0.420	0.423	0.512
Observations	3526	3526	3526

Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Age and age of household head are measured in years. Registration year coefficients are relative to 2001.

those whose households registered in the Cadastro prior to their birth will necessarily have a delay before they start receiving benefits. Nonetheless, in later regressions we carefully control for age by using birth year and survey wave fixed effects (which are colinear with year-of-age fixed effects) as well as controlling for age directly allowing the effect to vary quadratically.[15] We include three proxies for household wealth and find that households with more rooms have longer delays but neither an ownership nor a piped water indicator are significant. We include these controls in our analysis to capture changes in treatment conditional on household wealth. Overall, however, Table 2 gives little indication that individuals who face longer delays between Cadastro registration and Bolsa enrollment are systematically better or worse off, lending support to our assertion that duration of treatment conditional on enrollment date is as good as random.

4 Empirical Strategy

4.1 Impact of Early-life Rainfall

Before testing the effect of Bolsa, we directly test the relevance of birth year rainfall on child outcomes. For individual i in household h in municipality m born in birth year y and appearing in survey round t, we have:

$$Z_{ihmyt} = \alpha + \beta_1 R_{my} + \gamma X_{it} + \delta X_{ht} + \eta X_m + \delta_y + \delta_t + \epsilon_{ihmyt}, \tag{1}$$

Here, we focus primarily on the impact of early-life rainfall deviations (R_{my}) on our outcomes of interest (Z_{ihmyt}). As discussed above, we parameterize early-life rainfall to be percent deviation from the long-run municipal mean. This means our assumption is that higher values correspond to higher early-life endowments, since higher rainfall deviations should boost welfare at the time.

Individual controls (X_{it}) include age and age squared, gender, and race. Household controls (X_{ht}) include household size, the number of children under 6 and under 15, and proxies for household wealth, including whether or not the house is owned, how many rooms it has, and whether or not there is piped water. Since we employ data in 2005 and 2009 collected while households receive transfers, we use relatively stable measures of household wealth that are unlikely to change endogenously following transfers.[16] Due to challenges with

[15]There are some concerns that the z-scores are largely determined by age in months rather than years, especially during the first two years of life, and that changes in z-scores among very young children may be driving our results. Our results are robust to using age-in-months fixed effects and to dropping all children under the age of 2.

[16]Even so, we may still worry that our proxies for household wealth are endogenous to treatment. All results are robust to excluding these controls.

reliably matching parents to children in the data, rather than using parental information specifically, we rely on information about the household head, including their age and indicators for their gender and literacy.

We utilize two methods to control for municipality characteristics (X_m) : municipal fixed effects or a set of municipal-level controls including life expectancy at birth, infant mortality per 1000 births, the percentage of children between 7 and 14 that attend school, and the percentage of households with piped water and telephones (all from the *Instituto de Pesquisa Econômica Aplicada* (IPEA) municipal data collected in 2000). Bolsa provides municipalities with discretion in how exactly Bolsa is implemented (especially in the case where more households are eligible than the number of households for which there is sufficient funding), and these variables control for municipal-level measures that may be correlated with child welfare and eligibility for Bolsa. Finally, we include general birth year fixed effects (δ_y) to control for aggregate shocks that impact all regions as well as season of birth fixed effects and survey round fixed effects (δ_t). Robust standard errors are clustered by municipality. Overall, our results estimate the impact of municipal-level short-run rainfall deviations on child outcomes, controlling for a range of individual-, household-, and municipal-level factors.

A primary concern is the potential existence of omitted variables that might be correlated with our rainfall measures and our childhood health outcomes. There is not likely to be omitted variable bias given that our flexible controls include municipality controls or fixed effects (thus controlling for municipality-specific, time-invariant factors) and birth year fixed effects (thus controlling for common nationwide shocks). This approach is similar to other studies evaluating the impact of early-life shocks on children.[17]

4.2 Interacting Bolsa and Early-Life Rainfall

For our main analysis, we evaluate measures of both Bolsa treatment duration and early-life rainfall, our proxy for early childhood welfare. We first highlight how the interaction of these variables allows us to investigate whether Bolsa transfers are most effective among worse-off children (who might gain the most from the additional income and conditions) or better-off children (who might have better opportunities to

[17] For example, Shah and Steinberg (2017), who use early-life rainfall shocks along with household fixed effects, age fixed effects, and year of survey fixed effects. Other studies use single surveys, including Adhvaryu et al. (2019) who use birth year-by-state fixed effects alongside a range of individual, parental, household, and locality controls (with dummies in place of missing values). Kumar et al. (2016) evaluate early-life shocks while controlling for year of birth fixed effects, quarter of birth fixed effects, location fixed effects, a trend specific to quarter of birth, and a range of child and household controls. Also, Thai and Falaris (2014) use birth year and location fixed effects alongside individual and parental controls.

take advantage of the program). To conduct this analysis, we base our analysis on the following equation:

$$Z_{ihmyt} = \alpha + \beta_1 R_{my} + \beta_2 T_{it} + \beta_3 R_{my} T_{it} + \gamma X_{it} + \delta X_{ht} + \eta X_m + \delta_y + \delta_t + \epsilon_{ihmyt} \quad (2)$$

We define Bolsa treatment (T_{it}) in the following paragraphs, but first focus on the intuition of the effects of Bolsa, rainfall, and their interaction. We are interested in whether Bolsa positively impacts each outcome of interest (β_2) and whether Bolsa is differentially impactful among children that do or do not experience early-life shocks (β_3). For example, we hypothesize that more favorable early-life rainfall conditions positively impact child health ($\beta_1 > 0$) and that Bolsa has a positive effect on outcomes ($\beta_2 > 0$), but we do not have a hypothesis as to the differential effect of Bolsa for those who did or did not experience early-life shocks. A positive interaction term ($\beta_3 > 0$) would indicate that Bolsa is more effective among those who experienced better in utero conditions compared to those that did not. This would imply that Bolsa is less effective among children born in unexpectedly poor conditions. Alternatively, a negative interaction term ($\beta_3 < 0$) would indicate that Bolsa is less effective among those who experienced better early-life conditions or, conversely, more effective among those exposed to adverse early-life shocks. This would mean that Bolsa transfers during childhood drive recovery and allow for catch-up from early-life shocks. In this case Bolsa may help children catch up partially ($\beta_1 > 0;\ \beta_3 < 0;\ \beta_1 + \beta_3 > 0$) or fully ($\beta_1 > 0;\ \beta_3 < 0;\ \beta_1 + \beta_3 = 0$).

We next focus on the duration of Bolsa treatment, which is important to consider given that health often evolves through long-run processes that respond to investments over a period of time. Height in particular is a stock that builds up throughout early childhood and, as a result, increased investments and nutrition over a period of years may be important. We define T_{it} as the number of months individual i was enrolled in Bolsa in survey round t (either 2005 or 2009). The duration of treatment can take a number of functional forms and we find a cubic function to be the most appropriate because it captures the changes and platteaus in Bolsa's dynamic effects, although our results are largely robust to using a quadratic or linear function.[18] With the duration of treatment T_{it}, our actual results are based on the equation:

$$Z_{ihmyt} = \alpha + \beta_1 R_{my} + \beta_{2a} T_{it} + \beta_{2b} T_{it}^2 + \beta_{2c} T_{it}^3 + \beta_{3a} R_{my} T_{it} + \beta_{3b} R_{my} T_{it}^2 + \beta_{3c} R_{my} T_{it}^3 + C + \epsilon_{ihmyt} \quad (3)$$

where $C \equiv \gamma X_{it} + \delta X_{ht} + \eta X_m + \delta_y + \delta_t$ includes the same controls as above.

Our duration of treatment analysis provides reliable estimates of the impact of Bolsa so long as treatment

[18] See Appendix D

duration is as good as random conditional on our controls. In particular, we are concerned about endogenous selection into and out of Bolsa. Regarding selection out of Bolsa, we find that our data contains few individuals that stopped receiving transfers and we are thus not overly concerned about endogenous exit from the program.[19] Instead, we interpret our results as effects on individuals who are not close to graduating out of the program and, as a result, remain lower-income and overwhelmingly in Bolsa beneficiary households as of 2009. To address selection into Bolsa, we control for fixed effects capturing the year a household enrolled in the Cadastro (which must be done to be eligible to receive Bolsa transfers) and thus evaluate treatment duration conditional on when a household selected into becoming eligible. Additionally, we control for the same set of individual (X_{it}), household (X_{ht}), and municipal (X_m) controls that, we believe, provide reliable randomness in our treatment duration. Our municipal controls or fixed effects help control for differences in Bolsa implementation locally and our control for Cadastro enrollment addresses individual selection into the program. Individual variation in treatment duration results further from differences in age, with younger children potentially growing up in treated households as a result of their older siblings.

Note that in light of the context of our study, using municipal level controls or municipality fixed effects identify the effect of Bolsa by exploiting different features of the rollout of the program. In particular, our specification with municipality fixed effects relies solely on variation due to uneven rollout *within* municipalities. This means that identification relies on the within-municipality Bolsa rationing rules that were discussed in Section 3. Specifically, this strategy relies on the rationing of Bolsa within municipalities to be exogenous conditional on Cadastro registration, our measures of household wealth and family structure, and all of our other controls. This rules out, for example, municipalities that must ration Bolsa giving it to eligible households that are unobservably better-off (conditional on observed characteristics). Using municipality-level controls, on the other hand, exploits the uneven rollout of Bolsa *across* municipalities. That is, we must assume that the differences in targeting schemes utilized by municipalities are as good as random, conditional on our municipal-level controls. This rules out things like unobservably better-off municipalities systematically targeting Bolsa first to unobservably better-off people while unobservably worse-off municipalities do the opposite. In this way, our two ways of controlling for municipality characteristics should be thought of as complementary: they are not just different ways of getting at the same question, but, given the institutional context, they exploit very different types of variation. We report results from both specifications, providing evidence that relies on different sources of variation.

[19]Insofar as households graduate out of Bolsa because of higher incomes and better outcomes, our estimates would understate the effect of the program. As for the differential effect by early-life conditions, this would be biased only if the rate of graduation differed by birth-year rainfall.

Table 3: Effect of Rainfall on Height

	Height-for-Age Z-Score		Stunted		Moderately Stunted		Severely Stunted	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Birth Year Rainfall Deviation	0.0821	0.150	-0.0647**	-0.0659*	-0.0227	-0.0234	-0.0419**	-0.0424*
	(0.104)	(0.123)	(0.0312)	(0.0346)	(0.0264)	(0.0282)	(0.0191)	(0.0223)
Individual Controls	1	1	1	1	1	1	1	1
Household Controls	1	1	1	1	1	1	1	1
Municipality Controls	1	0	1	0	1	0	1	0
Municipality FE	0	1	0	1	0	1	0	1
Birth and Survey Year FE	1	1	1	1	1	1	1	1
Dep. Var. Mean	-0.508	-0.508	0.136	0.136	0.0817	0.0817	0.0544	0.0544
R^2	0.106	0.198	0.0684	0.153	0.0395	0.114	0.0368	0.118
Observations	3043	3043	3183	3183	3183	3183	3183	3183

Estimates are from Equation 1. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Birth year rainfall deviation is the difference in the natural logarithm of total rainfall in the individual's municipality of birth in the 12 months prior to birth and natural logarithm of the long-run municipal average annual rainfall. Height-for-age z-score is calculated based on World Health Organization Child Growth Standards. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively. Standard errors are clustered at the municipality level. *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively.

5 Results

5.1 The Effects of Rainfall on Health

We first evaluate the impact of early-life rainfall on childhood health, with Table 3 evaluating height-based outcomes and Table 4 evaluating weight-based outcomes. For each outcome, we include individual and household controls and birth and survey year fixed effects, along with either municipality controls or fixed effects. We find that higher birth-year rainfall deviations reduce the likelihood that children are stunted and severely stunted in particular. In terms of magnitude, a one standard deviation – or 20% – increase in birth-year rainfall reduces the probability that a child is stunted by 1.3 percentage points. Conversely, this indicates that children who experience lower than average rainfall in their birth year are more likely to be stunted as children. We also find weak evidence that higher birth-year rainfall deviations increase the likelihood of being obese, and consistent but statistically-insignificant evidence that early-life rainfall increases adolecent weight. A one standard deviation increase in rainfall significantly increases the likelihood that a child is obese by 1.5 percentage points. Overall, we see that birth-year rainfall has an independent effect on adolescent health, validating our use of this variation to investigate the circumstances under which Bolsa is most effective.

Table 4: Effect of Rainfall on Weight

	Weight-for-Age Z-Score		Weight-for-Height Z-Score		Underweight		Overweight		Obese	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Birth Year Rainfall Deviation	0.117	0.243	0.0790	0.147	0.00819	0.0149	0.0234	0.0604	0.0535*	0.0767**
	(0.139)	(0.155)	(0.184)	(0.209)	(0.0178)	(0.0184)	(0.0394)	(0.0428)	(0.0306)	(0.0331)
Individual Controls	1	1	1	1	1	1	1	1	1	1
Household Controls	1	1	1	1	1	1	1	1	1	1
Municipality Controls	1	0	1	0	1	0	1	0	1	0
Municipality FE	0	1	0	1	0	1	0	1	0	1
Birth and Survey Year FE	1	1	1	1	1	1	1	1	1	1
Dep. Var. Mean	-0.110	-0.110	0.139	0.139	0.0400	0.0400	0.177	0.177	0.0936	0.0936
R^2	0.0718	0.169	0.0641	0.225	0.0287	0.129	0.0425	0.143	0.0322	0.123
Observations	2813	2813	1682	1682	2873	2873	2873	2873	2873	2873

Estimates are from Equation 1. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Birth year rainfall deviation is the difference in the natural logarithm of total rainfall in the individual's municipality of birth in the 12 months prior to birth and natural logarithm of the long-run municipal average annual rainfall. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively. Standard errors are clustered at the municipality level. *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively.

It is possible that the effects of in utero rainfall diminish through time as children naturally catch-up from earlier shocks. However, there is considerable evidence that early-life shocks persist into adulthood (Maccini and Yang, 2009; Almond and Currie, 2011; Almond et al., 2018) and, in unreported results, we interact our rainfall variable with current age, finding no evidence that the effects diminish as children grow up. Given the persistent effect of in utero rainfall, we next explore whether Bolsa transfers can drive catch-up growth.

5.2 The Effects of Bolsa and Rainfall on Health

We next evaluate the impact of early-life rainfall interacted with the duration of treatment to evaluate the dynamic effects of Bolsa and their interactions with early-life endowments. Focusing on height-based outcomes, Table 5 provides further evidence that birth-year rainfall deviations are strongly related to childhood stunting and we also see several significant effects on the cubic duration of treatment function and its interaction with rainfall. We find strong and robust evidence that higher birth-year rainfall reduces the probability that a child is stunted, with a one standard deviation increase in rainfall reducing the likelihood that a child is stunted by 5.4 percentage points. Here, this effect occurs through changes in the probability of being moderately stunted, with a one-standard deviation increase in birth-year rainfall decreasing the probability of moderate stunting by 3.9 percentage points. Furthermore, the cubic duration of treatment function is significant for multiple outcomes when interacted with birth-year rainfall deviations, which we interpret graphically below. F-tests confirm the joint significance of the interactions' effect on stunting, in particular moderate stunting.

Table 5: Effect of Bolsa and Rainfall on Height

	Height-for-Age Z-Score		Stunted		Moderately Stunted		Severely Stunted	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bolsa Duration of Treatment	-0.013	-0.007	-0.002	-0.003	0.000	-0.001	-0.002	-0.001
	(0.009)	(0.010)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Bolsa Duration of Treatment^2	0.00035	0.00026	0.00003	0.00005	0.00000	0.00003	0.00003	0.00002
	(0.00023)	(0.00027)	(0.00007)	(0.00008)	(0.00004)	(0.00005)	(0.00005)	(0.00006)
Bolsa Duration of Treatment^3	-2.7e-06	-2.4e-06	-1.1e-07	-1.7e-07	-2.7e-08	-1.6e-07	-8.2e-08	-9.9e-09
	(1.7e-06)	(1.9e-06)	(4.5e-07)	(5.0e-07)	(3.0e-07)	(3.7e-07)	(3.6e-07)	(3.9e-07)
Birth Year Rainfall Deviation	0.355	0.425	-0.233**	-0.269***	-0.168**	-0.196***	-0.065	-0.073
	(0.310)	(0.350)	(0.092)	(0.093)	(0.072)	(0.074)	(0.067)	(0.069)
Duration x Rainfall Deviation	-0.042	-0.040	0.019**	0.023**	0.017**	0.020***	0.003	0.003
	(0.030)	(0.035)	(0.009)	(0.009)	(0.007)	(0.007)	(0.006)	(0.007)
Duration^2 x Rainfall Deviation	0.00120	0.00104	-0.00049**	-0.00055**	-0.00041**	-0.00046**	-0.00008	-0.00009
	(0.00076)	(0.00091)	(0.00021)	(0.00022)	(0.00017)	(0.00018)	(0.00015)	(0.00017)
Duration^3 x Rainfall Deviation	-8.7e-06*	-6.6e-06	3.4e-06**	3.7e-06**	2.6e-06**	2.9e-06**	7.7e-07	8.3e-07
	(5.2e-06)	(6.9e-06)	(1.4e-06)	(1.5e-06)	(1.1e-06)	(1.2e-06)	(1.0e-06)	(1.2e-06)
Individual Controls	1	1	1	1	1	1	1	1
Household Controls	1	1	1	1	1	1	1	1
Municipality Controls	1	0	1	0	1	0	1	0
Municipality FE	0	1	0	1	0	1	0	1
Birth and Survey Year FE	1	1	1	1	1	1	1	1
Dep. Var. Mean	-0.508	-0.508	0.136	0.136	0.082	0.082	0.054	0.054
R^2	0.111	0.203	0.071	0.157	0.042	0.116	0.043	0.125
Observations	3043	3043	3183	3183	3183	3183	3183	3183
Joint Significance of Duration Variables	0.374	0.306	0.700	0.447	0.525	0.457	0.290	0.366
Joint Signficiance of Interactions	0.422	0.509	0.078	0.077	0.125	0.073	0.436	0.471

Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Birth year rainfall deviation is the difference in the natural logarithm of total rainfall in the individual's municipality of birth in the 12 months prior to birth and natural logarithm of the long-run municipal average annual rainfall. Height-for-age z-score is calculated based on World Health Organization Child Growth Standards. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively. The p-values from F-tests of the joint significance of the three Bolsa receipt duration variables and the three interactions between Bolsa duration and rainfall deviations are presented in the final two rows of the table. Standard errors are clustered at the municipality level. *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Looking at weight-based outcomes in Table 6, we again see evidence that positive early-life rainfall deviations increase the weight of children. A 20 percent increase in birth-year rainfall increases the weight-for-age z-score by 0.19 standard deviations, including a 2.3 percentage point fall in the probability of being underweight and a 4.3 percentage point increase in the probability of being overweight. As with height-based outcomes, we see that the coefficients associated with the Bolsa treatment function are statistically significant for multiple outcomes, with F-tests indicating joint significance of the three interaction coefficients for the probability of being underweight.

Since the results of a cubic function are hard to interpret from regression results, we present our results graphically. To do so, we plot the predicted outcomes against treatment duration for groups with different early-life rainfall and compare the results visually. Based on the results in Tables 5 and 6 using the specification with municipality controls rather than fixed effects, Figures 3 and 4 present each predicted outcome

Table 6: Effect of Bolsa and Rainfall on Weight

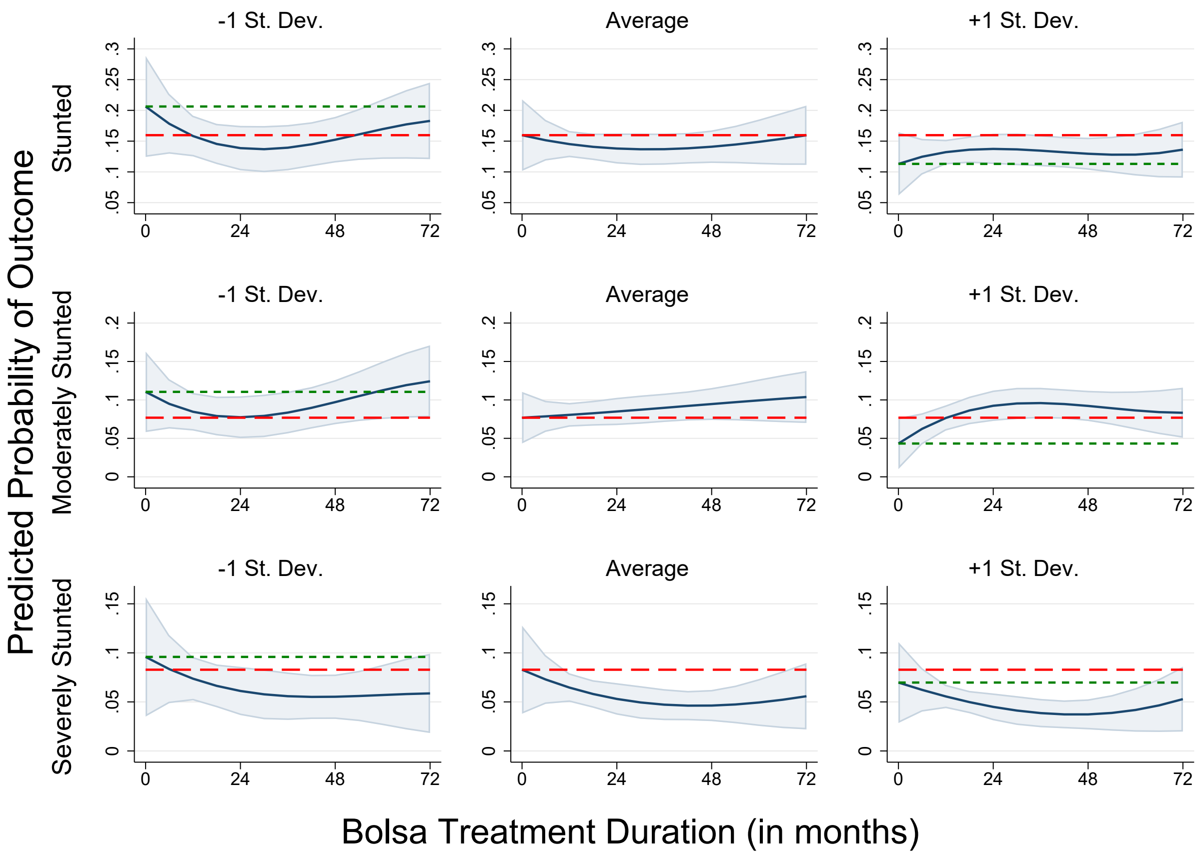
	Weight-for-Age Z-Score		Weight-for-Height Z-Score		Underweight		Overweight		Obese	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Bolsa Duration of Treatment	-0.018	-0.012	-0.004	0.003	-0.002*	-0.001	-0.006*	-0.005	-0.003	-0.003
	(0.011)	(0.013)	(0.015)	(0.017)	(0.001)	(0.002)	(0.003)	(0.004)	(0.002)	(0.003)
Bolsa Duration of Treatment^2	0.00038	0.00025	-0.00017	-0.00037	0.00008**	0.00005	0.00013	0.00012	0.00008	0.00008
	(0.00028)	(0.00032)	(0.00046)	(0.00052)	(0.00004)	(0.00004)	(0.00009)	(0.00011)	(0.00006)	(0.00007)
Bolsa Duration of Treatment^3	-2.6e-06	-1.7e-06	1.9e-06	3.8e-06	-5.5e-07**	-3.5e-07	-7.9e-07	-7.0e-07	-5.3e-07	-5.3e-07
	(2.0e-06)	(2.2e-06)	(3.9e-06)	(4.3e-06)	(2.7e-07)	(3.1e-07)	(6.6e-07)	(7.7e-07)	(4.0e-07)	(4.6e-07)
Birth Year Rainfall Deviation	0.571	0.936**	0.203	0.210	-0.101**	-0.113**	0.145	0.217*	0.116	0.143
	(0.403)	(0.444)	(0.572)	(0.614)	(0.047)	(0.053)	(0.118)	(0.126)	(0.084)	(0.088)
Duration x Rainfall Deviation	-0.053	-0.075*	-0.032	-0.002	0.014***	0.015***	-0.010	-0.013	-0.003	-0.004
	(0.038)	(0.040)	(0.071)	(0.073)	(0.005)	(0.005)	(0.011)	(0.012)	(0.008)	(0.008)
Duration^2 x Rainfall Deviation	0.00134	0.00178*	0.00133	0.00015	-0.00034***	-0.00035**	0.00025	0.00029	0.00005	0.00006
	(0.00101)	(0.00104)	(0.00220)	(0.00231)	(0.00012)	(0.00013)	(0.00030)	(0.00031)	(0.00021)	(0.00022)
Duration^3 x Rainfall Deviation	-9.1e-06	-1.2e-05	-1.3e-05	-3.6e-06	2.1e-06**	2.1e-06**	-2.2e-06	-2.3e-06	-4.9e-07	-5.6e-07
	(7.5e-06)	(7.6e-06)	(1.9e-05)	(2.0e-05)	(8.8e-07)	(9.7e-07)	(2.2e-06)	(2.3e-06)	(1.5e-06)	(1.5e-06)
Individual Controls	1	1	1	1	1	1	1	1	1	1
Household Controls	1	1	1	1	1	1	1	1	1	1
Municipality Controls	1	0	1	0	1	0	1	0	1	0
Municipality FE	0	1	0	1	0	1	0	1	0	1
Birth and Survey Year FE	1	1	1	1	1	1	1	1	1	1
Dep. Var. Mean	-0.110	-0.110	0.139	0.139	0.040	0.040	0.177	0.177	0.094	0.094
R^2	0.079	0.175	0.071	0.233	0.034	0.135	0.049	0.149	0.037	0.127
Observations	2813	2813	1682	1682	2873	2873	2873	2873	2873	2873
Joint Significance of Duration Variables	0.273	0.630	0.194	0.309	0.244	0.594	0.288	0.512	0.527	0.668
Joint Signficiance of Interactions	0.588	0.328	0.876	0.680	0.023	0.030	0.381	0.269	0.580	0.654

Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Birth year rainfall deviation is the difference in the natural logarithm of total rainfall in the individual's municipality of birth in the 12 months prior to birth and natural logarithm of the long-run municipal average annual rainfall. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively. The p-values from F-tests of the joint significance of the three Bolsa receipt duration variables and the three interactions between Bolsa duration and rainfall deviations are presented in the final two rows of the table. Standard errors are clustered at the municipality level. *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively.

(each row) by the duration of treatment for birth-year rainfall that is average (middle column) as well as one standard below (left column) and above (right column) local historical averages. We include 95% confidence intervals by the duration of treatment. For comparison, we keep the vertical axis for each outcome consistent and draw a red dashed horizontal line at the predicted outcome for normal rainfall conditions with no treatment (the farthest left point on the middle graph) and a similar green dotted line for no treatment in that particular rainfall context. For readability, we truncate the graphs at 72 months since our data is sparse at longer treatment durations.

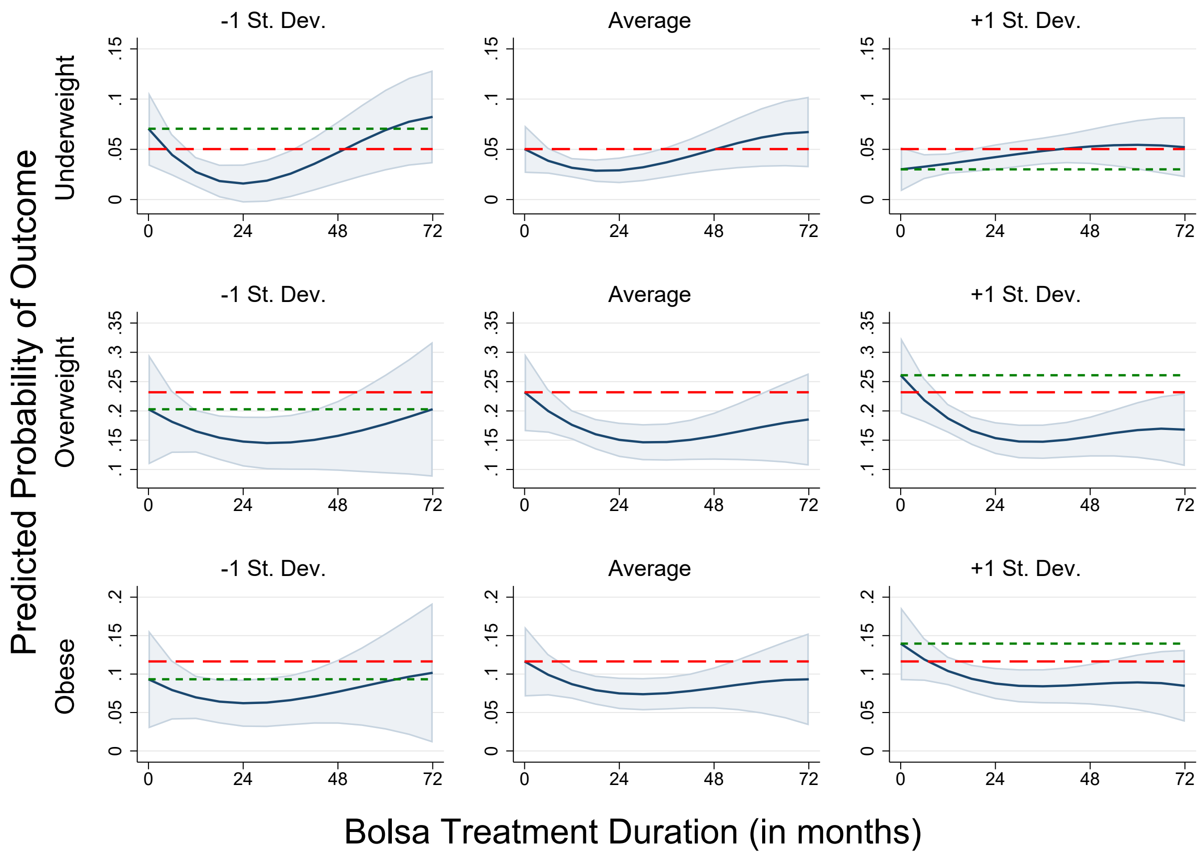
Focusing on the stunting results in Figure 3, the green dotted lines indicate that the predicted probability of being stunted at the lowest level of treatment is higher when individuals experience a negative one standard deviation birth-year rainfall shock and lower for a positive rainfall shock. In relation to the effects of Bolsa, we highlight three main results. First, among children who faced a one standard deviation negative birth-year rainfall shock (the left column) Bolsa significantly reduces the likelihood of stunting, moderate stunting, and severe stunting after only one year of treatment. The significance then lasts through 3 years in the case of moderate stunting, 4.5 years for stunting, and 6 years for severe stunting. Second, Bolsa significantly reduces

Figure 3: Effect of Bolsa Receipt Duration on Stunting by Birth-Year Rainfall Deviation



Notes: Predicted values are calculated using estimates in Table 5. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Columns denote, from left to right, in utero rainfall deviation one standard deviation (20%) below average, average rainfall, and one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Stunted, Moderately Stunted, and Severely Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively.

Figure 4: Effect of Bolsa Receipt Duration on Weight by Birth-Year Rainfall Deviation



Notes: Predicted values are calculated using estimates in Table 6. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Columns denote, from left to right, in utero rainfall deviation one standard deviation (20%) below average, average rainfall, and one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively.

the likelihood of severe stunting among all children, again with the effect becoming significant after about one year of treatment in each case and lasting through almost the entire 6 year duration. Thus, we find evidence that after one year of treatment, Bolsa reduces the worst kind of stunting among all children and all types of stunting among children who faced worse early-life conditions. Third, among children who faced higher early-life rainfall, we find no fall in the likelihood of stunting, resulting from the decrease in severe stunting and corresponding increase in moderate stunting. A similar result appears to hold among children who faced normal early-life conditions, although the increase in moderate stunting is not significant and we observe an almost significant fall in the reduction of being stunted from about 1-3 years. Taken together, these results indicate that Bolsa is effective quickly and that Bolsa is most effective among those who would otherwise be stunted. While some evidence of Bolsa's effect appears to disappear with longer treatment durations in Figure 3, in the next section we find that Bolsa's effect stabilizes at meaningful magnitudes among young recipients that receive transfers at critical growth periods. Furthermore, we cannot statistically rule out a monotonic effect of longer Bolsa duration on any of our stunting measures.[20]

Figure 4 evaluates the likelihood that an individual is underweight, overweight, or obese. Focusing on the duration of Bolsa treatment, we again highlight three key findings. First, among children who faced low early-life rainfall conditions, Bolsa significantly condenses the distribution towards healthier weights, with significant improvements ranging from half a year to about 4 years. Specifically, the likelihood of being underweight is reduced for durations of half a year to almost 4 years, the likelihood of being overweight decreases from 1-3 years of treatment, and the likelihood of being obese is not quite significant around 1-2 years of treatment. Overall, we interpret this as showing that Bolsa moves children to healthier weights, although the results are not significant beyond 4 years of treatment. Second, we see the likelihoods of being underweight, overweight, or obese fall for children with normal early-life conditions as well, though the durations are significant for half a year through five years and the fall in obesity is larger and more significant. Third, among children who faced higher rainfall early in life, we observe a strong fall in the likelihood of being overweight or obese (with both significant after half a year and lasting through the end of the graph) combined with a small increase in the likelihood of being underweight. Generally, we see evidence that Bolsa decreases the likelihood of being overweight or obese starting after a year of treatment and that it decreases the likelihood of being underweight from about 1-3 years of treatment. Because children exposed

[20]For children exposed to a given level of rainfall, for none of these outcomes is it the case that the estimated marginal treatment effect of an additional month of Bolsa receipt is positive at one treatment duration and negative at another. For the outcomes considered in Figure 4, we can rule out monotonic effects only for the effect of Bolsa on the probability of being underweight for children exposed to average or below average rainfall.

to higher rainfall conditions were predisposed to be heavier, both the more dramatic effect of Bolsa on the probability of being overweight or obese for those exposed to high rainfall early in life as well as the more negative effect of Bolsa on the probability of being underweight for those exposed to low rainfall are results indicating that Bolsa serves to undo the negative effects of in utero conditions. Here we again find Bolsa is most effective among those predisposed to poor outcomes.

In Appendix E, we analyze the effect of Bolsa on the mean values of anthropometric z-scores rather than the mass in the tails of the height and weight distributions as above. Consistent with Bolsa's reduction in obesity, we find that longer durations of treatment tend to reduce the mean weight-for-height and weight-for-age Z-scores. However, we do not find clear evidence of differential effects of Bolsa by early-life conditions on these outcomes.

Overall, we see that following negative birth-year shocks, even relatively short periods of Bolsa transfer receipt can reduce the likelihood that children are stunted and over- or underweight, but the results are less clear at longer treatment durations. In terms of catch-up, we observe evidence that Bolsa is more effective among those exposed to early-life conditions that predispose them to worse health outcomes. For those exposed to low levels of in utero rainfall, Bolsa is found to significantly reduce the likelihood of stunting (severe stunting in particular) after about one year of treatment and the likelihood of being underweight (after about half a year through 4 years). For those exposed to normal or positive birth year conditions, Bolsa also reduces the likelihood of severe stunting as well as being overweight or obese. After a relatively short period of transfers, Bolsa serves to undo the negative effects of adverse in utero conditions and leads to catch up in child health.

5.3 Heterogeneity

5.3.1 By Age That Children Start Bolsa

Having shown that both the duration of Bolsa benefit receipt and children's in utero environments matter for adolescent outcomes, we now turn to the issue of how early in life interventions must occur in order for catch up from adverse in utero conditions to be possible. Since height is largely determined early in life (Bhutta et al., 2008; Dewey and Huffman, 2009; Victora et al., 2010; Dewey and Adu-Afarwuah, 2008; Dewey and Begum, 2011) with several studies finding possible catch-up growth through age five (Crookston et al., 2010; Outes and Porter, 2013; Singh et al., 2013), we break our sample into those who receive Bolsa beginning before or after their fifth birthday, limiting the sample to children over age 5 at the time of the survey. Using this natural break, we investigate whether and for what outcomes catch up growth can occur later or earlier in childhood. We present these results in Figure 5 and Figures F16 and F17 in Appendix F, focusing only on low and high early-life rainfall for brevity.[21]

As seen in Figure 5, Bolsa's reduction in stunting is driven primarily by children who begin receiving Bolsa before the age of five. First, we interpret the results for children who receive Bolsa by age 5, as shown in the left two columns. The likelihood of severe stunting is significantly reduced after about 1-1.5 years of transfers, with a larger reduction among children who faced a more adverse in utero environment. While the effect of Bolsa stabilizes at a likelihood of severe stunting of about 0.05, the baseline level of stunting is higher for children who experienced worse in utero environments (about 0.19) compared to those that experienced better in utero conditions (0.13). Additionally, Bolsa increases the likelihood of moderate stunting among both groups, suggesting that many of the youngest beneficiaries shift from severe stunting to moderate stunting as a result of Bolsa. Overall, there is a significant reduction in the overall likelihood of moderate or severe stunting only among children who receive Bolsa before the age of 5 and experienced worse in utero conditions. The effect is significant for durations of 2-4 years and almost significant at longer treatment durations. The significant impact on severe stunting among younger beneficiaries is consistent with evidence that children who are severely stunted early in life are less likely to experience catch-up growth (Tanner, 1981; Adair, 1999; Crookston et al., 2010). As seen in Figure F17, the effect of Bolsa on height among young children exposed to worse in utero conditions also appears as a similar increase in the height-for-age z-score from around 2-4 years of treatment.

Second, we focus on children who begin receiving Bolsa after age 5 in Figure 5. The only significant effect occurs among children who experienced better in utero conditions, with Bolsa significantly reducing the likelihood of severe stunting but increasing the likelihood of moderate stunting. This indicates that, among children who start benefits after age 5, Bolsa partially alleviates stunting (from severe to moderate) but only among children with more positive in utero conditions. However, this does not translate into large changes in the height-for-age z-scores in Figure F17, with a reduction in height-for-age among children exposed to worse in utero conditions and an almost significant reduction among those with better in utero conditions. Furthermore, note that even when statistically significant, the magnitude of the effect of Bolsa on height is much smaller for children receiving Bolsa only after age 5 than those receiving it earlier in life.[22]

[21] In Appendix F, we also discuss balance between the group of children receiving and not receiving Bolsa by age 5, finding that one group does not appear to be systematically more advantaged than the other.

[22] In unreported results, we estimate equation (3) with the interaction of a before-5 indicator with all treatment variables (including Bolsa duration, rainfall, and their interaction). A joint significance test

Together, we interpret these results as indicating that, when provided to children under 5, conditional cash transfers can drive catch-up growth while also reducing the worst kind of stunting among all children. However, among children who start receiving transfers after age 5, Bolsa does not enable catch-up and provides marginally more benefits to children with better in utero environments, although the overall effect of the program is much smaller for those receiving it later in childhood. Our finding of possible catch-up growth among children younger than 5 is consistent with several earlier studies and here we show that conditional cash transfer programs can cause this catch-up growth.

In Appendix F, we evaluate the effects of Bolsa on weight and find – consistent with the notion that weight adjusts more rapidly than height – that Bolsa can help catch-up in weight for some children after age 5.

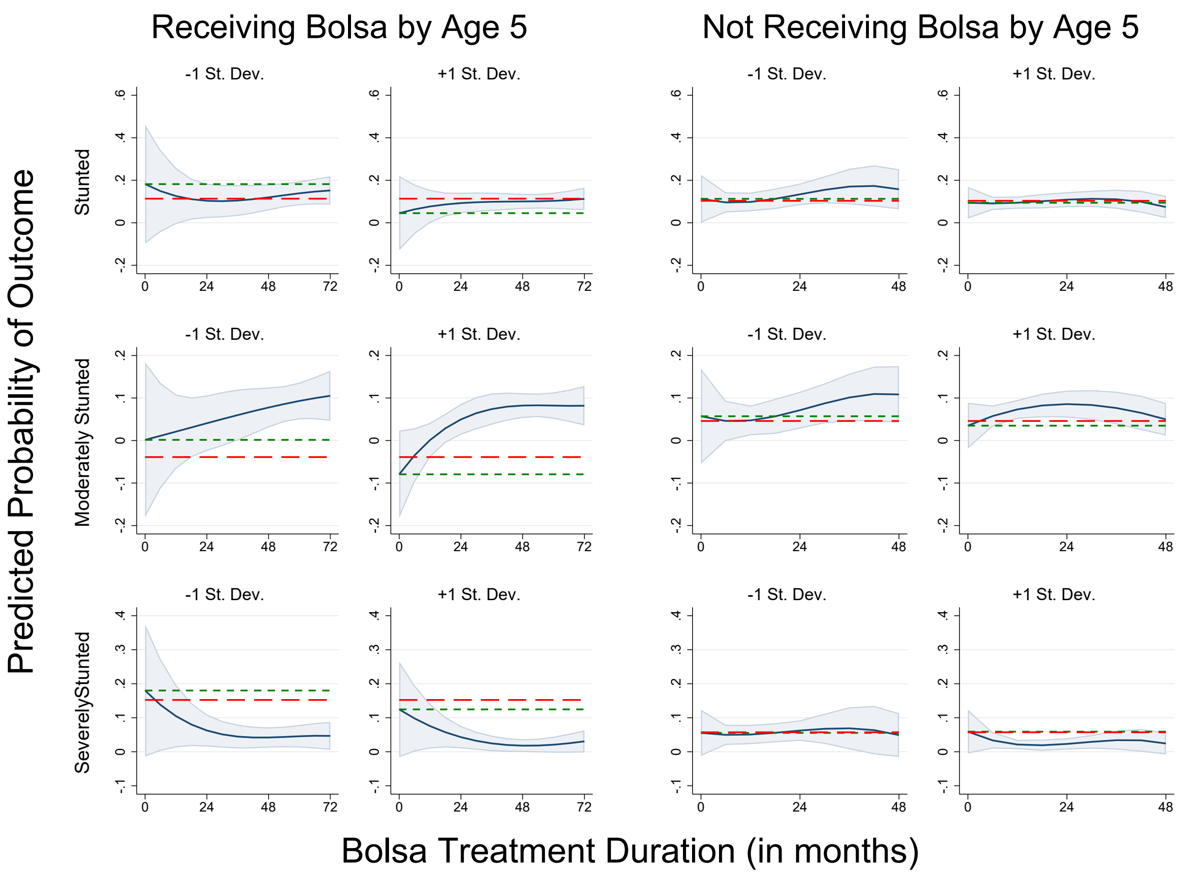
Together, these results indicate that interventions are more effective at impacting height when received earlier in life. Furthermore, earlier benefits enable some catch-up growth, with children born during worse conditions exhibiting significant gains in height, including higher average heights, a lower likelihood of stunting, and a transition from severe to moderate stunting. Among children starting to receive benefits before age 5, the effect of Bolsa appears to be larger among those who were born during less advantageous conditions, while the opposite is true of those getting Bolsa later in childhood.

5.3.2 By Gender

In Appendix G we investigate heterogeneity in the effect of Bolsa on the ability of disadvantaged children to catch up from in utero shocks by gender. This issue is important for understanding both the biological as well as social phenomena that may make the return to social programs differential for boys and girls. For example, biological differences in how sensitive children are to in utero shocks may make the returns to investments targeted to one gender more efficient. Similarly, parents may invest their own resources to protect the human capital of children exposed to adverse shocks differentially by gender, giving Bolsa differential effectiveness. We find that reductions in stunting caused by even short periods of exposure to Bolsa for girls, especially those who faced less advantageous in utero rainfall conditions. In fact these children are able to fully catch up to girls exposed to more favorable in utero conditions in terms of stunting. These results indicate that targeting Bolsa toward girls exposed to worse early-life conditions may be particularly impactful. This finding is consistent with several other studies finding greater catch-up growth in height among girls (Ruel et al., 1995; Adair, 1999; Outes and Porter, 2013).

provides evidence of significant differences between children who receive transfers before age 5 and after for the impact of Bolsa on both stunting and moderate stunting, but not other outcomes.

Figure 5: Effect of Bolsa Receipt Duration on Stunting by Birth-Year Rainfall Deviation and Age Starting Bolsa



Notes: Predicted values are calculated by estimating Equation 3 separately for children who began receiving Bolsa before age 5 (in the first two columns) and those who began receiving Bolsa after age 5 (in the last two columns). Each of these samples includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The first and third columns denote in utero rainfall deviation one standard deviation (20%) below average, while the second and fourth denote in utero rainfall one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively.

5.4 Robustness Checks

We conduct several robustness checks, focusing on alternative measures of rainfall, alternative functional forms capturing the effect of Bolsa, and reliance on the 2005 survey only. We find that our results are highly robust to these changes.

First, rainfall studies tend to use one of several measures to capture how rainfall departs from local, long-run averages. We utilize the difference in the natural logarithm of rainfall in the 12 months prior to an individual's birth minus the natural logarithm of the average annual rainfall locally, a monotonic measure that we find to best capture the impact of rainfall variation for Brazil as a whole. In Appendix A, we present evidence of a strong, robust, positive relationship between this rainfall measure and local agricultural production, with a one standard deviation increase in local rainfall corresponding to a 6.3% increase in agricultural production. We assume this increase in agricultural production corresponds to higher local wages and welfare. Thus, we believe that our rainfall deviations measure accurately captures the relationship between rainfall and welfare throughout Brazil.

Given their prevalence in the literature, we evaluate two alternative potential rainfall measures. First, we use a binary measure in which normal rainfall occurs when the rainfall deviation is within one standard deviation of the local, long-run average and a shock exists otherwise (as in Adhvaryu et al., 2019). Given the strength of our monotonic relationship between rainfall and agricultural production, we don't believe that combining negative and positive shocks is appropriate for our data, but we provide evidence that the effects of Bolsa are largely robust to this change in Appendix A. Second, we use an alternative measure that counts the total number of months in the year before birth in which rainfall was within one standard deviation of the long-run municipal mean level of rainfall for that month (similar to the approach in Duque et al., 2019). The effect of rainfall using this measure is muted, but the effects of Bolsa are again largely robust to the change in rainfall measure.

Second, we allow for alternative functional forms for the effect of Bolsa duration, including both linear and quadratic measures alongside the more flexible cubic measure in our main results. In Appendix D, we see that our results are extremely robust along this dimension, with both linear and quadratic functional form assumptions generating strikingly similar results.

Third, we replicate our results using only the 2005 survey in Appendix C. While the use of both the 2005 and 2009 surveys enables us to estimate longer treatment effects and to add more observations and individuals to our sample, the variation in our sample is more plausibly exogenous in the 2005 survey. As seen in Figure

1, the 2005 survey captures variation in treatment duration drawing on the backlog of applicants, given that the number of households registering for the Cadastro far exceeds the number of families starting Bolsa (or its predecessors) from 2001-2003, with the backlog catching up in 2004 and 2005. This variation in the start of treatment is largely explained by differences in municipality rollout and the expansion of Bolsa funding because of federal policy choices. And while our 2005 survey provides no data beyond 4.5 years of treatment, it provides a considerable number of observations at shorter durations of treatment, as shown in Figure 2. Our 2005-only results are very similar to our main results presented above.

6 Conclusion

This paper contributes to the literature on the impacts of early-life endowment shocks interacted with childhood social programs. In particular, we use exogenous early-life rainfall variation to measure endowment shocks during a critical period in child health development. Additionally, we evaluate the impact of childhood access to a conditional cash transfer program by comparing beneficiaries that enrolled at the same time across different durations of treatment.

Our main finding is that while low birth-year rainfall increases the probability that children are stunted by 1.3 to 5.4 percentage points, Bolsa is able to undo these effects and allow disadvantaged children to catch up to their peers after a relatively short period of transfers. Bolsa is more beneficial for children that faced negative in utero environments, with significant reductions in the likelihood of stunting after about one year of treatment. We find similar effects on the likelihood of being underweight, overweight, or obese, with Bolsa treatment being particularly effective at undoing the negative effects of in utero rainfall shocks. Taken as a whole, these results indicate that Bolsa not only leads to positive impacts for children, but that it is most effective among those with lower human capital endowments and so can allow those exposed to adverse early-life conditions to catch up to others. While these beneficial impacts do not appear as strong at longer durations of treatment, we do find evidence that even treatment lasting only a few years can have significant positive effects.

These findings hold many important policy implications. First, there is growing evidence that early-life shocks negatively impact individuals throughout their lives and potentially even future generations (Almond and Currie, 2011; Currie and Vogl, 2013; Almond et al., 2018). This paper provides some additional support along these lines, finding that reduced birth-year rainfall increases the probability that children are stunted. More importantly, we take the crucial next step of investigating the ways in which these long-run harms can be mitigated, potentially by targeting children at critical periods in ways that enable catch-up in health and cognitive development. This paper provides evidence that access to conditional cash transfers can reduce the likelihood that children are stunted or are an unhealthy weight. Furthermore, we find that this effect occurs across durations of treatment from 1- to 3 or more years, indicating that benefits must last for at least a year before child health improves. Finally, we find that the program is most effective among those whose in utero conditions predisposed them to negative adolescent health outcomes, indicating that the most disadvantaged children are also the most efficient to target. Given that Mexico recently ended its popular Progresa/Oportunidades program, the future of CCT programs is not guaranteed. This paper finds that conditional cash transfer programs may hold additional benefits that protect households from shocks that are beyond their control. These benefits may indicate that the cost effectiveness of CCTs is higher than previously believed.

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Appendix

The following appendices provide additional robustness checks and details on our data.

Appendix A shows that our measure of in utero rainfall captures economic conditions well and that our results are robust to alternative parameterizations.

Appendix B explains the details of the construction of our variables relating to the duration of Bolsa transfer receipt and Cadastro enrollment.

Appendix C presents robustness checks using only data from the 2005 survey wave.

Appendix D presents robustness checks using alternative functional forms for duration of Bolsa transfers receipt.

Appendix E presents results for the effect of Bolsa on mean anthropometric Z-score measures.

Appendix F examines heterogeneity in the effect of Bolsa and its interaction with in utero conditions by the age at which a child starts receiving Bolsa transfers.

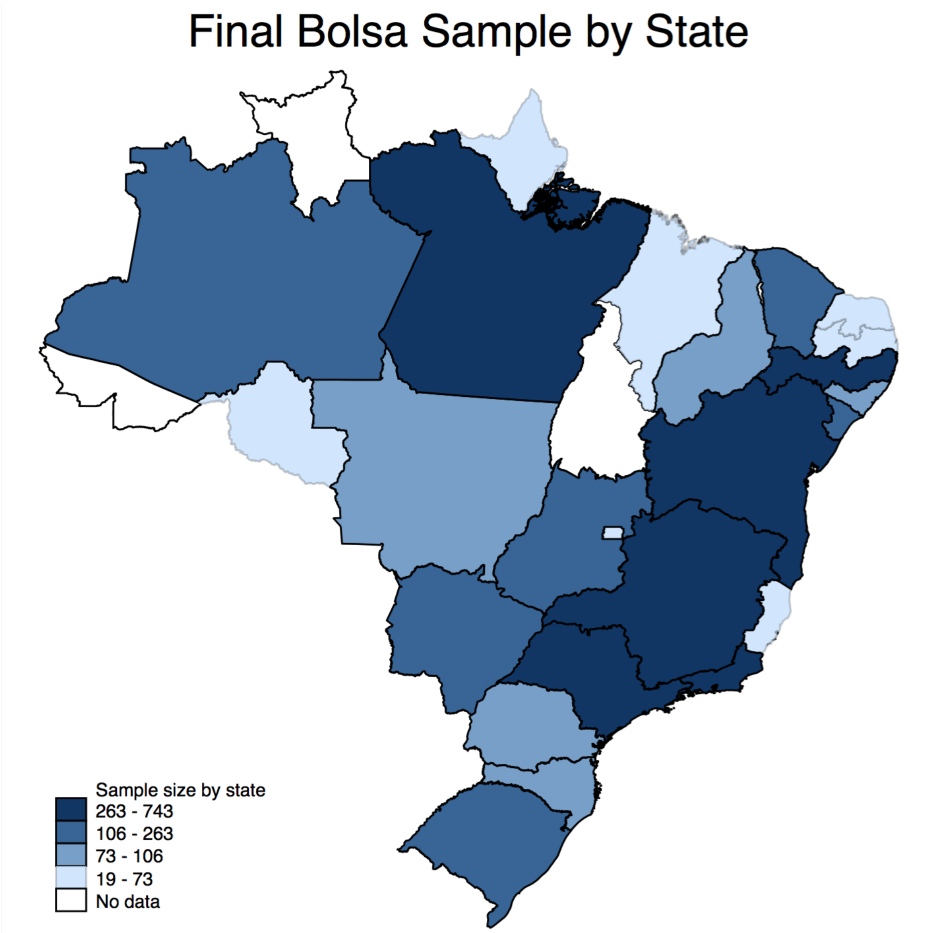
Appendix G examines heterogeneity in the effect of Bolsa and its interaction with in utero conditions by the gender of the child.

A Investigating Rainfall Measures

As discussed in Section 3.1, in this paper we are not primarily interested in the impact of rainfall on adolescent outcomes. Rather, our primary interest in rainfall comes as an exogenous source of variation that affects early life endowments that may be either complimentary to or substitutable with later investments, particularly the *Bolsa Família* program. In light of this, the fact that using our rainfall measure we find that rainfall impacts adolescent outcomes and that Bolsa interacts with rainfall in interesting ways is itself evidence that our rainfall measure is suitable for this purpose. Nonetheless, our results will be stronger if we better capture the relationship between rainfall and early-life endowments. As shown in Figure A1, our sample is drawn from throughout Brazil, comprising a number of varied climates. This means that our rainfall measure must be general enough to capture the relationship between rainfall and early-life conditions throughout Brazil. Recall that the measure we use is the difference in the natural logarithm of the total rainfall in the 12 months prior to an individual's birth and the natural logarithm of the average annual rainfall in the municipality in which an individual resides at the time of the survey (using all years since 1980). In this appendix, we validate both the monotonic relationship between rainfall and favorable early life conditions that this functional form assumes as well as the importance of the critical developmental period our rainfall measure captures.

First, we show that our rainfall measure captures changes in Brazil during our sample period. Agriculture is important for the economic conditions into which the children in our sample are born, with a more productive agricultural sector indicating favorable economic conditions. With this in mind, we compare our rainfall deviations variable with municipal-level data on total agricultural production from the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* or IBGE). As reported in Table A1, we regress the natural log of the total value of agricultural production on our rainfall deviation measure, first using all years for which we have agricultural data (columns 1-3) and then the range of years used in our study (columns 4-6). We control for year fixed effects and latitude (columns 1 and 4) before adding either state fixed effects (columns 2 and 5) or municipality fixed effects (columns 3 and 6, where latitude is dropped). We find robust evidence of a significant, positive, and economically meaningful relationship between rainfall deviations and agricultural production. Columns 4 through 6 indicate that a one standard deviation increase in local rainfall leads to a 5.0 to 6.3% increase in agricultural production. We then graph the conditional correlation between agricultural production and rainfall deviations in Figure A2. The vertical axis depicts the residuals from a regression of the natural log of agricultural production

Figure A1: Map of Sample



Notes: Shading indicates the number of observations in the sample from each state. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers.

Table A1: Effect of Rainfall Deviations on the Natural Log of Agricultural Production

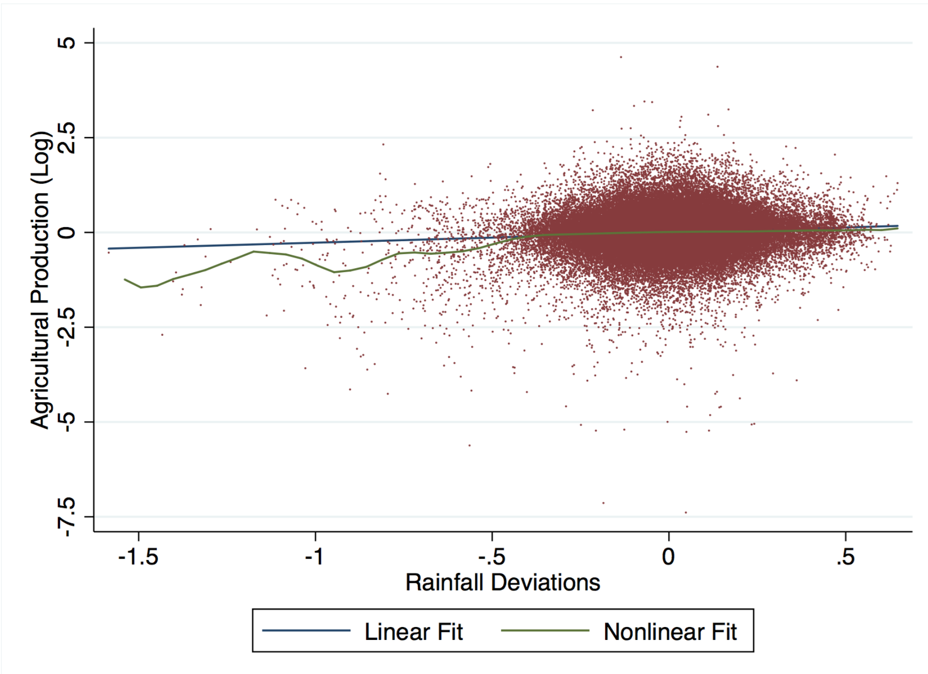
	All Available Years			Range of Years Used in Analysis		
	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall Deviation	0.335***	0.311***	0.251***	0.123**	0.209***	0.0390**
	(0.0162)	(0.0152)	(0.00810)	(0.0597)	(0.0571)	(0.0161)
Latitude	-0.0567***	-0.0183***		-0.0689***	-0.0392***	
	(0.000412)	(0.00222)		(0.00107)	(0.00564)	
Year Fixed Effects	1	1	1	1	1	1
Municipality Fixed Effects	0	0	1	0	0	1
State Fixed Effects	0	1	0	0	1	0
R^2	0.155	0.253	0.799	0.139	0.281	0.959
Observations	163686	163686	163686	25749	25749	25749

Notes: Agricultural production is the total value of agricultural production measured in constant 2000 prices (R$) by municipality and year. The top 5% of observations are trimmed as outliers. Rainfall deviation measures are the difference between the natural logarithm of a given year's rainfall a municipality and the natural logarithm of the mean rainfall in that same municipality from 1940 to 2010. The first three columns include all years for which we have agricultural production data (including 1973 through 2009) and the final three columns include only the range of years for our study (1994 through 2009). All results include all municipalities in Brazil.

on year fixed effects and municipality fixed effects, which corresponds to column 6 in Table A1, but without controlling for rainfall deviations. The horizontal axis depicts the residuals from a regression of rainfall deviations on the same set of controls. We plot the linear fit (which corresponds to the coefficient on rainfall deviations in Table A1 as well as a nonlinear fit using an Epanechnikov kernal function and local-mean smoothing, providing visual evidence that the linear estimate is a reasonable approximation of the nonlinear fit. In unreported results available upon request, we estimate Table A1 with either our rainfall deviations variable of an indicator variable equal to 1 if local rainfall is more than one standard deviation away from the local long-run mean. Rainfall deviations is significant more often, more significant, and produces a slightly higher R-squared value. Overall, we interpret these results as evidence that rainfall deviations provides the best fit for agricultural production in Brazil. We assume that higher municipal-level agricultural production results in higher local wages and household welfare.

Next, we present evidence that our results are robust to alternative measures of rainfall. In particular, we utilize two additional rainfall measures. The first of these is an indicator variable for whether or not the rainfall level in the year before a child's birth was within one standard deviation of the municipal long-run mean level of rainfall. We can then compare the outcomes and effectiveness of Bolsa for children born under

Figure A2: Conditional Correlation of Rainfall Deviations and the Natural Log of Agricultural Production



Notes: This figure is based on Column 6 from Table A1. The markers depict the residuals of regressions of the variables on the x- and y-axes on municipality and year fixed effects. Agricultural production is the total value of agricultural production measured in constant 2000 prices (R$) by municipality and year. The top 5% of observations are trimmed as outliers. Rainfall deviation measures are the difference between the natural logarithm of a given year's rainfall a municipality and the natural logarithm of the mean rainfall in that same municipality from 1940 to 2010. The linear relationship depicts the conditional relationship between rainfall deviations and the natural log of agricultural production found in Column 6 of Table A1. The nonlinear fit is based on a smoothed local polynomical using an Epanechnikov kernal function and local-mean smoothing.

Table A2: Effect of Rainfall on Height

	Height-for-Age Z-Score		Stunted		Moderately Stunted		Severely Stunted	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Normal Birth Year Rainfall	0.0263	0.0437	-0.000166	-0.00187	0.00303	0.00150	-0.00319	-0.00336
	(0.0440)	(0.0470)	(0.0119)	(0.0127)	(0.0104)	(0.0116)	(0.00791)	(0.00863)
Individual Controls	1	1	1	1	1	1	1	1
Household Controls	1	1	1	1	1	1	1	1
Municipality Controls	1	0	1	0	1	0	1	0
Municipality FE	0	1	0	1	0	1	0	1
Birth and Survey Year FE	1	1	1	1	1	1	1	1
Dep. Var. Mean	-0.508	-0.508	0.136	0.136	0.0817	0.0817	0.0544	0.0544
R^2	0.106	0.198	0.0672	0.151	0.0393	0.114	0.0356	0.117
Observations	3043	3043	3183	3183	3183	3183	3183	3183

Estimates are from Equation 1. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Normal Birth Year Rainfall is an indicator for whether the total rainfall in the twelve months before birth was more than one standard deviation away from the municipal average annual rainfall. Height-for-age z-score is calculated based on World Health Organization Child Growth Standards. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively. Standard errors are clustered at the municipality level. *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively.

"normal" early-life conditions relative to those born during a "shock" of above or below average rainfall. We present evidence in Tables A2 and A3 that this measure is less effective at capturing variation in in utero conditions that affect adolescent health outcomes. More importantly, in Figures A3–A5, we show that the effect of Bolsa, and its interaction with rainfall are largely robust to this alternative measure of early-life conditions.

Our other measure of rainfall is a continuous measure of the number of months in the year before birth that the monthly municipal level of rainfall was within one standard deviation of the long-run municipal mean level of rainfall for that month. This count of the number of months of normal rainfall is similar to that used by Duque et al. (2019). Here we again see that the direct effect of rainfall appears to be muted (Tables A4 and A5) but that the effect of Bolsa is consistent with our main results (Figures A6–A8).

Table A3: Effect of Rainfall on Weight

	Weight-for-Age Z-Score		Weight-for-Height Z-Score		Underweight		Overweight		Obese	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Normal Birth Year Rainfall	0.0280	0.0549	0.0388	0.0606	-0.00197	-0.00264	-0.00122	0.0143	0.0101	0.0186
	(0.0574)	(0.0592)	(0.0845)	(0.0878)	(0.00811)	(0.00796)	(0.0168)	(0.0178)	(0.0136)	(0.0151)
Individual Controls	1	1	1	1	1	1	1	1	1	1
Household Controls	1	1	1	1	1	1	1	1	1	1
Municipality Controls	1	0	1	0	1	0	1	0	1	0
Municipality FE	0	1	0	1	0	1	0	1	0	1
Birth and Survey Year FE	1	1	1	1	1	1	1	1	1	1
Dep. Var. Mean	-0.110	-0.110	0.139	0.139	0.0400	0.0400	0.177	0.177	0.0936	0.0936
R^2	0.0716	0.168	0.0642	0.225	0.0287	0.128	0.0424	0.142	0.0313	0.121
Observations	2813	2813	1682	1682	2873	2873	2873	2873	2873	2873

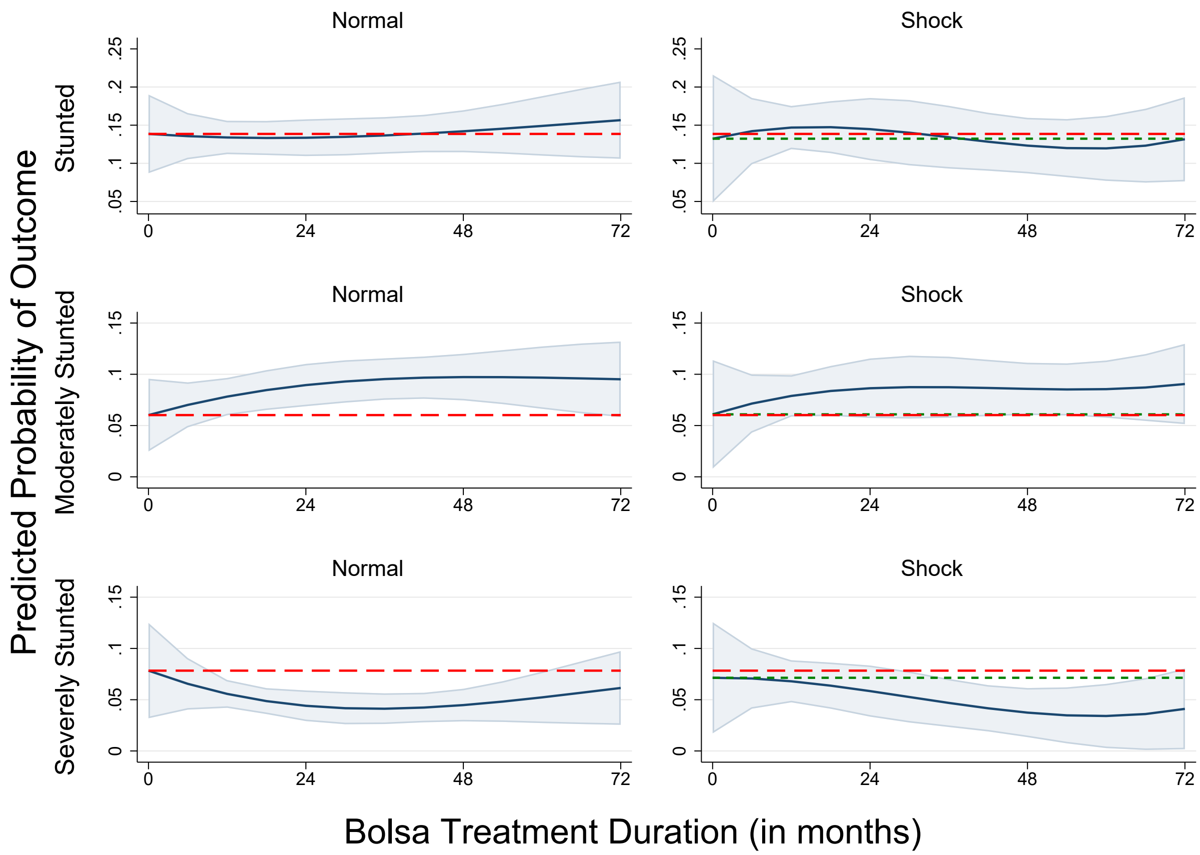
Estimates are from Equation 1. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Normal Birth Year Rainfall is an indicator for whether the total rainfall in the twelve months before birth was more than one standard deviation away from the municipal average annual rainfall. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively. Standard errors are clustered at the municipality level. *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A4: Effect of Rainfall on Height

	Height-for-Age Z-Score		Stunted		Moderately Stunted		Severely Stunted	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Months of Normal Birth Year Rainfall	-0.00946	-0.0188	0.00446	0.00673	0.00181	0.000993	0.00264	0.00573*
	(0.0177)	(0.0179)	(0.00401)	(0.00431)	(0.00327)	(0.00331)	(0.00282)	(0.00329)
Individual Controls	1	1	1	1	1	1	1	1
Household Controls	1	1	1	1	1	1	1	1
Municipality Controls	1	0	1	0	1	0	1	0
Municipality FE	0	1	0	1	0	1	0	1
Birth and Survey Year FE	1	1	1	1	1	1	1	1
Dep. Var. Mean	-0.508	-0.508	0.136	0.136	0.0817	0.0817	0.0544	0.0544
R^2	0.106	0.198	0.0675	0.152	0.0394	0.114	0.0358	0.118
Observations	3043	3043	3183	3183	3183	3183	3183	3183

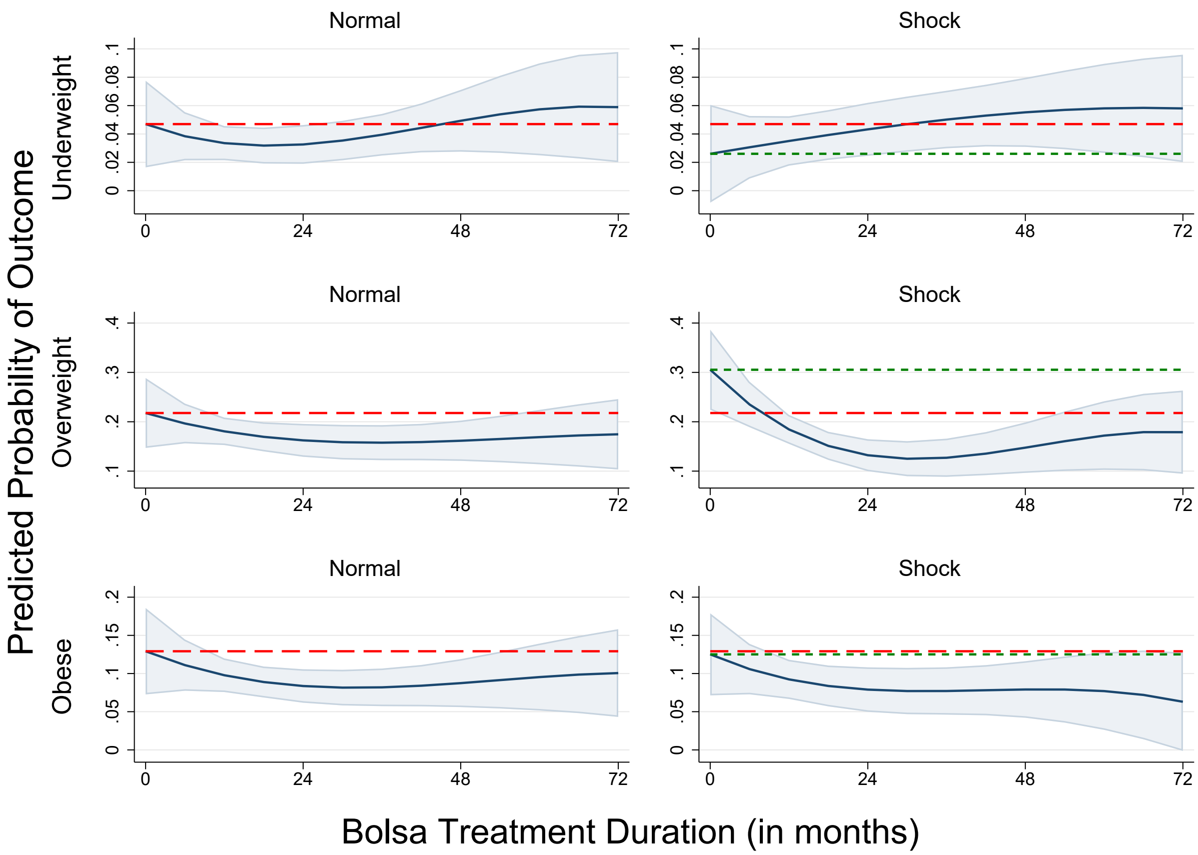
Estimates are from Equation 1. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Months of Normal Birth Year Rainfall is the count of months in the 12 months prior to birth during which the monthly level of rainfall was within one standard deviation of the municipality's average rainfall for that month. Height-for-age z-score is calculated based on World Health Organization Child Growth Standards. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively. Standard errors are clustered at the municipality level. *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Figure A3: Effect of Bolsa Receipt Duration on Stunting by Birth-Year Rainfall Status



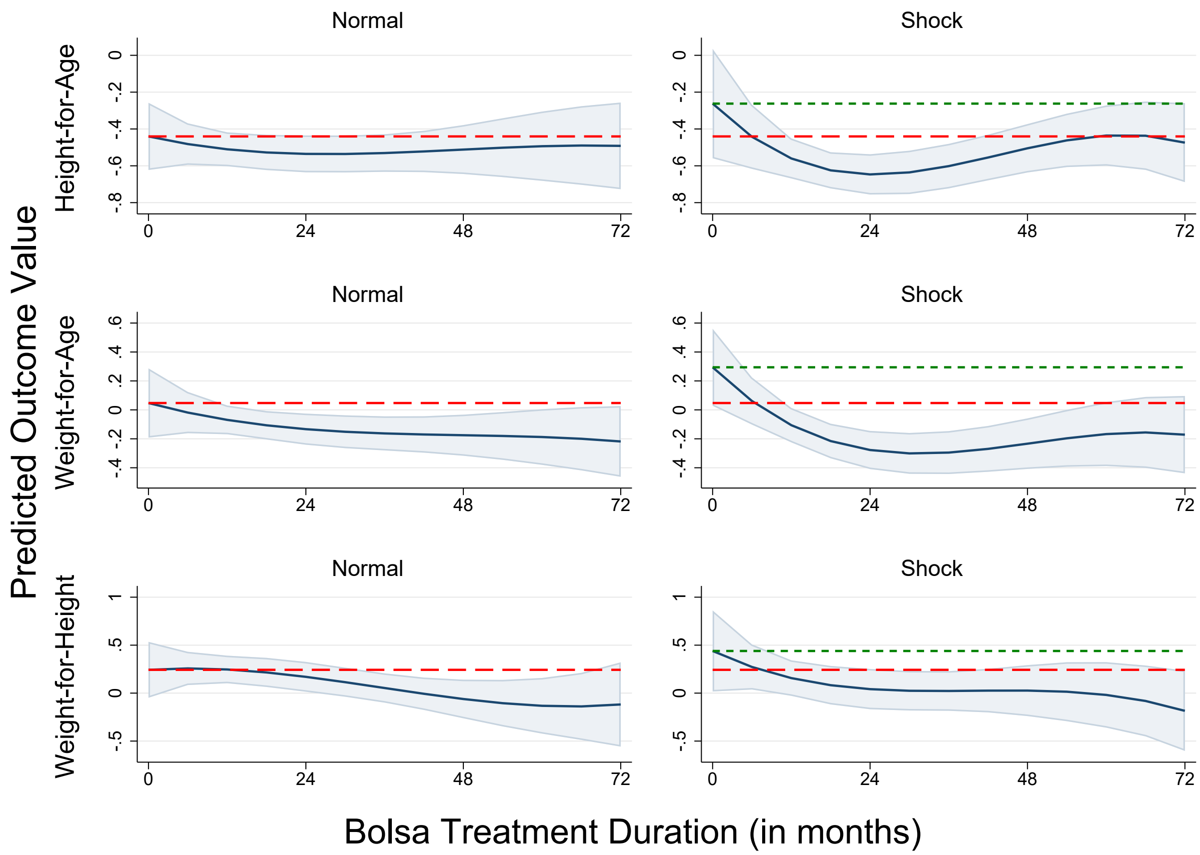
Notes: Predicted values are calculated by estimating Equation 3 using an indicator for normal birth-year rainfall as the rainfall measure. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The left column denotes rainfall in 12 months before birth within one standard deviation (20%) of the municpal average annual rainfall. The right column denotes in utero rainfall outside of this range. Red dashed lines denote the average level of the outcome for an individual exposed to normal in utero rainfall with a Bolsa treatment duration of zero months, while the green dotted line is the analogous average for those exposed to a rainfall shock in utero. Predicted values are bounded by a 95% confidence interval. Stunted, Moderately Stunted, and Severely Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively.

Figure A4: Effect of Bolsa Receipt Duration on Weight by Birth-Year Rainfall Status



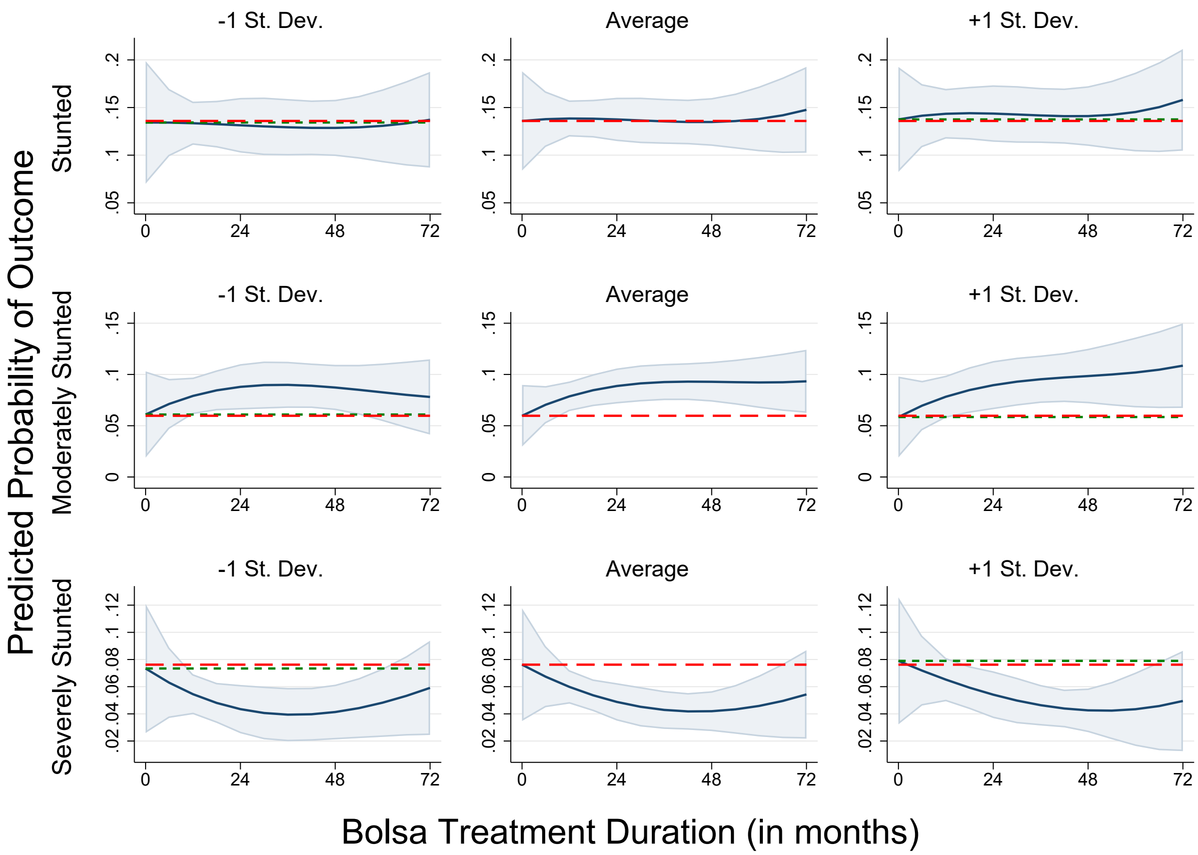
Notes: Predicted values are calculated by estimating Equation 3 using an indicator for normal birth-year rainfall as the rainfall measure. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The left column denotes rainfall in 12 months before birth within one standard deviation (20%) of the municpal average annual rainfall. The right column denotes in utero rainfall outside of this range. Red dashed lines denote the average level of the outcome for an individual exposed to normal in utero rainfall with a Bolsa treatment duration of zero months, while the green dotted line is the analogous average for those exposed to a rainfall shock in utero. Predicted values are bounded by a 95% confidence interval. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively.

Figure A5: Effect of Bolsa Receipt Duration on Anthropometric Z-Scores by Birth-Year Rainfall Status



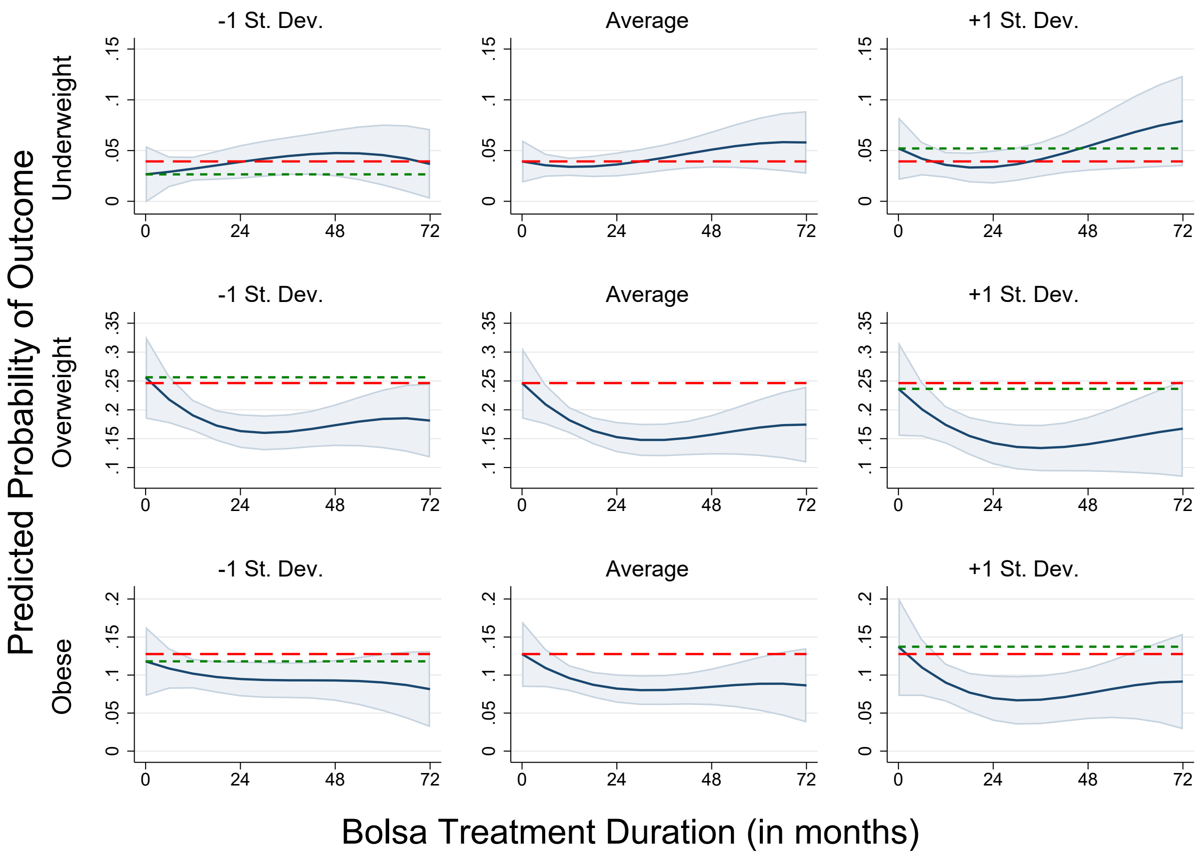
Notes: Predicted values are calculated by estimating Equation 3 using an indicator for normal birth-year rainfall as the rainfall measure. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The left column denotes rainfall in 12 months before birth within one standard deviation (20%) of the municpal average annual rainfall. The right column denotes in utero rainfall outside of this range. Red dashed lines denote the average level of the outcome for an individual exposed to normal in utero rainfall with a Bolsa treatment duration of zero months, while the green dotted line is the analogous average for those exposed to a rainfall shock in utero. Predicted values are bounded by a 95% confidence interval. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards.

Figure A6: Effect of Bolsa Receipt Duration on Stunting by Months of Normal Rainfall in Birth Year



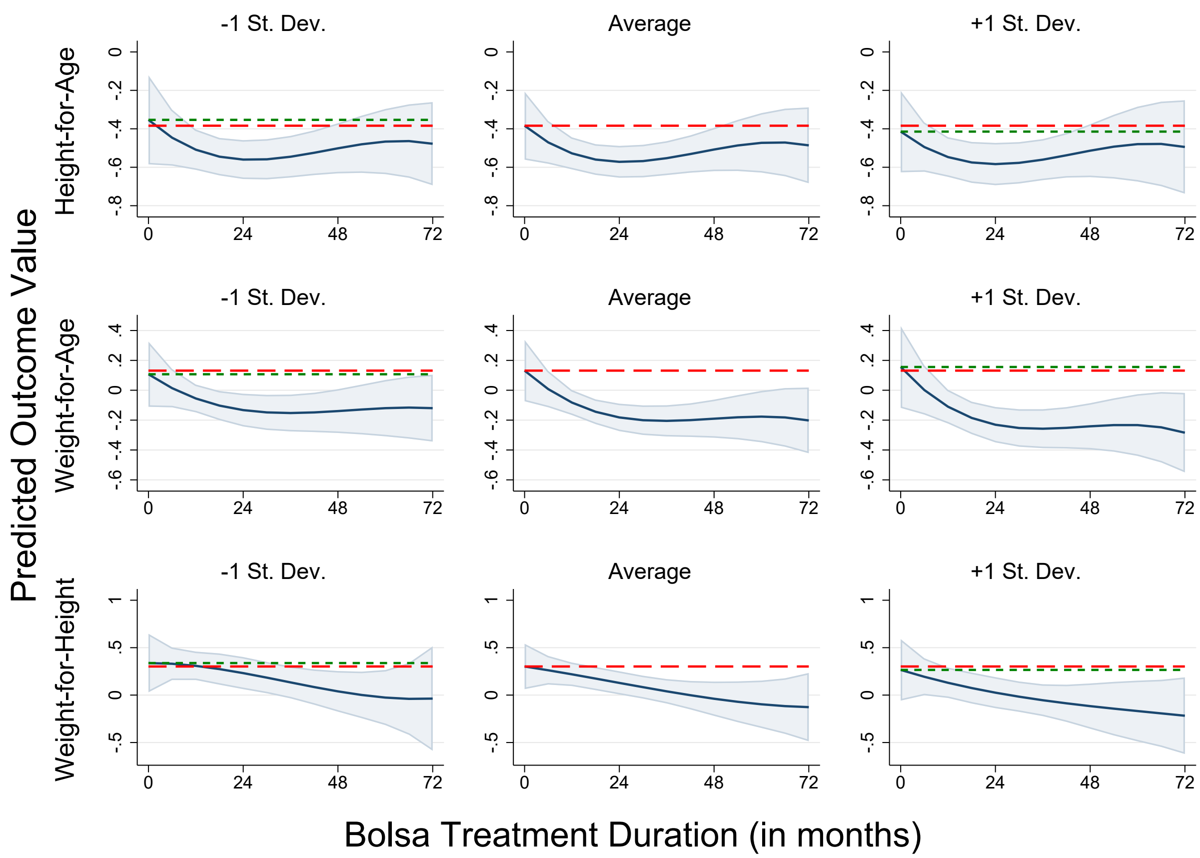
Notes: Predicted values are calculated by estimating Equation 3 a count of the number of months in the 12 months before birth within one standard deviation of the long-run municipal monthly rainfall level for that month as the rainfall measure. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Columns denote, from left to right, a number of months in the year before birth in which rainfall is within one standard deviation of the mean that is one standard deviation (20%) below average, average, and one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to the average number of normal in utero rainfall months with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively.

Figure A7: Effect of Bolsa Receipt Duration on Weight by Months of Normal Rainfall in Birth Year



Notes: Predicted values are calculated by estimating Equation 3 a count of the number of months in the 12 months before birth within one standard deviation of the long-run municipal monthly rainfall level for that month as the rainfall measure. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Columns denote, from left to right, a number of months in the year before birth in which rainfall is within one standard deviation of the mean that is one standard deviation (20%) below average, average, and one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to the average number of normal in utero rainfall months with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively.

Figure A8: Effect of Bolsa Receipt Duration on Anthropometric Z-Scores by Months of Normal Rainfall in Birth Year



Notes: Predicted values are calculated by estimating Equation 3 a count of the number of months in the 12 months before birth within one standard deviation of the long-run municipal monthly rainfall level for that month as the rainfall measure. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Columns denote, from left to right, a number of months in the year before birth in which rainfall is within one standard deviation of the mean that is one standard deviation (20%) below average, average, and one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to the average number of normal in utero rainfall months with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards.

Table A5: Effect of Rainfall on Weight

	Weight-for-Age Z-Score		Weight-for-Height Z-Score		Underweight		Overweight		Obese	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Months of Normal Birth Year Rainfall	-0.0285	-0.0356**	-0.0578**	-0.0615**	0.00303	0.00431*	-0.00724	-0.00754	-0.00412	-0.00302
	(0.0174)	(0.0178)	(0.0265)	(0.0282)	(0.00273)	(0.00251)	(0.00571)	(0.00595)	(0.00443)	(0.00451)
Individual Controls	1	1	1	1	1	1	1	1	1	1
Household Controls	1	1	1	1	1	1	1	1	1	1
Municipality Controls	1	0	1	0	1	0	1	0	1	0
Municipality FE	0	1	0	1	0	1	0	1	0	1
Birth and Survey Year FE	1	1	1	1	1	1	1	1	1	1
Dep. Var. Mean	-0.110	-0.110	0.139	0.139	0.0400	0.0400	0.177	0.177	0.0936	0.0936
R^2	0.0724	0.169	0.0669	0.227	0.0291	0.129	0.0430	0.143	0.0314	0.121
Observations	2813	2813	1682	1682	2873	2873	2873	2873	2873	2873

Estimates are from Equation 1. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Months of Normal Birth Year Rainfall is the count of months in the 12 months prior to birth during which the monthly level of rainfall was within one standard deviation of the municipality's average rainfall for that month. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively. Standard errors are clustered at the municipality level. *, ** and *** indicate significance at the 10%, 5%, and 1% level, respectively.

B Construction of Duration Variables

The creation of *Bolsa Família* integrated several distinct programs, including both conditional and unconditional cash transfers, and participants receive different monthly transfers based on which of these sub-programs they qualify for. As a result, we must decide how to treat the predecessor programs and their evolution before the creation of *Bolsa Família*. While the primary component of Bolsa is a conditional cash transfers to children who meet health and educational requirements, individuals continue to receive benefits based on other predecessor programs, including an unconditional cash transfer to households in extreme poverty. As a result, we choose to integrate information about these pre-existing programs into our treatment duration variable. For example, a household that started receiving *Bolsa Escola* in 2002 and then transitioned into *Bolsa Família* in 2003 is considered as having started the overall Bolsa program in 2002.

In the 2005 survey, start dates are reported for *Bolsa Família* as well as for each predecessor program, including *Bolsa Escola*, *Bolsa Alimentação*, Auxílio/Vale Gás, and *Cartão Alimentação*. Because Bolsa transfers – as with most other CCT programs – are paid to the mother with no restrictions on spending, they are treated as a household benefit. While the CCT conditions apply to specific children, benefits can accrue throughout the family, for example, through increased expenditures and better nutrition. Because the 2005 survey collected data on individual start dates for each program, in cases where multiple individuals report getting Bolsa, we define the household start date as the earliest start date reported by any individual. We then combine start dates for all of these programs into a single household start date (measuring when benefits from any program were first received) according to the following. First, we change any predecessor program start dates that are reported as infeasible (before the start of the program) to the earliest possible start date.[23] Second, we define the Bolsa household start date as the earliest date reported for the receipt of Bolsa or any of its predecessor programs. According to the household start date, we calculate the household treatment duration as the number of months from that date through the November 2005 survey. Given this household duration of treatment measure, we construct individual duration of treatment variables as either (a) the household duration for all children born before the initial receipt date or (b) the child's age

[23] These are June 2001 for *Bolsa Escola*, September 2001 for *Bolsa Alimentação*, January 2002 for *Auxílio/Vale Gás*, and February 2003 for *Cartão Alimentação*. While *Bolsa Família* transfers began in October 2003, we allow for Bolsa start dates from June 2001 under the assumption that individuals report these dates based on predecessor programs. We change Bolsa dates before June 2001 to be June 2001. Furthermore, some predecessor program start dates are reported after the program rolled into *Bolsa Família*. We allow these dates under the assumption that households started a specific component of Bolsa at that time and reported it for the appropriate predecessor program, for example stating that *Bolsa Escola* receipt began in 2005.

(in months) for all children in treated households born after the initial receipt date.

In the 2009 survey, start dates are provided at the household level and only for Bolsa, making the construction of treatment duration simpler. Consistent with adjustments described above, we make one change to the reported Bolsa start dates. Dates before the start of any predecessor program are implausible and we adjust these responses to be the earliest possible predecessor program start date (about 4% of responses are before 2001). Other responses (about 20% between 2001 and 2003) provide start dates when predecessor programs were in effect, but Bolsa had not officially integrated them. Due to the transition of these predecessor programs into the Bolsa program, we allow these dates without modification. The remaining responses are valid Bolsa dates between 2003 and 2009. We construct individual treatment duration variables as above.

Given the non-random design of Bolsa, it is important to control for selection. Since households must choose to enroll in the Cadastro (Single Registry) in order to become eligible for Bolsa, it is possible that households differ based on whether and when they initially register. While we are able to measure the Bolsa treatment duration in months, the year of Cadastro registration is much more commonly reported than the month, leading us to control for the year that a household registered in order to maximize our sample size. The Cadastro was officially passed as law in October 2001 and, as with Bolsa, we change any earlier-reported years to 2001.

Finally, we exploit the panel nature of our data to harmonize the start dates across surveys for households that appear in both survey waves. First, if a household only reports a Bolsa start date in one survey, but reports receiving benefits in both surveys and does not report having stopped transfers, we use the single reported start date in both surveys.[24] We do the same with the Single Registry date for households registered during both surveys. Second, there are 200-300 cases where a household reports dates that are inconsistent in 2005 and 2009. In these cases, we use the 2005 date under the assumption that the initial response is more reliable, since it was closer in time to the relevant event.

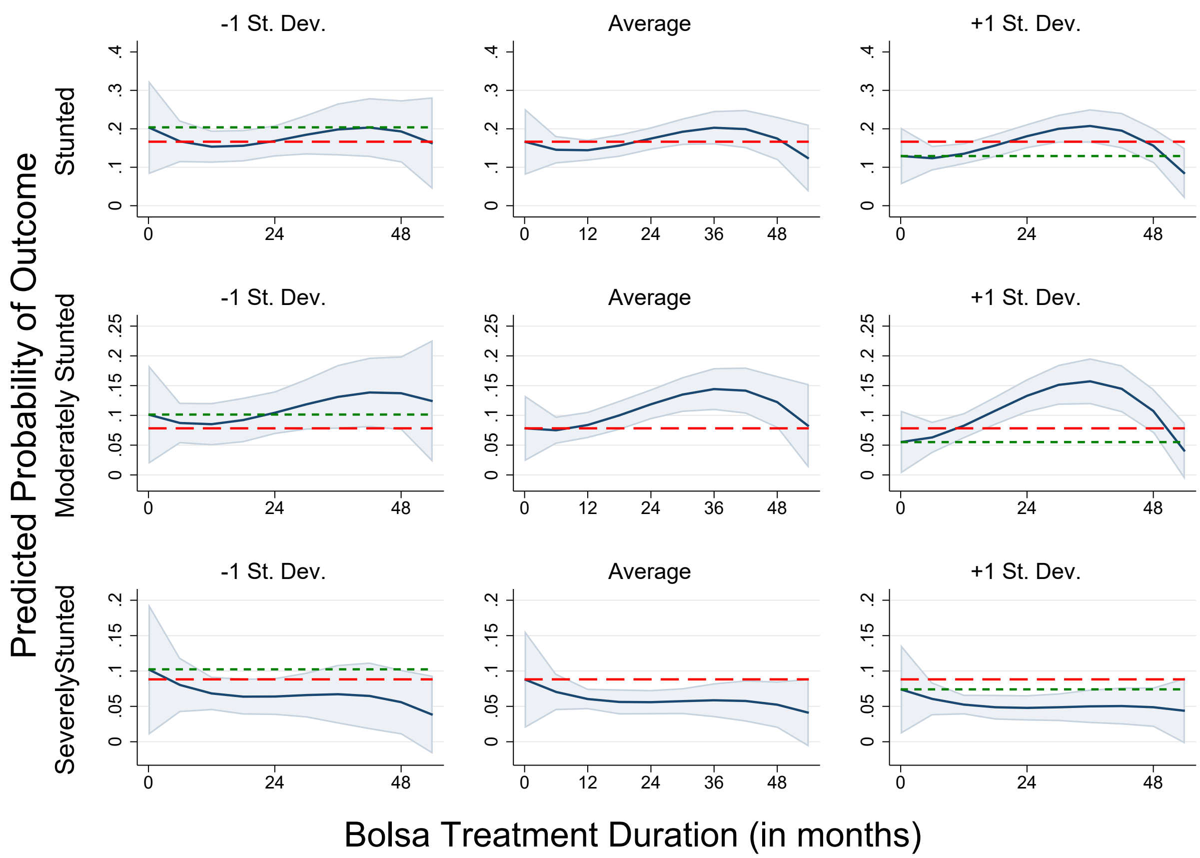
Our findings are generally robust to dropping misreported dates instead of correcting them as described above.

[24] We only make this change to observations from the 2005 survey wave if the start date reported in 2009 is 2005 or earlier.

C 2005 Survey Wave Only

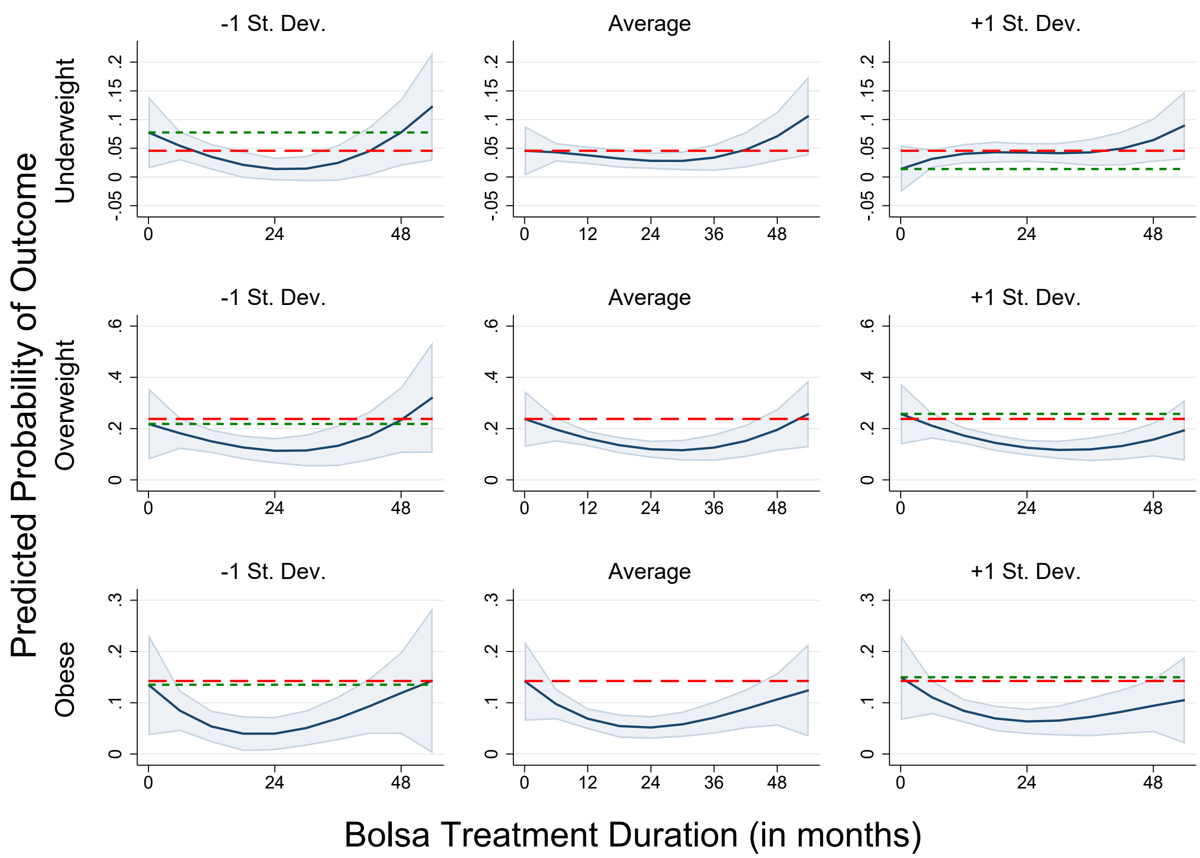
As seen in Figure 2, most of the variation in the timing of Bolsa receipt and Cadastro registration come before 2005. Furthermore, because of the confusion surrounding the rollout of the Bolsa program, the variation earlier in our sample is more plausibly exogenous than that later in our sample. In order to assess the importance of these points, we recreate our main results using only data from the 2005 survey wave. In this section, we show that when using this subset of our data, our results are consistent, lending credence to our main estimates.

Figure C9: Effect of Bolsa Receipt Duration on Stunting by Birth-Year Rainfall Deviation



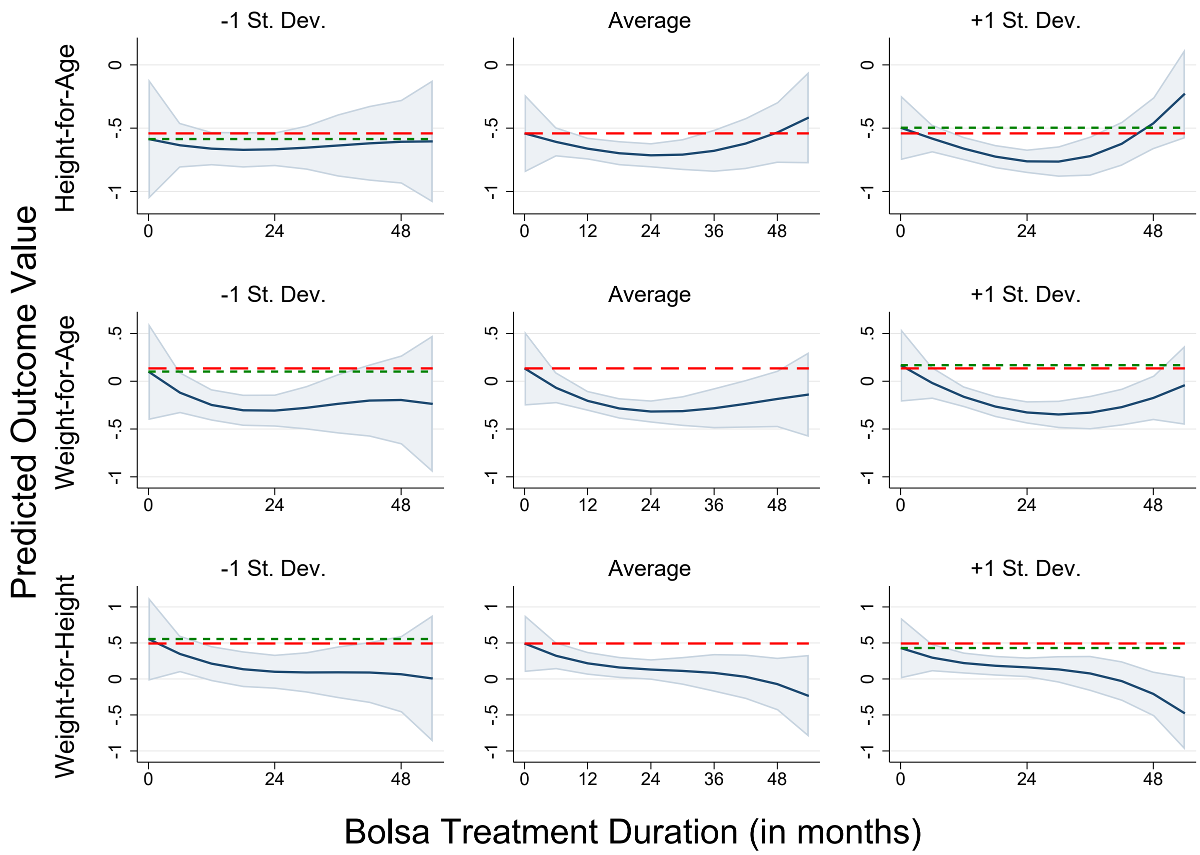
Notes: Predicted values are calculated by estimating Equation 3. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The sample is further limited to only responses in the 2005 survey wave. Columns denote, from left to right, in utero rainfall deviation one standard deviation (20%) below average, average rainfall, and one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively.

Figure C10: Effect of Bolsa Receipt Duration on Weight by Birth-Year Rainfall Deviation



Notes: Predicted values are calculated by estimating Equation 3. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The sample is further limited to only responses in the 2005 survey wave. Columns denote, from left to right, in utero rainfall deviation one standard deviation (20%) below average, average rainfall, and one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively.

Figure C11: Effect of Bolsa Receipt Duration on Anthropometric Z-Scores by Birth-Year Rainfall Deviation

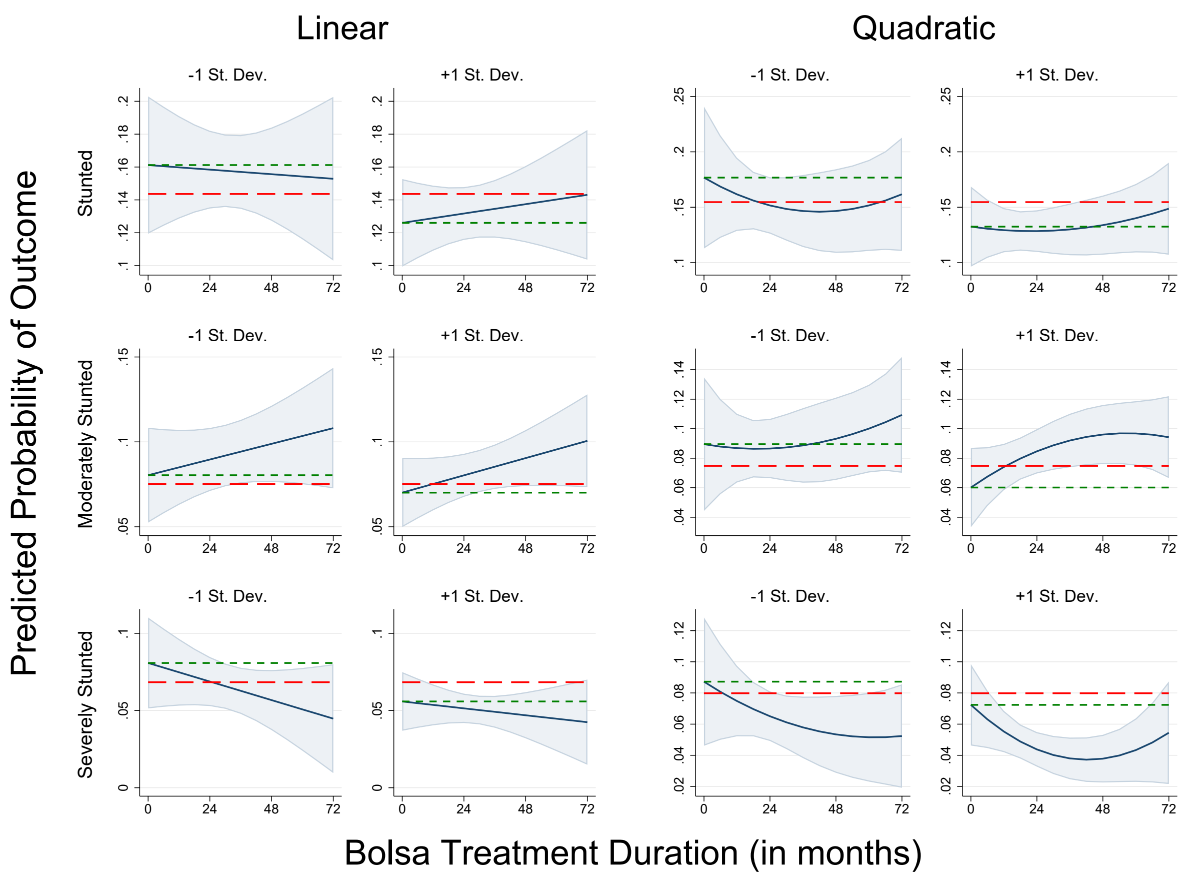


Notes: Predicted values are calculated by estimating Equation 3. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The sample is further limited to only responses in the 2005 survey wave. Columns denote, from left to right, in utero rainfall deviation one standard deviation (20%) below average, average rainfall, and one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards.

D Functional Form

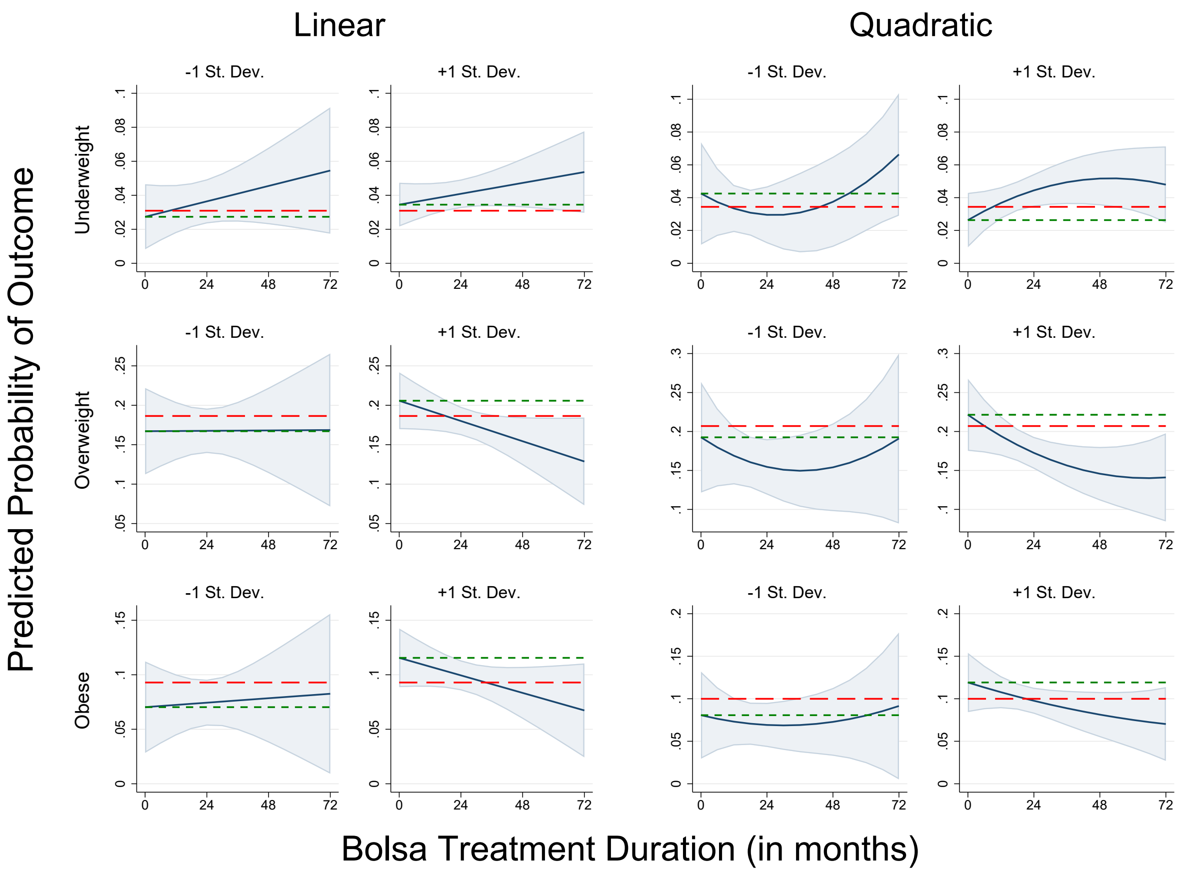
In this section, we evaluate alternative functional forms for the effect of longer durations of Bolsa treatment. In our main results, we use a cubic functional form. We see that our results are extremely robust along this dimension, with both linear and quadratic functional form assumptions generating strikingly similar results.

Figure D12: Effect of Bolsa Receipt Duration on Stunting by Birth-Year Rainfall Deviation



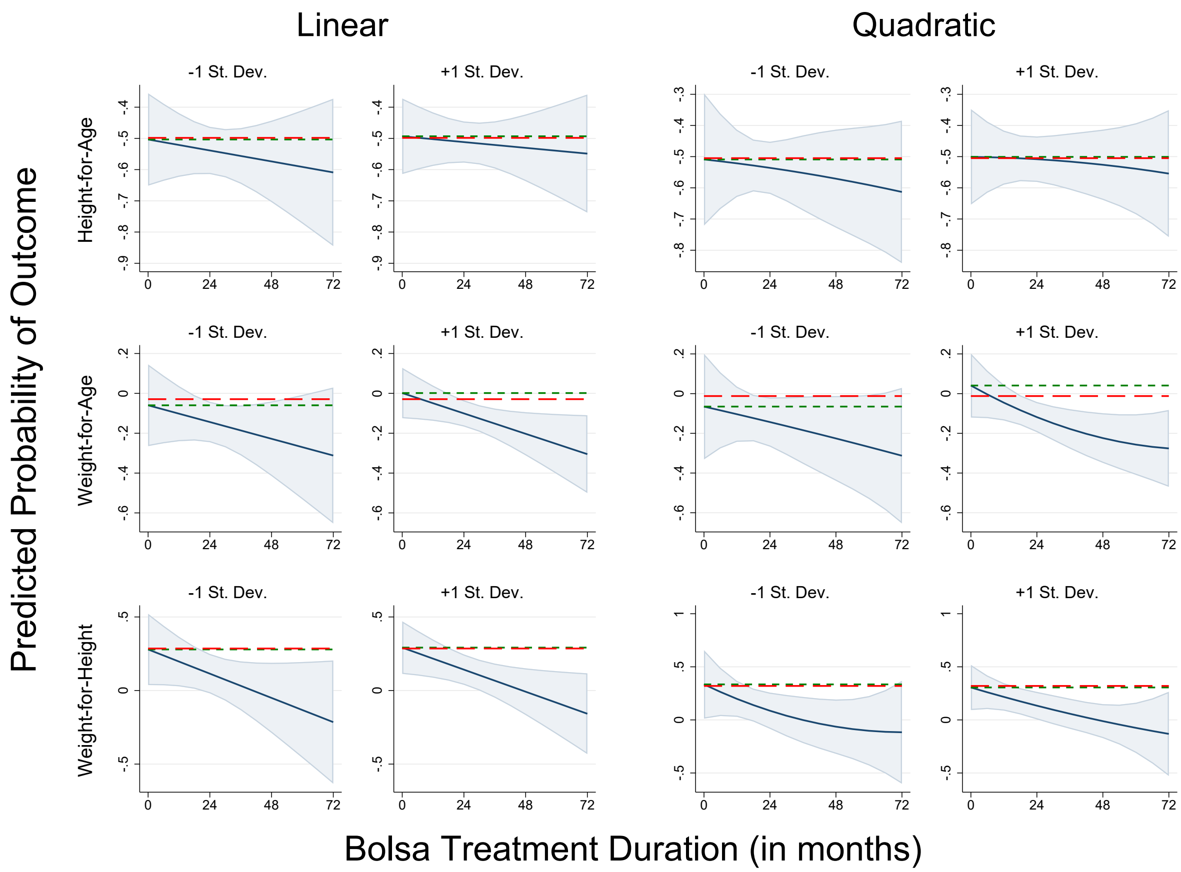
Notes: Predicted values are calculated by estimating Equation 3 using only the linear (in the first two columns) or linear and quadratic (in the last two columns) duration terms. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The first and third columns denote in utero rainfall deviation one standard deviation (20%) below average, while the second and fourth denote in utero rainfall one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively.

Figure D13: Effect of Bolsa Receipt Duration on Weight by Birth-Year Rainfall Deviation



Notes: Predicted values are calculated by estimating Equation 3 using only the linear (in the first two columns) or linear and quadratic (in the last two columns) duration terms. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The first and third columns denote in utero rainfall deviation one standard deviation (20%) below average, while the second and fourth denote in utero rainfall one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively.

Figure D14: Effect of Bolsa Receipt Duration on Anthropometric Z-Scores by Birth-Year Rainfall Deviation

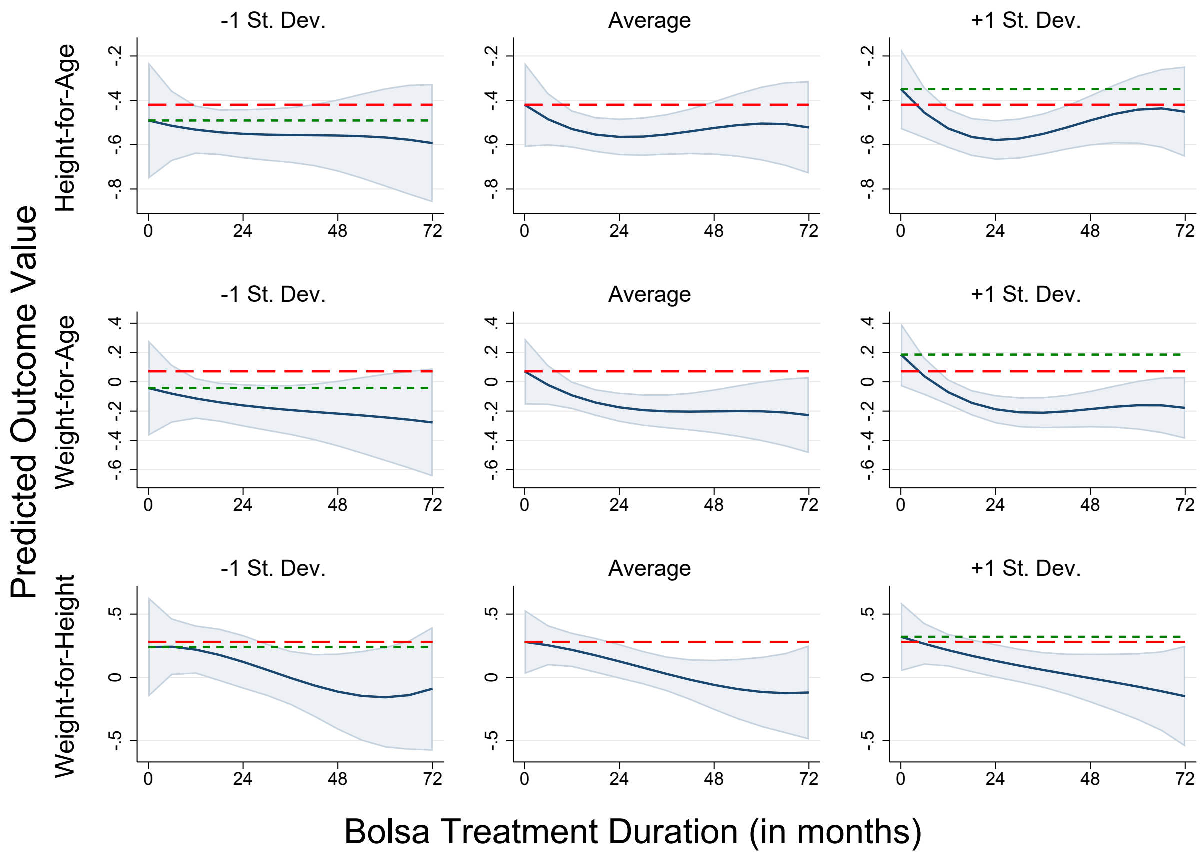


Notes: Predicted values are calculated by estimating Equation 3 using only the linear (in the first two columns) or linear and quadratic (in the last two columns) duration terms. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The first and third columns denote in utero rainfall deviation one standard deviation (20%) below average, while the second and fourth denote in utero rainfall one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards.

E Effect of Bolsa on Mean Anthropometric Z-Score Values

In this appendix, we analyze the effect of Bolsa on the mean level of anthropometric z-scores. In the main text, we analyze the mass in the tails of these height and weight distributions because these parts of the distribution are more indicative of potential health problems. Analyzing only the mean may mask important nuance surrounding the effect of Bolsa on the probability of being an unhealthy weight, whether too high or too low. Nonetheless, in the interest of throroughness, we present results for the mean values as well, again finding Bolsa leveling differences across birth-year rainfall levels. First, among children exposed to low levels of rainfall, we don't observe many significant changes in health z-scores other than a small decrease in weight-for-height from 3-5 years of treatment. In light of our results on other weight-based outcomes (presented in Table 6 and Figure 4), this result indicates that Bolsa treatment compresses the distribution of body weight for children exposed to low levels of birth-year rainfall without significantly raising the mean. Second, children exposed to normal and high early-life rainfall both saw large decreases in the likelihood of being overweight or obese in Table 6, and this drives a reduction in the weight-for-age and weight-for-height z-scores for both groups closer to zero (with significant reductions start at half a year and two years). Similarly, Morris et al. (2004) find that a Bolsa predecessor program reduced weight-for-age z-scores in a small sample from Northeast Brazil, which they suggest might occur due to misperceptions that children would lose benefits if they grew well. Our results suggest that lower average weights may be explained more by weight reductions at the higher end of the weight distribution. Third, despite the reductions in stunting, no group displays a significant increase in height-for-age, with significant decreases for children with average and high rainfall among certain ranges. Unlike with our other outcomes, we do not see clear evidence of differential impacts of Bolsa based on early-life rainfall.

Figure E15: Effect of Bolsa Receipt Duration on Anthropometric Z-Scores by Birth-Year Rainfall Deviation



Notes: Predicted values are calculated using estimates in Tables 5 and 6. Sample includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. Columns denote, from left to right, in utero rainfall deviation one standard deviation (20%) below average, average rainfall, and one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards.

F Heterogeneity in Effect by Age Starting Bolsa

In this appendix, we investigate the differential impact on weight of Bolsa by starting age and birth-year rainfall. As noted in Section 5.3.1, medical evidence indicates that intervention early in life is likely to be more important for height than weight, given that the latter is more susceptible to shorter-term changes in health. In this section, we first present evidence of the balance of beneficiary characteristics across groups along this dimension of heterogeneity before presenting evidence that this is the case, with Bolsa significantly affecting weight even among children who only begin receiving transfers after age five. Furthermore, we present evidence not only that weight can be affected by interventions later in adolescence, but that the intervention is potentially more effective among children exposed to more adverse in utero conditions.

In Table F6 , we present the means of various individual and household characteristics for children that received or did not receive Bolsa by age five. The starkest difference is that children first receiving Bolsa between their fifth birthday and the time of the sample are somewhat older, which is to be expected given that for older children, this period is longer. There are a number of other statistically significant differences between the groups, these differences are small in magnitude and do not indicate that one group is systematically better off than the other. For example, children receiving Bolsa later in life are more likely to have a literate household head but live in homes with fewer rooms on average. These results indicate that comparisons across these groups of children are reasonable comparisons to make.

We evaluate the effects of Bolsa on weight in Figure F16 and related z-scores in Figure F17. First, children born during more adverse conditions who start receiving Bolsa before age 5 (the far left column) are more likely to be overweight, with an increase from 0 to 0.2 that stabilizes after two years of treatment at a probability in line with other groups in our sample. There is no statistically-significant effect on the likelihood of being underweight or obese, although both see almost significant increases at the longest duration. This results in no significant increase in the weight-for-age z-score, although it is the closest that any of our groups get to a significant increase. Because height does increase significantly, the weight-for-height z-score is lower. Second, children born during more advantageous conditions who start receiving transfers before age 5 (second column) see a decrease of almost 0.2 percentage points in the likelihood of being overweight and a smaller increase in the likelihood of being obese, both significant after about a year and stabilizing for later durations of treatment. This suggests that some of these children are going from being overweight to more average weights, which helps explain the significant reduction in the weight-for-age and weight-for-height z-scores. Third, children who start receiving Bolsa after age 5 show similar trends overall, with

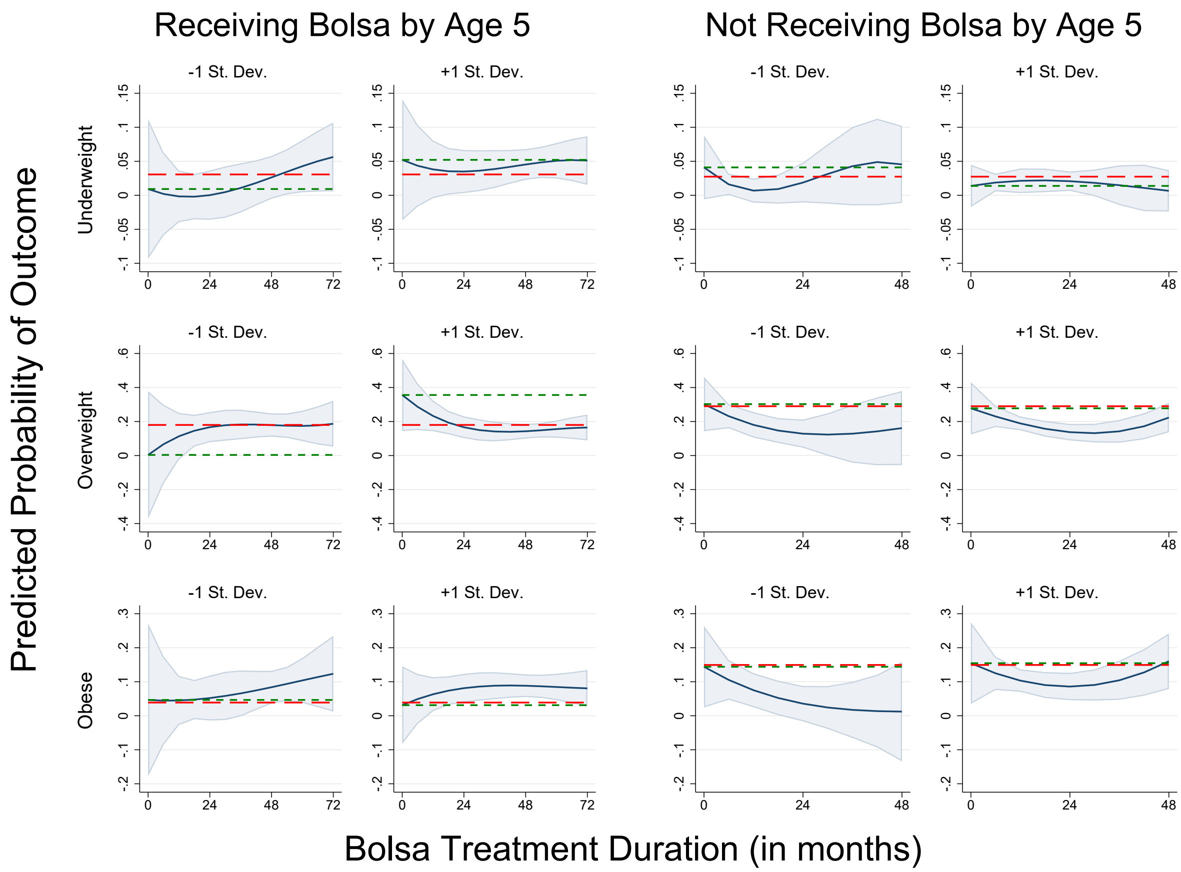
Bolsa causing a significant reduction in the likelihood of being overweight (0.1 to 0.2 percentage points) or obese (0.05 to 0.15 percentage points) after about one year of treatment, with some insignificance at higher durations caused mostly by increasing confidence intervals. One difference, however, is that for children who start treatment later, Bolsa significantly reduces the likelihood of being underweight from about 0.5-2 years of treatment, providing some evidence that Bolsa can help catch-up in weight for some children after age 5. Overall, these results indicate that Bolsa compresses the distribution of weights, with a reduced likelihood of heavier weights and a decrease in the average weight, especially among children whose in utero conditions predisposed them to heavier weights.

Consistent with medical evidence that height is more strongly determined early in life than weight, we find that weight is more responsive to transfers at older ages, when Bolsa decreases average weights by reducing the likelihood of children being overweight or obese.

Table F6: Variable Means by Enrollment Status on Fifth Birthday

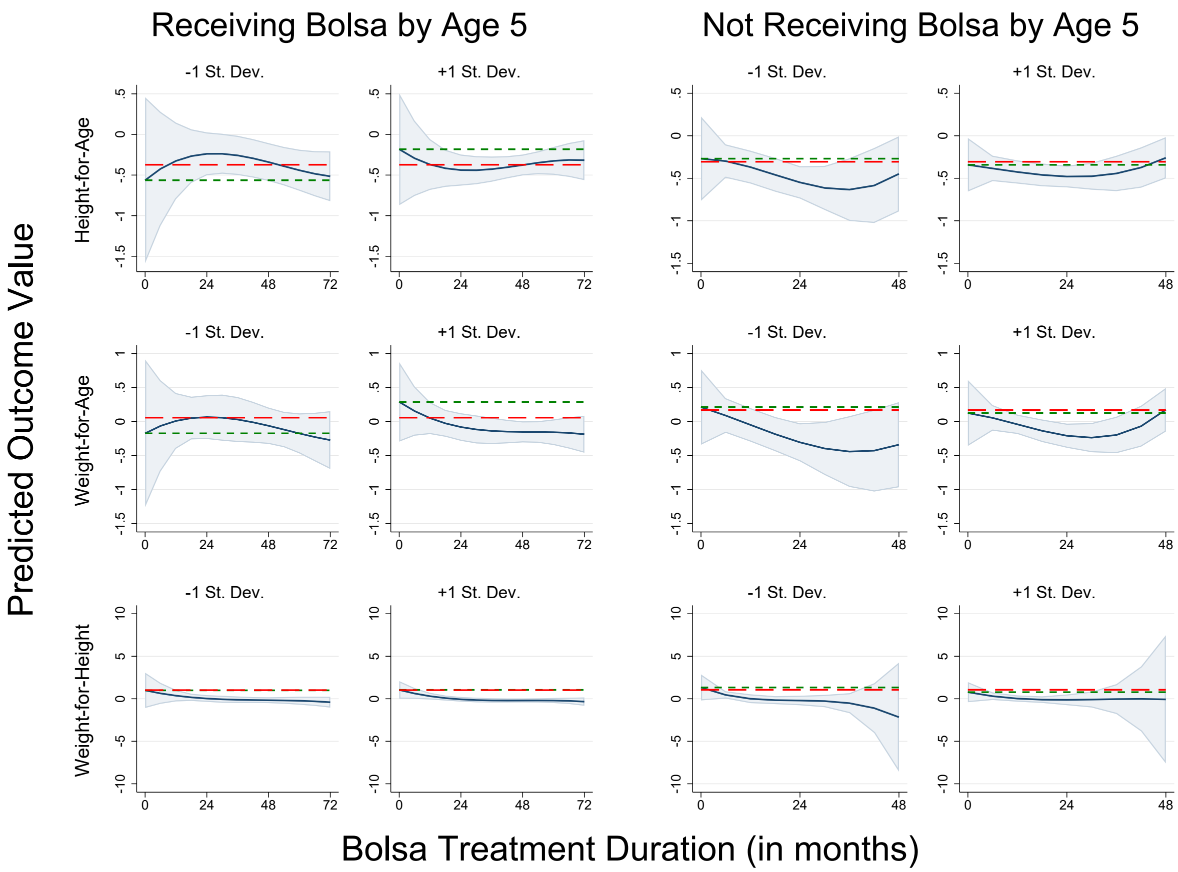
	Nonenrolled	Enrolled	Difference	Significance
Age	8.293	6.765	1.528	0.000
Female (=1)	0.476	0.528	-0.052	0.011
While (=1)	0.301	0.295	0.006	0.742
Black (=1)	0.108	0.108	0.000	0.998
Born in Rainy Season (=1)	0.331	0.321	0.010	0.613
Head of Household is Female (=1)	0.392	0.417	-0.025	0.213
Head of Household Age	39.674	40.430	-0.756	0.124
Head of Household is Literate (=1)	0.849	0.820	0.029	0.063
Household Members (#)	5.591	5.996	-0.405	0.000
Household Members under Age 6 (#)	0.895	1.037	-0.142	0.000
Household Members under Age 15 (#)	2.993	3.098	-0.105	0.069
Household Owns Home (=1)	0.557	0.581	-0.023	0.257
Rooms in Home (#)	4.621	4.735	-0.114	0.081
Piped Water in Home (=1)	0.832	0.817	0.015	0.324
Rural (=1)	0.134	0.193	-0.059	0.000

Figure F16: Effect of Bolsa Receipt Duration on Weight by Birth-Year Rainfall Deviation and Age Starting Bolsa



Notes: Predicted values are calculated by estimating Equation 3 separately for children who began receiving Bolsa before age 5 (in the first two columns) and those who began receiving Bolsa after age 5 (in the last two columns). Each of these samples includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The first and third columns denote in utero rainfall deviation one standard deviation (20%) below average, while the second and fourth denote in utero rainfall one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively.

Figure F17: Effect of Bolsa Receipt Duration on Anthropometric Z-Scores by Birth-Year Rainfall Deviation and Age Starting Bolsa

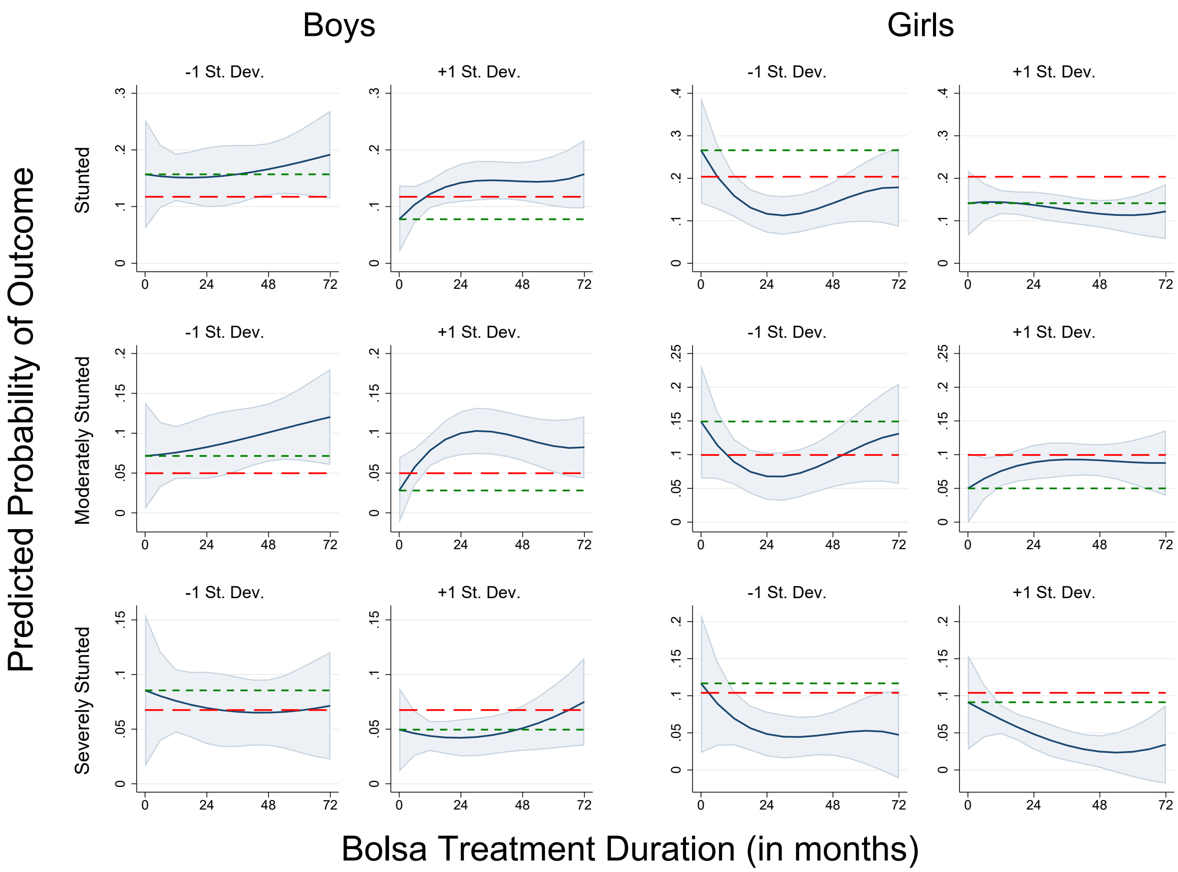


Notes: Predicted values are calculated by estimating Equation 3 separately for children who began receiving Bolsa before age 5 (in the first two columns) and those who began receiving Bolsa after age 5 (in the last two columns). Each of these samples includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The first and third columns denote in utero rainfall deviation one standard deviation (20%) below average, while the second and fourth denote in utero rainfall one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards.

G Heterogeneity in Effect by Gender

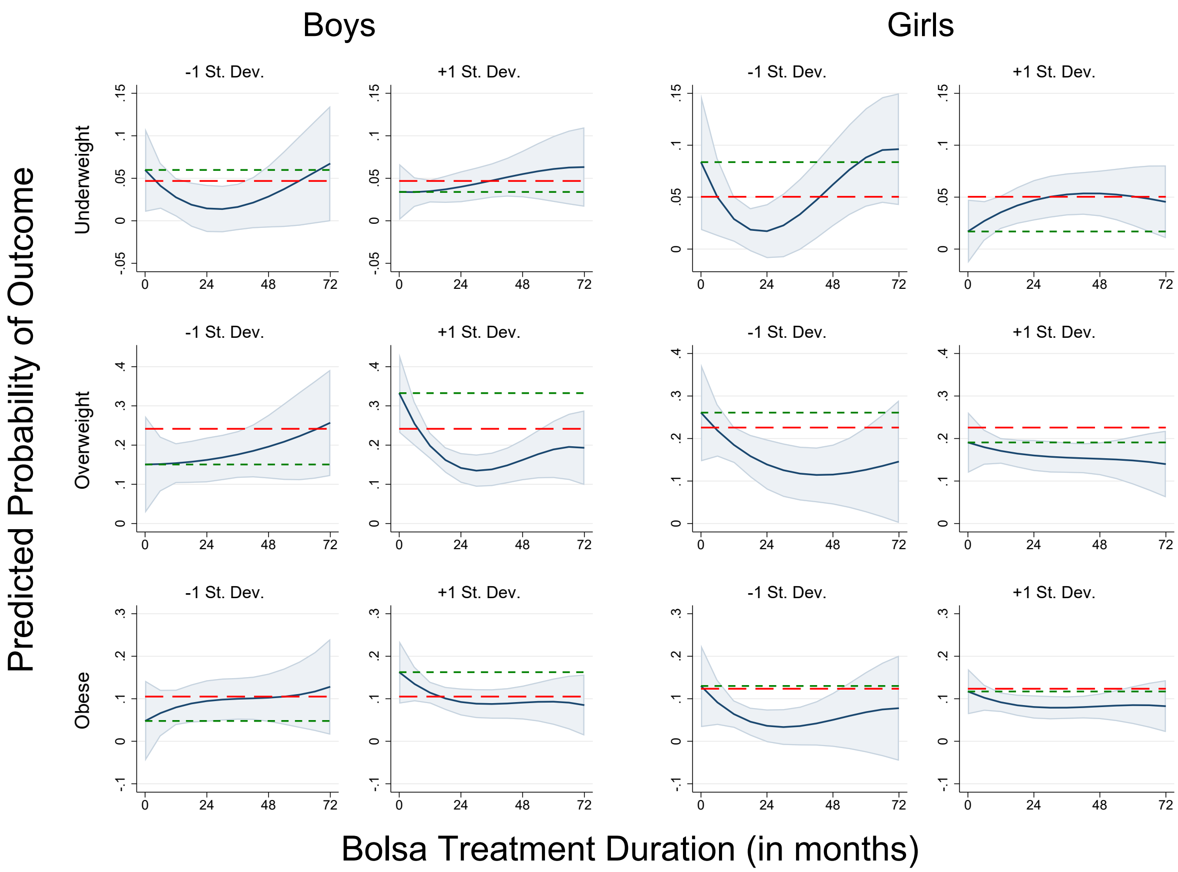
We next evaluate potential heterogeneity by gender in Figures G18, G19, and G20. First, the reduction in stunting is driven by the effect of Bolsa on girls born during more adverse conditions. Bolsa causes a reduction in stunting of 10-15 percentage points among girls who experienced low in utero rainfall, including significant reductions in the likelihood of severe and moderate stunting. The effects become significant after one year of treatment and persist through all 6 years in the case of stunting and severe stunting. Among girls born during more beneficial environments, Bolsa causes a reduction in severe stunting, though many girls appear to instead be moderately stunted with no significant reduction in stunting overall. Note that these results together indicate that even relatively short durations of Bolsa transfer receipt are able to undo the negative effects of adverse in utero conditions for girls. Focusing on height-for-age z-scores, Bolsa does not quite cause an increase among girls who faced adverse birth-year rainfall and a significant fall from 1-3 years among girls born in better conditions. Second, Bolsa reduces the likelihood of being overweight or obese similarly among all girls, with a corresponding reduction in the weight-for-age and weight-for-height z-scores. However, there is evidence that Bolsa reduces the likelihood of being underweight among girls born in worse environments, but the effect is only significant from 0.5-2 years of treatment. Among boys, there is no effect on the likelihood of being underweight among either group. For boys born in worse environments, there is some evidence of weight gain: there is an increase in the likelihood of being overweight and an almost significant increase in obesity, resulting in an almost significant increase in weight-for-height from 1-3 years of treatment. Among boys born in better environments, there is a significant reduction in the likelihood of being overweight and a smaller increase in obesity, resulting in a fall in weight-for-age (for all durations after half a year) and weight-for-height (from 1-3 years) z-scores. Overall, Bolsa appears to be most beneficial for girls, especially those exposed to low in utero rainfall, although this conclusion depends on the outcome in question.

Figure G18: Effect of Bolsa Receipt Duration on Stunting by Birth-Year Rainfall Deviation and Gender



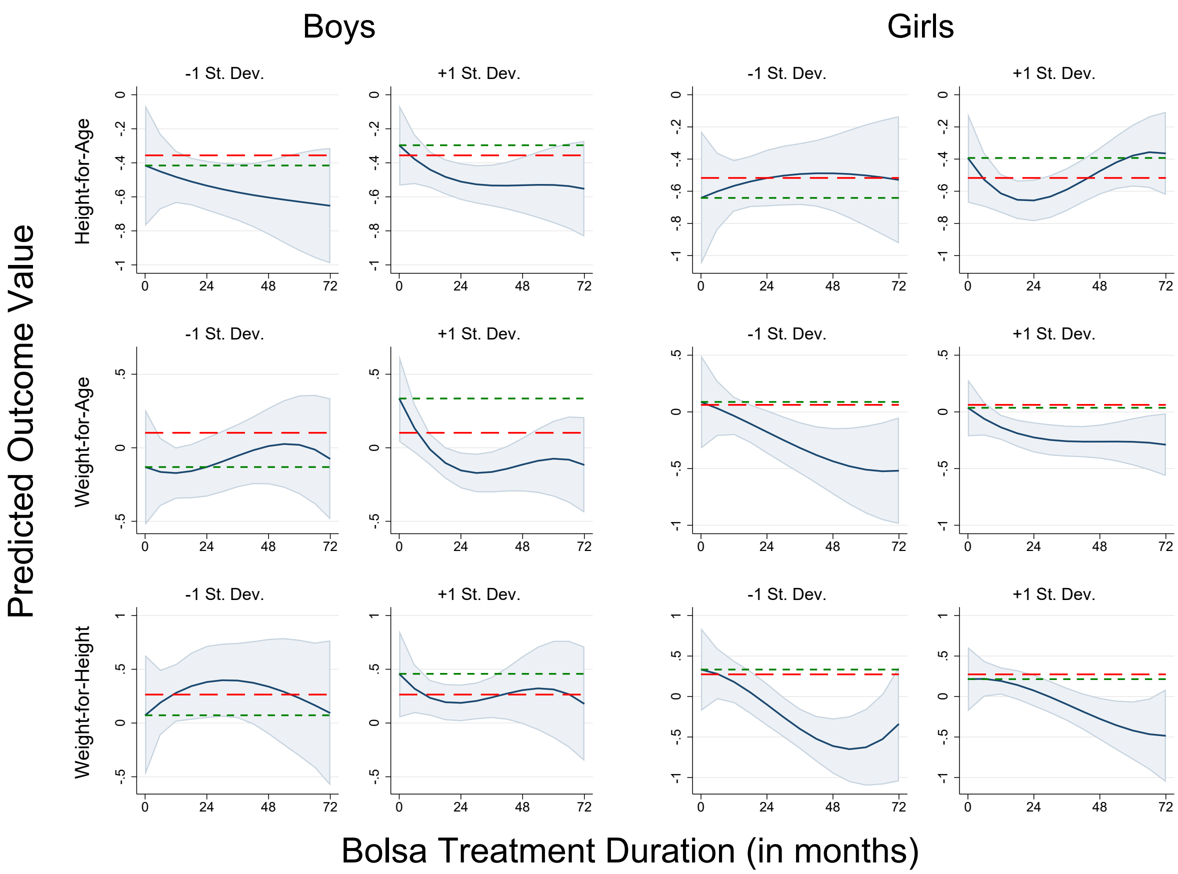
Notes: Predicted values are calculated by estimating Equation 3 separately for boys (in the first two columns) and girls (in the last two columns). Each of these samples includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The first and third columns denote in utero rainfall deviation one standard deviation (20%) below average, while the second and fourth denote in utero rainfall one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Stunted, Moderately Stunted, and Severly Stunted are indicators for having a height-for-age z-score less than -2, between -2 and -3, and less than -3, respectively.

Figure G19: Effect of Bolsa Receipt Duration on Weight by Birth-Year Rainfall Deviation and Gender



Notes: Predicted values are calculated by estimating Equation 3 separately for boys (in the first two columns) and girls (in the last two columns). Each of these samples includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The first and third columns denote in utero rainfall deviation one standard deviation (20%) below average, while the second and fourth denote in utero rainfall one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Underweight, Overweight, and Obese are indicators for having a weight-for-age z-score less than -1, greater than 1, and greater than 2, respectively.

Figure G20: Effect of Bolsa Receipt Duration on Anthropometric Z-Scores by Birth-Year Rainfall Deviation and Gender



Notes: Predicted values are calculated by estimating Equation 3 separately for boys (in the first two columns) and girls (in the last two columns). Each of these samples includes individuals age 10 and under who reside in their municipality of birth and currently receive Bolsa transfers. The first and third columns denote in utero rainfall deviation one standard deviation (20%) below average, while the second and fourth denote in utero rainfall one standard deviation above average. Red dashed lines denote the average level of the outcome for an individual exposed to average in utero rainfall with a Bolsa treatment duration of zero months. Green dotted lines denote the average level of the outcome for an individual with a Bolsa treatment duration of zero months who was exposed to in utero rainfall consistent with the column. Predicted values are bounded by a 95% confidence interval. Anthropometric z-scores are calculated based on World Health Organization Child Growth Standards.