WPS7081

Policy Research Working Paper 7081

Weather Shocks and Health at Birth in Colombia

Mabel Andalón
João Pedro Azevedo
Carlos Rodríguez-Castelán
Viviane Sanfelice
Daniel Valderrama

WORLD BANK GROUP
Poverty Global Practice Group
November 2014

Abstract

Poor health at birth has negative long-run effects on individual well-being and is also detrimental for intergenerational mobility. This paper examines whether health outcomes at birth are affected by in utero increased exposure to rainfall and temperature shocks in Colombia, one of the countries in the world with the highest incidence of extreme weather events per year. The paper uses a fixed effects design to gauge the causal effect using variation in fetal exposure to these shocks by municipality and date of birth. The analysis finds negative effects of temperature shocks on birth health outcomes and no effect of rainfall shocks. The results indicate that heat waves lead to a 0.5 percentage point reduction in the probability of being born at full term and a decline of 0.4 percentage point in the probability of newborns classified as healthy. The timing of exposure to the shock matters and it matters differently for different outcomes. These findings are critical to prioritize responses to counteract the negative effects of weather, particularly hot shocks, which are projected to become more frequent and intense with changing climate.

This paper is a product of the Poverty Global Practice Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at crodriguezc@worldbank.org and jazevedo@worldbank.org.

Weather Shocks and Health at Birth in Colombia

Mabel Andalón[1] João Pedro Azevedo[2] Carlos Rodríguez-Castelán[3]

Viviane Sanfelice[4] Daniel Valderrama[5]

Keywords: Weather Shocks, Birth Health, Colombia
JEL codes: C25, D63, I15, O54, Q54
Sector Board: Poverty (POV)

The authors would like to thank Ana Elisa Bucher and Fernanda Zermoglio from the World Bank's Climate Change Unit for their indispensable advice and contributions, also to Javier Baez for his thoughtful comments, and to participants of the 17th Annual LACEA Meeting that took place in Lima, Peru on November, 2012. The findings, interpretations and conclusions in this paper are entirely those of the authors. They do not necessarily represent the view of the World Bank Group, its Executive Directors, or the countries they represent.

[1] IZA. E-mail: andalon.mabel@gmail.com
[2] World Bank. E-mail: jazevedo@worldbank.org (corresponding author)
[3] World Bank. E-mail: crodriguezc@worldbank.org (corresponding author)
[4] University of Rochester. E-mail: sanfelicev@gmail.com
[5] World Bank. E-mail: dvalderramagonza@worldbank.org

1. Introduction

Poor health at birth has large long-run effects on individual well-being. Poor health at birth adversely affects health in childhood and adulthood (Almond et al., 2005; Black et al., 2007, Alderman et al., 2006; Almond, 2006) and educational outcomes (Behrman and Rosenzweig 2004; Glewwe et al., 2001). Poor health at birth is also detrimental for intergenerational mobility because its impacts on health and educational outcomes lead to reduced earnings (Case and Paxson, 2008; Duflo, 2001), and low-income parents are more likely to have health-ill children (Case and Paxson, 2006). Therefore, identifying shocks that affect health at birth is of particular interest to researchers and policy makers. One intriguing hypothesis is that health outcomes at birth can be affected by extreme weather events, which are often cited as the most important risk factor faced by rural households (Giné, Townsend and Vickers, 2008).

This paper investigates the impact of exposure to extreme weather events while *in utero* on birth outcomes in rural Colombia over the period 1999-2008. Weather-related shocks can affect child health in rural areas if they affect the consumption of food and other nutrition and health inputs. This occurs, for example, if the shocks affects households' real income either through price changes or through profits from prolific or lean harvests (Hoddinott 2006; Conroy et al., 2011). Extreme weather events can also affect child health and behaviors by increasing stress levels of the pregnant mother in an unpredictable and unusual way (Shore et al., 1986, Maida, 1989, Dunkel-Schetter, 2011). Finally, weather events can have consequences on the health of pregnant mothers and their offspring by creating changing environments that lead to faster (or slower) spread of diseases (Aguilar and Vicarelli, 2011).

Colombia is one of the countries with the highest incidence of extreme weather events, which have also increased considerably in the last three decades. According to the Global Climate Risk Index, in 2010 Colombia was the third most affected country by the impacts of weather-related loss events (storms, floods, heat waves, etc.), just behind Pakistan and Guatemala (Germanwatch, 2012). Moreover, the number of disaster events registered in the decade of the 2000s in Colombia has increased more than 60 percent with respect to the decade of the 1970s (World Bank, 2012). Colombia is particularly exposed to rainfall and temperature shocks. The exposure level distribution in the country indicates that 28 percent of the territory has high flooding potential (World Bank, 2012). Temperature records in Colombia also vary widely year to year (Catarious and Espach, 2009). Hydro-meteorological patterns in Colombia are affected by ENSO, a recurrent climatic event that takes place between every two and seven years due to temperature changes in the Pacific Ocean. ENSO oscillates between its two extremes: El Niño (warm event) and La Niña (cold event) causing extreme weather events such as droughts, floods and heat waves.[6] According to a recent World Bank report, between 1950 and 2011 there were 15 El Niño episodes and 13 La Niña. With changing climate, El Niño and La Niña phenomena, the associated droughts and floods and the incidence of very high and low temperatures will become even more frequent and intense, affecting 80 percent of Colombians who live in areas highly vulnerable to climate change (Catarious and Espach, 2009).[7]

Our paper contributes to a growing economics literature that analyzes how outcomes at birth are affected by shocks *in utero*.[8] This literature is generally limited to examining the effects of stress-related shocks or shocks that affect maternal nutrition on weight at birth or gestational length, leaving unanswered the potential for effects on other measures of health at birth. The effect of natural disasters on weight at birth and gestational length is mixed. Exposure during pregnancy to a range of natural disasters in the US or a hurricane in Texas has little to no effect on birth weight or preterm birth (Simeonova, 2009, Currie and Rossin-Slaterc, 2013), but exposure to the worst shaking of the 2005 earthquake in Chile negatively affected both weight and the likelihood of birth at term (Torche, 2011). Birth weight (or normal birth weight) is also negatively affected by exposure to Ramadan among Arab mothers (Almond and Mazumder, 2011) or by other types of stress related shocks, such as conflict-related deaths in West Gaza (Mansour and Rees, 2011), exposure to landmine explosions in Colombia (Camacho, 2008) and exposure to the September 11th, 2001 attacks in New York City (Eccleston, 2011). The attacks in New York and the explosions in Colombia also had a small, adverse effect on gestational length.

---

6 El Niño events and the associated droughts take place when temperatures in the Pacific Ocean become warmer than usual, while La Niña event and the associated flooding occurs when temperatures in the Pacific Ocean get colder than usual.

7 These effects of climate change add to the global warming trend and the changes in precipitation levels registered in Colombia and throughout the globe. In Colombia, the average temperature increased at a rate of 0.1 to 0.2 °C per decade since 1961 and the precipitation patterns have both increased and decreased, depending on the region (Catarious and Espach, 2009).

8 A related stream of the literature has analysed the effects of a range of fetal shocks and conditions on outcomes later on in life. The motivation for these studies is the "fetal origins" hypothesis by David J. Barker, which posits that circumstances *in utero* can have long-lasting impacts on future disease. Expanding on this hypothesis, economists have found a wealth of later-life impacts of prenatal shocks and conditions including test scores, educational attainment and income, along with health. For a review of this literature see Almond and Currie (2011).

This paper makes two contributions to the literature exploring how outcomes at birth are affected by prenatal shocks. First, rather than considering occasional shocks, we consider the effects of extreme weather shocks, whose incidence and frequency are increasing as a result of climate change (IPCC, 2007). Second, we examine the effects of weather shocks on weight and gestational length, but expand the analysis to other birth outcomes. Two of the aforementioned studies examined the effects on other outcomes and found detrimental effects: the 2001 New York attacks lowered the five minute Apgar score, which is a summary measure of the newborn's health based on her Appearance, Pulse, Grimace, Activity and Respiration (Eccleston, 2011) and the hurricane in Texas increased the probability of abnormal conditions of the newborn such as being on a ventilator more than 30 minutes (Currie and Rossin-Slaterc, 2013). These studies pertain to particular regions in the U.S., but our study is in a developing country setting and we use administrative, nationally representative birth records, which enhances the external validity of our findings.

Ours is not the first study looking at the wellbeing impact of weather shocks, but it is the first one considering fetal exposure to both extremes of rainfall (drought or flood) and temperature (extremely cold or hot) focusing on health outcomes at birth in a developing country context. Past empirical literature in this area focuses on the effects of after-birth exposure to one type of weather shock on outcomes in childhood and adulthood. This literature has found that excess rainfall during the first two years of life improves the survival probabilities of children in rural India (Rose, 1999), but has detrimental effects on children's height, weight, language capacities and cognitive development in rural Mexico (Aguilar and Vicarelli, 2011; Conroy et al. 2011). Positive rainfall shocks at birth improve the health, educational attainment and labor market outcomes of women in rural Indonesia, but not of men (Maccini and Yang, 2009). Exposure to a drought leads to growth faltering in childhood in Zimbabwe only if experienced in the second year of life (Hoddinott and Kinsey, 2001; Hoddinott, 2006), but has no effect on height-for-age among children in rural Mexico (Conroy et al. 2011). High temperature days increase annual mortality, particularly among rural populations in India (Burgess et al., 2014). Both extremely cold and hot days lead to higher age-adjusted mortality rates in the U.S., but have no effect on infant mortality in the U.S. (Deschênes and Moretti, 2009; Deschênes and Greenstone, 2011) or on children's height-for-age in rural Mexico (Conroy et al., 2011). The effects of weather shocks experienced by pregnant women on the health of their offspring are less explored by this literature.

This paper contributes to the strand of the economics literature analyzing the effects of weather shocks by focusing on exposure during the gestational period on health outcomes at birth. Existing literature looking at the health effects of weather shocks while in utero has found no effects of excess rainfall on children's height and weight in rural Mexico (Aguilar and Vicarelli, 2011; Conroy et al. 2011) or on adult height in rural Indonesia (Maccini and Yang, 2009). However, a drought in an arid African area has been shown to increase malnutrition and mortality for children under the age of 12 months (Kudamatsu et al, 2012). Rather than analyzing the effects of weather shocks *in utero* on outcomes in childhood and adulthood, we focus on outcomes at birth. One related study shows that exposure to extreme hot temperatures during the second and third trimester of pregnancy leads to small reductions in birth weight (7 to 11 grams) in the U.S. (Deschênes et al., 2011). A second (unpublished) study provides evidence that a negative rainfall shock one year before birth worsens health at birth in the semiarid region of Northeastern Brazil; a 31% decrease in rainfall reduces birth weight by 1.9 grams and the likelihood of full-term pregnancies by 0.6 percentage points (Rocha and Soares, 2012).[9] We improve upon these two studies in two main ways. First, we consider a wider range of health outcomes at birth, namely birth weight, gestational length, length at birth and the Apgar score and find that previously unexplored outcomes are actually more responsive to severe weather events. Second, we study the effect of both extremes of precipitation and temperature shocks using nationally representative data from a developing country.

We identify the causal effect of weather shocks on birth outcomes by merging monthly temperature and rainfall data with unique, nationally representative, administrative data on birth records in Colombia from 1999 to 2008. We identify extreme precipitation and temperature events based on the magnitude of the deviation from the historical average monthly rainfall level in a given municipality. To gauge the causal effect, we rely on the exogenous variation in fetal exposure to these shocks by municipality and date of birth using a fixed effects design. Our identification strategy relies on the fact that temporary rainfall and temperature deviations from the historical average in the individual's region of birth while *in utero* are uncorrelated with latent determinants of health at birth. Our detailed data also allow us to explore how the effect of weather shocks varies according to the timing during gestation.

[9] The effects are stronger during the 2nd trimester of gestation, for girls, and for children born during the dry season. The paper also finds evidence for an increase in infant mortality rate by 2.14 per 1,000 newborns with higher effects on infant mortality during the first 6 months of life, and on mortality due to intestinal infections and malnutrition.

A potential problem pervading ours and all previous analyses concerns *fetus* selection due to adverse weather conditions. The problem is that only surviving foetuses are recorded in our data set. Hence, shocks that lead to fetal deaths of weak *fetuses* may lead the population of surviving newborns to be stronger than it would otherwise have been. As Currie (2009) argues, fetal selection suggests that estimated coefficients may understate the true negative effects of health insults.

We find very limited effects of rainfall shocks on birth outcomes in Colombia, but robust effects of temperature shocks. In particular, we find that (1) some health at birth outcomes improve with exposure to cold shocks and worsen with exposure to hot shocks, and (2) the timing of exposure to the shock while *in utero* matters, and it matters differently for different outcomes. Exposure to a heat wave at any point in pregnancy reduces the proportion of full term and healthy newborns, and it also decreases length when exposure occurs during the third trimester. The effects of temperature shocks are small, but in line with what the previous literature has found.

The paper is structured as follows. Section 2 discusses the data sample and presents summary statistics. Section 3 discusses the econometric framework and identification strategy. Section 4 presents the results, reports diagnostic tests on the internal validity of the estimates and robustness tests. Section 5 concludes with a summary of our findings and recommendations for policy.

2. Data

2.1 Data on health at birth

We use administrative data from the Colombian national registry of live births over 1999-2008, which are available from the vital statistics, collected by the Administrative Department of Statistics (DANE). In contrast with the data used in previous studies on the effects of shocks *in utero* on birth outcomes, which tend to be limited to a geographic area within a country, the data we use have universal coverage of all birth records in Colombia. The data contain several measures of health at birth, including weight, length, gestational age, and the Apgar score, which is measured 1 and 5 minutes after birth. The existing literature tends to focus on a very limited set of birth outcomes, most notably birth weight and gestation. This study breaks new ground by also looking at height at birth and the Apgar score carried out 5 minutes after the full birth of the baby. We use the 5 minute Apgar score because it is regarded as more reflective of the baby's overall health and more predictive of survival and neurologic abnormalities at one year of age (Chase and Greenberg, 1965; James, 1960). Birth records also include other important information about the child (sex, birth order, and multiple births), the mother (age and educational attainment), the method of delivery (vaginal, caesarean section or instrumented), and birth location (health institute, home, other).

We analyze both weight at birth (measured in grams) and an indicator for normal weight, which takes the value of one if the weight of the liveborn infant is more than 2,500 grams. We use the 2,500 cutoff because the medical literature has identified it as the threshold over which the probability of perinatal mortality and morbidity, inhibited growth and cognitive development, and chronic diseases later in life drops substantially. We also construct and indicator for full term baby taking the value of one if the baby is born at 38 weeks of gestation or more and is zero otherwise. Our fourth health outcome is length at birth (in centimeters). Lastly, we use a dummy variable that indicates overall health of the newborn based on an Apgar score of at least 8 points, which is the cutoff point used in the medical literature.

The Colombian registry is also unique in that it can be merged with the temperature and rainfall data based on the mother's municipality of residence. We use information on the children's date of birth and municipality of residence of the mother to calculate whether a child was exposed to a weather shock during the mother's pregnancy (1st, 2nd, or 3rd trimester) counting backwards from the time of the birth.

Between 1999 and 2008, 7.215 million births occurred in Colombia. The analysis sample is limited to rural areas, 1.498 million births (which represent approximately 20% of all births) We also limit the sample to first births, as there are well-known differences in average outcomes by birth order (Currie and Moretti, 2003). This decision yields a potential sample of 425,403 births. We drop information on births with missing maternal and child characteristics, which leaves us with 410,837 observations. We also drop the 4,774 observations with birth at weight below the 1 percentile (less than 1,500 grams) and above the 99 percentile (more than 4,300 grams).

2.2 Data on weather shocks

The climatic data used to measure the presence of severe weather shocks in Colombia are publicly available and come from the University of East Anglia Climate Research Unit (UEA CRU-TS2p1). The data are monthly time-series of temperature and rainfall from 1901 to 2008. The monthly series are available as interpolated gridded data with a spatial resolution of 0.5 x 0.5 degrees (Mitchell, 2005). This data set was spatially merged with a map of Colombia for 2009 with the geographic limits to construct a longitudinal data set with information on precipitation and temperature at the municipality level over the period 1901 to 2008.

In the estimations, binary variables for exposure to a rainy (possibly flood) or dry (possibly drought) event and a hot or cold wave are used to analyze the impact of weather shocks during pregnancy on health outcomes at birth. These variables are based on the standardized precipitation and temperature z-scores, which measure the number of standard deviations from the long-term mean (1901-1997) for each municipality-month pair. The use of standardized precipitation and temperature z-scores to identify weather shocks is supported by extensive applications in the climatology literature (Heim 2002; Keyantash and Dracup 2002). The threshold to identify weather shocks in the main analysis is 0.7/-0.7 standard deviations. A flood (heat wave) in the municipality-month of birth is identified whenever the standardized precipitation (temperature) z-score is above 0.7 standard deviations from the long-term mean. A drought (cold wave) month in the municipality-month of birth is identified whenever the standardized precipitation (temperature) z-score is below

0.7 standard deviations from the long-term mean. In sensitivity analysis we assess the relevance of the cutoff point used to define the shock by changing the threshold to 1/-1 standard deviations.

Table 1 shows the distribution of rainfall and temperature weather shocks by municipality-month of birth pairs (events) over the period 1999 to 2008. The table shows sufficient climate variability in both rainfall and temperatures. Floods are the most common weather event. 21.8% of the municipality-month pairs experienced a drought and in 32.8% a flood was registered. In terms of temperature, 26.9% experienced cold weather and 21.1% experienced a heat wave. Using the +/- 1 S.D. cutoff, extreme floods are also the most frequent shocks. We see that 24.9% are classified as extreme floods and 13.8% as extreme heat waves; 13.6% of the events can be classified as extreme droughts and 18.1% as extreme cold events.

Figure 1 shows the variation in the share of municipalities that experienced weather shocks by month and year from 1999 to 2008. Panel A shows the distribution of rainfall and Panel B shows the distribution of temperatures. Both panels show that there is substantial within month variation across years. To take an example, Panel A shows that in January of 2006 there was a high incidence of municipalities with z-scores above 0.7 s.d. (corresponding to 18.3% of the municipalities). In January of the following year, the rainfall in most municipalities was between -0.7 and 0.7 s.d., but a significant share of municipalities experienced rainfall below 0.7 s.d. of the historic mean (corresponding to 52.3% of the municipalities). In January of 2008 all municipalities recorded a rainfall at or close to the average, so neither positive nor negative precipitation shocks were registered. This variation highlights that children who were born in the same month of consecutive years were exposed to different climate even if born in the same municipality.

Table 2 presents summary statistics (means and standard deviations) for our main analysis sample of births in rural areas of Colombia between 1998 and 2009. The average birth weight for children in the sample is 3,079 grams, and 89 percent of children have a healthy weight at birth (weigh at least 2,500, the standard cutoff for low birth weight used in the medical literature). The average length at birth is 49.3 cm. 98 percent of babies have a normal Apgar test score 5 minutes after birth and 86 percent of them are considered to have been born at term (at least 38 weeks of gestation). In each trimester of pregnancy, about 50 percent of children were exposed to a dry event, about 65 percent were exposed to a rainy event (this is unsurprising because extensive rainfall has been observed in recent years in Colombia), about 45 to 48 percent were exposed to a cold wave and about 35 to 37 percent were exposed to a heat wave.

3. Econometric Framework and Identification Strategy

The analysis of the impacts of weather shocks on birth outcomes model is based on the following specification, which we estimate using Ordinary Least Squares (OLS):

$$Y_{i,j,m,\mathrm{y}} = \alpha + \beta Shock_{j,m,\mathrm{y}} + \theta_{\mathrm{j}} + \delta_m + \tau_{\mathrm{y}} + \varepsilon_{i,j,m,\mathrm{y}}, \quad (1)$$

where $Y_{i,j,m,y}$ is the birth outcome of child *i*, born in municipality *j*, in month *m* and year *y*. $Shock_{\mathrm{j,m,y}}$ is an indicator for whether the child was exposed to a weather shock (heat or cold wave, flood and drought) in his municipality of in at least one month while she was *in utero*. This specification includes municipality of birth fixed effects θ_{j}. The vector δ_m are month of birth fixed effects, while the vector τ_{y} are birth year fixed effects, and $\varepsilon_{i,j,m,\mathrm{y}}$ is a child-specific error term. Standard errors are clustered at the municipality level (1,014 clusters).

The identification strategy relies on the unpredictability of the timing of extreme weather events. We control for selection into areas that, for example, might be more prone to be hit by weather shocks and might be more disadvantaged in terms of health care infrastructure by including municipality fixed effects. We also control for overall seasonal effects by including year and month birth fixed effects. After controlling for municipality, year and month of birth fixed effects, our identification strategy relies on the fact that weather shocks while *in utero* are uncorrelated with any latent determinants of birth outcomes, such as mother and child characteristics. Under our identification strategy, the inclusion of mother and child characteristics should have no effect on the estimated relationship between weather shocks and outcomes at birth, so our main regressions exclude mother and child characteristics. In sensitivity analysis we show that including a set of mother and child characteristics $X_{i,j,m,y}$ does not affect the main results. Denoting with * the omitted category, the mother's characteristics include age, education levels (primary*, secondary or high school, tertiary) and the child characteristics include an indicator for whether the baby is a boy, and an indicator for multiple births.

To examine whether there are "key periods" during pregnancy when exposure to a weather event is more likely to result in worse birth outcomes we re-estimate the model in (1) varying the timing of exposure to the shock. In particular, we estimate:

$$Y_{i,j,m,y} = \alpha + \beta^1 Shock\_trim1_{j,m,y} + \beta^2 Shock\_trim2_{j,m,y} + \beta^3 Shock\_trim3_{j,m,y} + \theta_j + \delta_m + \tau_y + \varepsilon_{i,j,m,y} \quad (2)$$

In equation 2, $Shock\_trim1$ is an indicator equal to 1 if an extreme weather event occurred in the child's municipality of birth during the first trimester of her mother's pregnancy, and 0 otherwise. W_trim2 and W_trim3 are similar indicators for the second and third trimesters, respectively.

4. Findings

4.1 Effects of exposure to weather shocks during pregnancy

Table 3 presents the main results of the effect of temperature and rainfall variations on the five health outcomes at birth we analyze: weight, normal weight (>2,500 grams), length, full-term (>=38 weeks) and healthy Apgar (score>=8). The first two rows of table 3 show the effects of temperature variations and the last two rows the effects of rainfall shocks. In all cases we measure the effect of having experienced a weather shock in at least one month while *in utero*. The newborn is considered to have experienced a weather shock in a given month if the rainfall or temperature in her municipality of birth was above or below 0.7 standard deviations with respect to historical monthly-specific mean. For each outcome we report the specification that controls for municipality, month and year of birth fixed effects. Clustered standard errors at the municipality level are reported in parentheses.

Table 3 shows that experiencing a cold wave during pregnancy increases the likelihood of having a normal Apgar score 5 minutes after birth, but does not affect any of the other outcomes. To our knowledge, this is the first study documenting the effects of cold waves on outcomes at birth. Now, experiencing a heat wave in at least one month while the mother is pregnant reduces the probability of birth at full term and to likelihood to be a healthy newborn, as measured by the Apgar score. Temperatures hotter than average do not seem to affect birth weight outcomes in rural Colombia, which contrasts with the findings by Deschênes et al. (2011), who found that extreme hot temperatures in the U.S. reduced birth weight. As evidenced by our findings and those of the handful of previous studies, heat waves either have none or detrimental effects on health outcomes (Burgess et al., 2014; Deschênes et al., 2009; Deschênes and Moretti, 2009; Deschênes and Greenstone, 2011).

Table 3 also shows that exposure to a dry month while *in utero* in Colombia increases the probability of being classified as a baby with normal weight at birth (>2500 grams) and increases the Apgar score. Unlike Rocha and Soares (2012), we do not find evidence that rain scarcity reduces birth weight or the likelihood of full-term pregnancies in a statistical sense at conventional levels of significance. *Fetal* exposure to extensive rain at any point in pregnancy does not significantly affect any of the health outcomes at birth we study. This is in line with previous studies finding no evidence to support that positive rainfall shocks affect infant height, weight and cognitive ability in Mexico (Aguilar and Vicarelli, 2011) or that they affect adult health, education and labor outcomes in Indonesia (Maccini and Yang, 2009).

In line with previous studies, the effects of weather shocks are small in magnitude. Our study also shows that the positive effect of cold waves and the negative effect of heat waves are similar in magnitude. For example, exposure to temperatures 0.7 standard deviations above the long-term average in at least one month during pregnancy leads to a 0.5 percentage point reduction in the probability to be born at full term, as compared to an average of 88.8%. Exposure to temperatures 0.7 standard deviations below the historical mean raises by 0.05 the percentage of newborns classified as healthy 5 minutes after birth.

4.2 Effects of exposure to a weather shock at each trimester of pregnancy

A natural extension is to consider whether the timing of exposure to weather events matters. We report estimates from equation (2), which includes weather shocks during each trimester of the mother's pregnancy. In this specification, a child is considered to have been exposed to a weather shock in the first trimester of her mother's pregnancy if there was a weather shock in her municipality of birth during any of the first three months she was *in utero*. These results are reported in Table 4. For ease of comparison, we repeated the basic specification that measures exposure in any month during pregnancy.

The results reported in Table 4 show substantial heterogeneity in the timing of exposure across outcomes. A cold wave in any trimester of the mother's pregnancy does not affect weight at birth, but leads to other health outcomes. Although the effects remain small, they are statistically significant for the length of gestation and the Apgar score in the third trimester. They are also significant for the Apgar score in the second trimester. Also, exposure to a cold wave during the second and third trimesters of pregnancy increases length at birth, but the effect is only significant at the 10% level.

Table 4 also shows that exposure to hotter than average temperatures at any point during pregnancy does not affect weight at birth, but has pervasive effects on other health outcomes. A heat wave reduces the likelihood of being born at full term if exposure occurs during the first or second trimester and decreases the likelihood of having a healthy score in the Apgar test 5 minutes after birth if exposure occurs at any time during pregnancy. Although we fail to find a significant effect of a heat wave's exposure at any point in the mother's pregnancy on length at birth, the results in Table 4 point to a negative, substantial effect if exposure occurs in the third trimester.

The bottom half of Table 4 shows that exposure to scarce rainfall in the third quarter of pregnancy raises the probability of being born at full term, but the effect is only significant at the 10% level. Positive or negative rainfall shocks during the second or third trimester of pregnancy does not significantly affect any of the other outcomes we analyze. The positive effect of exposure to dry weather on the Apgar test 5 minutes after birth is driven by the effect in the first trimester. Also, although we did not find that exposure to extensive rainfall at any point of the pregnancy significantly affects length at birth; we do find that it has a positive effect if exposure occurs during the first trimester of pregnancy.

4.3 Internal validity of the estimates

The estimates in the previous section rest on the assumption that children who faced weather shocks while *in utero* are similar to those who were not exposed to them after controlling for month, year and municipality of birth fixed effects. We provide evidence that exposure to weather shocks is random estimating exposure of weather shock effects with covariates included. If exposure to weather shocks is random, the effect of weather shocks on birth outcomes should be insensitive to the inclusion of maternal and child covariates.

Panel B of Table 5 shows coefficient estimates of weather shocks that include maternal and child characteristics in addition to the municipality, month and year of birth fixed effects. Denoting with * the omitted category, the mother's characteristics include age, education levels (primary*, secondary or high school, tertiary) and the child characteristics include an indicator for a baby boy, and an indicator for multiple births. Panel A in Table 5 reproduces the baseline estimates that exclude maternal and child characteristics. It is reassuring to see that the sign, magnitude and significance of most of the estimated coefficients obtained with covariates included are nearly identical to those obtained when the covariates are excluded.[10] This evidence supports the hypothesis that exposure to weather shocks is random, indicating that the effects estimated in the previous section are internally valid.

4.4. Robustness tests

A *priori,* it is not clear whether more extreme weather shocks have a larger or smaller effect on birth outcomes than milder ones. Extreme weather events could have larger effects if, for example, they affect prices of food or other health inputs. But it is also possible that in the event of extreme weather events, pregnant women are better able to protect themselves and their offspring by receiving help from formal and informal safety networks, such as relatives or social programs. The effect of extreme weather shocks versus milder ones is thus an empirical question. Our measures of weather shocks in our baseline specifications are based on temperatures and rainfall that are 0.7 standard deviations above and below the historic monthly-specific mean. We examine how sensitive are the results to more extreme weather events by varying the threshold used to define the shock adopting the cut-off of 1 standard deviation from the mean.

Table 6 compares the results of the effects of mild weather shocks (Panel A) and extreme ones (Panel B). The effects of exposure to a mild or severe hot, dry or rainy event while *in utero* are very similar. Cold waves continue to be health improving when we consider a more extreme version of the shocks, but the outcome affected does depend on the severity of the shock. In particular, exposure to a cold event while *in utero* has a positive effect on the probability of testing normal in the

[10] All other covariates behave as expected. The older the mother the healthier the baby is born, but the positive effect on health outcomes decreases with age. Mother's education affects positively all outcomes and it does so more if the mother has tertiary education. Boys are heavier and taller than girls, but are less likely to be born at full term or to have a healthy Apgar score. The effect of multiple births on health outcomes is negative.

Apgar score 5 minutes after birth, but the effect disappears when the baby is exposed to an extremely cold event. In contrast, an extremely cold event has a positive effect on the likelihood of being born at term (at least 38 weeks of gestation), but a milder cold wave has no effect on this outcome.

5. Conclusion

This paper finds that the health of Colombian newborns is highly sensitive to exposure to weather shocks while *in utero*. We examine the effect of temperature and rainfall shocks on a wide arrange of outcomes at birth of Colombians born between 1999 and 2008. The health of babies is generally not affected by exposure to rainfall shocks during *fetal* life. However, exposure to cold shocks improves, and exposure to hot shocks worsens, certain health indicators. The effects are sensitive to the timing of exposure to the shock (1^{st}, 2^{nd} or 3^{rd} trimester of pregnancy). For example, exposure to a cold shock in the third trimester of pregnancy increases the proportion of births that are full-term by 0.6 percentage points and the share of healthy born babies by 0.4 percentage points. In contrast, exposure to heat waves at any point in the pregnancy reduces the share of babies born at full term by 0.5 percentage points and the share of healthy babies by 0.4 percentage points. Birth weight outcomes are not affected by weather shocks during *fetal* life.

These results relate to a growing literature in development and health economics that documents the sensitivity of health outcomes at birth in developing countries to varying types of shocks and conditions while *in utero* (e.g. Camacho, 2008; Rocha and Soares, 2012). The results are also related to the body of research in economics that has analyzed the effects of weather shocks, particularly floods and droughts, on individual wellbeing during childhood and adulthood. The evidence in this paper suggests that temperature shocks, which have largely been ignored by the previous literature, have detrimental effects on health outcomes at birth. This suggests that the coping strategies allowing pregnant women to protect their offspring in the event of a heat wave in Colombia are only partial. What makes this last result so striking is that the incidence and frequency of hot shocks in Colombia and worldwide are increasing and will continue to increase as a result of climate change.

Our findings that newborns are vulnerable to environmental conditions have important implications for policy. The long-run effects of health at birth on later health, schooling, and income, and their implications for economic mobility should be factored into cost-benefit analyses of programs targeting this subpopulation. Our findings provide additional justification for interventions that shield infants from the health consequences of temporary environmental shocks, such as food security policies, weather insurance, social insurance schemes and public health investments. However, future research should aim to enhance our understanding of the mechanisms that lead weather shocks to affect health outcomes at birth and other measures of individual welfare, as this will aid policy makers to prioritize the interventions that are more likely to counteract the effects of weather shocks associated with climate change.

References

Aguilar, A., & Vicarelli, M. 2011. *El Niño and Mexican Children: Medium-term Effects of Early-life Weather Shocks on Cognitive and Health Outcomes.*

Alderman, Harold, Hoddinott, John, & Kinsey, Bill. 2006. Long term consequences of early childhood malnutrition. *Oxford Economic Papers*, **58**(3), 450–474.

Almond, Douglas. 2006. Is the 1972 influenza pandemic over? Long-term effects of in utero influenza exposure in the post-1940 U.S. population. *Journal of Political Economy*, **114**(4), 672–712.

Almond, Douglas, & Currie, Janet. 2011. Killing Me Softly: The Fetal Origins Hypothesis. *Journal of Economic Perspectives*, **25**(3), 153–172.

Almond, Douglas, & Mazumder, Bhashkar. 2011. Health capital and the prenatal environment: the effect of Ramadan observance during pregnancy. *American Economic Journal: Appied Economics*, **3**(4), 56–85.

Almond, Douglas, Chay, Kenneth Y., & Lee, David S. 2005. The Costs of Low Birth Weight. *Quarterly Journal of Economics*, **120**(3), 1031–1083.

Behrman, Jere R., & Rosenzweig, Mark R. 2004. Returns to Birthweight. *The Review of Economics and Statistics*, **86**(2), pp. 586–601.

Black, S. E., Devereux, P.J., & Salvanes, K.G. 2007. From the Cradle to the Labor Mar- ket? The Effect of Birth Weight on Adult Outcomes. *Quarterly Journal of Economics*, **122**(1), 409–439.

Burgess, Robin, Deschênes, Olivier, Donaldson, Dave, & Greenstone, Michael. 2014 (May). *The Unequal Effects of Weather and Climate Change: Evidence from Mortality in India.*

Camacho, Adriana. 2008. Stress and Birth Weight: Evidence from Terrorist Attacks. *American Economic Review: Papers and Proceedings*, **98**(2), 511–515.

Campos G, Ana, Holm-Nielsen, Niels, Díaz G, Carolina, Rubiano V, Diana M, Costa P, Carlos R, Ramírez C, Fernando, & Dickson, Eric. 2012. *Analysis of Disaster Risk Management in Colombia A Contribution to the Creation of Public Policies*. Tech. rept. The World Bank Colombia and GFDRR.

Case, A., & Paxson, C. 2006. Childrens health and social mobility. *The Future of Children*, **16**(2), 151–73.

Case, A., & Paxson, C. 2008. Stature and status: height, ability, and labor market outcomes. *Journal of Political Economy*, **116**(3), 499–532.

Catarious, David M, & Espach, Ralph H. 2009. *Impacts of Climate Change on Colombia's National and Regional Security*. Tech. rept. CNA Analysis and Solutions.

Conroy, Hector V., Skoufias, Emmanuel, & Vinha, Katja. 2011. The impacts of climate variability on welfare in rural Mexico.

Currie, Janet 2009. Healthy, Wealthy, and Wise: Socioeconomic Status, Poor Health in Childhood, and Human Capital Development. *Journal of Economic Literature*, **47**, 87–122.

Currie, Janet & Moretti, Enrico. 2003. Mothers Education and the Intergenerational Transmission of Human Capital: Evidence from College Openings. *Quarterly Journal of Economics*, **118**(4), 1495–1532.

Currie, Janet, & Rossin-Slaterc, Maya. 2013. Weathering the storm: Hurricanes and birth outcomes. *Journal of Health Economics*, **32**, 487–503.

Deschênes, Olivier, & Greenstone, Michael. 2011. Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the US: Dataset. *American Economic Journal: Applied Economics*, **3**(October), 152–185.

Deschênes, Olivier, & Moretti, Enrico. 2009. Extreme Weather Events, Mortality, and Migration. *Review of Economics and Statistics*, **91**(4), 659–81.

Deschênes, Olivier, Greenstone, Michael, & Guryan, Jonathan. 2011. Climate Change and Birth Weight. *American Economic Review: Papers and Proceedings*, **99**(2), 211–217.

Duflo, Esther. 2001. Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment. *American Economic Review*, **91**(4), 795–813.

Dunkel-Schetter, C. 2011. Psychological science on pregnancy: stress processes, biopsychosocial models, and emerging research issues. *Annual Review of Psychology*, **62**, 531–558.

Eccleston, M. 2011 (November). *In Utero Exposure to Maternal Stress: Effects of 9/11 on Birth and Early Schooling Outcomes in New York City.*

Giné, Xavier, Townsend, Robert, & Vickery, James. 2008. Patterns of Rainfall Insurance Participation in Rural India. *World Bank Economic Review*, **22**, 539–566.

Glewwe, P.and Jacoby, H., & King, E. 2001. Early Childhood Nutrition and Academic Achievement: A Longitudinal Analysis. *Journal of Public Economics*, **81**, 345–368.

Germanwatch. 2011. Global Climate Risk Index 2012: Who suffers most from extreme weather events? Weather-related loss events in 20010 and 1991-2010. -- Bonn, Germany.

Heim, Richard. 2002. A review of twentieth-century drought indices used in the United States. *Bulletin of the American Meteorological Society*, **84**, 1149–1165.

Hoddinott, John. 2006. Shocks and their consequences across and within households in Rural Zimbabwe. *Journal of Development Studies*, **42**(2), 301–321.

Hoddinott, John, & Kinsey, Bill. 2001. Child Growth in the Time of Drought. *Oxford Bulletin of Economics and Statistics*, **63**(4), 409–436.

IPCC. 2007. *Fourth Assessment Report: Climate Change 2007. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Tech. rept. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Keyantash, John & Dracup, John. 2004. An aggregate drought index: assessing drought severity based on uctuations in the hydrological cycle and surface water storage. *Water Resources Research*, **40**(W09304).

Kudamatsu, M., Persson, T., & Strmberg, D. 2012. Weather and Infant Mortality in Africa. *CEPR Discussion Paper, No. 9222*, **November**.

Maccini, Sharon, & Yang, Dean. 2009. Under the Weather: Health, Schooling and Economic Consequences of Early-Life Rainfall. *American Economic Review*, **99**(3), 1006–1026.

Maida, C.A. 1989. Psychological Impact of disasters: victims of the Baldwin Hills Fire. *Journal of Traumatic Stress*, **10**.

Mansour, H., & Rees, D. 2011. Prenatal Stress on Birth Weight: Evidence from the Al-Aqsa Intifada. *IZA DP No. 5535*.

Mitchell, Timothy D. 2005. An improved method of constructing a database of monthly climate observations and associated high resolution grids. International Journal of Climatology, **10**, 693–712.

Rocha, R., & Soares, R. 2012. Water Scarcity and Birth Outcomes in the Brazilian Semiarid.*IZA Discussion Paper No. 6773*.

Rose, E. 1999. Consumption Smoothing and Excess Female Mortality in Rural India. *The Review of Economics and Statistics*, **81**(1), 41–49.

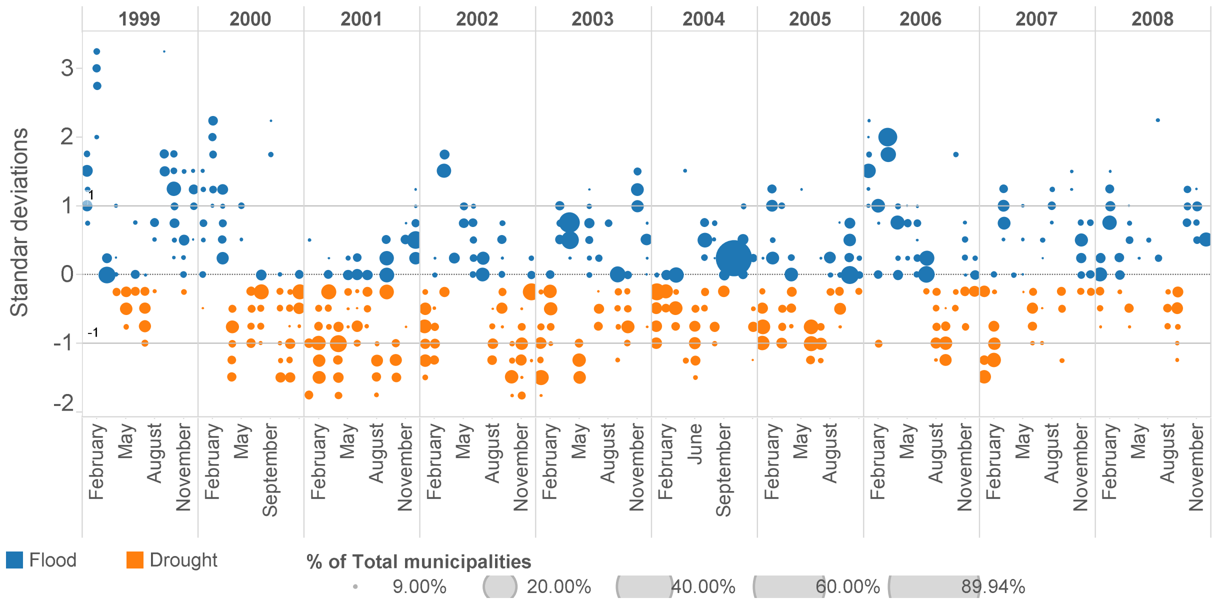
Shore, J.H., Tatum, E.L., & Vollmer, W.M. 1986. Evaluation of Mental Effects of disaster, Mount St. Helens Eruption. *American Journal of Public Health*, **76**(Suppl), 76–83.

Simeonova, Emilia. 2009. Out of Sight, Out of Mind? The Impact of Natural Disasters on Pregnancy Outcomes. *CESIFO Working Paper No. 2814*, October.

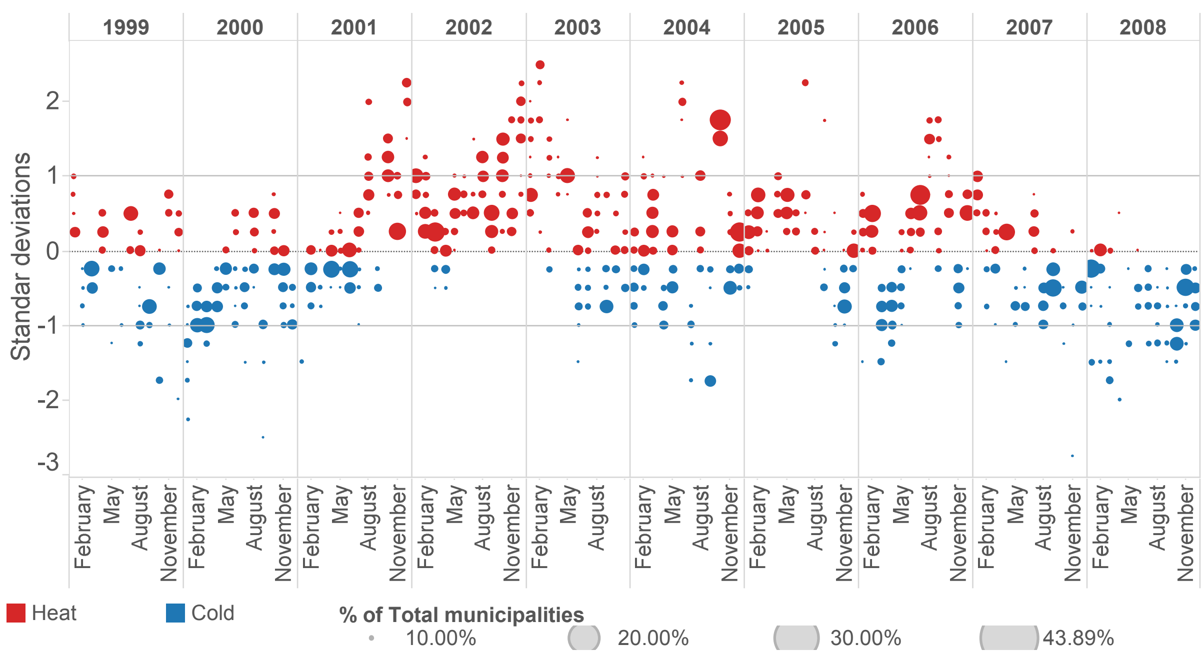
Torche, Florencia. 2011. The effect of maternal stress on birth outcomes: exploiting a natural experiment. *Demography*, **48**(4), 1473–1491.

Figure 1. Z-scores of rainfall and temperature by month over the period 1998-2008

A. Rainfall



B. Temperature



Note: The temperatures and precipitations values that are concentrated by a number of municipalities below 10% was not considered in the graph. The values of temperature and rainfall were grouped for each 0.25 standard deviations.

Table 1. Distribution of the weather shocks in the sample by municipality-month of birth

Weather shock	Rainfall		Temperature		S.D from historic mean	Rainfall		Temperature	
	Freq	%	Freq	%		Freq	%	Freq	%
Drought/Cold < -0.7 S.D.	20,468	21.8	25,319	26.9	< -1	12,739	13.6	17,022	18.1
					-0.7 to -1	7,729	8.2	8,297	8.8
Normal Weather	42,727	45.5	48,845	52.0	-0.7 and 0.7	42,727	45.5	48,845	52.0
Flood/Hot >0.7 S.D.	30,777	32.8	19,808	21.1	0.7 to 1	7,379	7.9	6,838	7.3
					>1	23,398	24.9	12,970	13.8
Total	93,972	100	93,972	100	Total	93,972	100	93,972	100

Table 2. Descriptive Statistics

Variable	Mean	S.D.
a. Outcomes		
Birth weight (grams)	3079.8	449.2
Normal weight (% with weight>2500 gr)	88.8	31.5
Full-term baby (% born >=38 weeks)	86.2	34.5
Length (cm.)	49.3	2.5
Healthy Apgar (% with score>=8 points)	98.3	13.1
b. Weather shocks		
Cold third trimester of pregnancy (%)	48.1	50.0
Cold second trimester of pregnancy (%)	46.1	49.9
Cold first trimester of pregnancy (%)	44.7	49.7
Cold at least one month in pregnancy (%)	66.9	47.1
Hot third trimester of pregnancy (%)	34.5	47.5
Hot second trimester of pregnancy (%)	36.0	48.0
Hot first trimester of pregnancy (%)	37.3	48.4
Hot at least one month in pregnancy (%)	57.1	49.5
Drought third trimester of pregnancy (%)	49.3	50.0
Drought second trimester of pregnancy (%)	49.0	50.0
Drought first trimester of pregnancy (%)	48.7	50.0
Drought at least one month in pregnancy (%)	82.8	37.8
Flood third trimester of pregnancy (%)	65.2	47.6
Flood second trimester of pregnancy (%)	65.0	47.7
Flood first trimester of pregnancy (%)	64.8	47.8
Flood at least one month in pregnancy (%)	93.4	24.9
c. **Maternal and Child Characteristics**		
Mother's age (years)	19.7	4.4
Baby boy (%)	51.3	50.0
Multiple births (%)	2.5	15.7
Mother's education elementary (%)	47.0	49.9
Mother's education secondary or high school (%)	50.1	50.0
Mother's education tertiary (%)	2.9	16.7
Observations	406,063	

Note: Weather shocks are defined based on +/-0.7 S.D. from the historic month-specific long-run average in the municipality of birth. We report statistics for shocks that could have been experienced in at least one month during pregnancy (e.g. cold at least one month in pregnancy) and shocks to which newborns were exposed during at least one month in each of the trimesters (e.g. cold third trimester of pregnancy).

Table 3. Effect of temperature and rainfall shocks during pregnancy on birth outcomes

	Weight	Weight normal	Full term	Length	Healthy Apgar
Cold	0.593	-0.000	0.002	0.000	**0.005*** **
	(2.388)	(0.002)	(0.002)	(0.014)	**(0.001)**
Hot	-3.531	0.000	**-0.005*** **	-0.018	**-0.004*** **
	(2.015)	(0.001)	**(0.002)**	(0.012)	**(0.001)**
Drought	-2.014	**0.004*** **	0.002	-0.010	**0.004*** **
	(2.378)	**(0.002)**	(0.002)	(0.013)	**(0.001)**
Flood	5.061	0.001	0.004	-0.024	0.002
	(3.319)	(0.002)	(0.002)	(0.019)	(0.001)
Observations	406,063	406,063	396,613	403,954	383,541

Note: Each cell corresponds to a different regression. Regressions also include municipality of birth fixed effects, month of birth fixed effects and year of birth fixed effects. Clustered standard errors at the municipality level in parentheses. *** p<0.01, **p<0.05.

Table 4. Effect of temperature and rainfall shocks in each trimester of pregnancy on birth outcomes

	Weight	Weight normal	Full term	Length	Healthy Apgar
Cold any month in pregnancy	0.593	-0.000	0.002	0.000	**0.005*** **
	(2.388)	(0.002)	(0.002)	(0.014)	**(0.001)**
Cold trimester 3	1.975	0.002	**0.006*** **	0.019	**0.004*** **
	(2.133)	(0.001)	**(0.002)**	(0.012)	**(0.001)**
Cold trimester 2	1.568	-0.001	0.001	0.019	**0.002** **
	(2.051)	(0.001)	(0.002)	(0.011)	**(0.001)**
Cold trimester 1	0.173	-0.000	0.001	0.005	0.000
	(2.082)	(0.001)	(0.002)	(0.011)	(0.001)
Hot any month in pregnancy	-3.531	0.000	**-0.005*** **	-0.018	**-0.004*** **
	(2.015)	(0.001)	**(0.002)**	(0.012)	**(0.001)**
Hot trimester 3	-2.788	-0.000	-0.001	**-0.032*** **	**-0.006*** **
	(2.041)	(0.002)	(0.002)	**(0.012)**	**(0.001)**
Hot trimester 2	0.735	0.001	**-0.005*** **	-0.002	**-0.003*** **
	(1.945)	(0.001)	**(0.002)**	(0.012)	**(0.001)**
Hot trimester 1	-2.493	-0.001	**-0.004** **	-0.019	**-0.003*** **
	(2.138)	(0.001)	**(0.002)**	(0.013)	**(0.001)**
Drought any month in pregnancy	-2.014	**0.004*** **	0.002	-0.010	**0.004*** **
	(2.378)	**(0.002)**	(0.002)	(0.013)	**(0.001)**
Drought trimester 3	0.269	0.002	0.001	0.011	0.001
	(1.686)	(0.001)	(0.001)	(0.010)	(0.001)
Drought trimester 2	-1.332	0.001	0.001	-0.006	-0.000
	(1.596)	(0.001)	(0.001)	(0.009)	(0.001)
Drought trimester 1	0.250	0.002	0.001	0.015	**0.003*** **
	(1.646)	(0.001)	(0.001)	(0.009)	**(0.001)**
Flood any month in pregnancy	5.061	0.001	0.004	-0.024	0.002
	(3.319)	(0.002)	(0.002)	(0.019)	(0.001)
Flood trimester 3	-0.172	-0.001	-0.002	0.002	0.001
	(1.767)	(0.001)	(0.001)	(0.009)	(0.001)
Flood trimester 2	1.891	-0.001	0.002	0.008	-0.000
	(1.811)	(0.001)	(0.001)	(0.010)	(0.001)
Flood trimester 1	1.891	0.001	0.001	**0.025*** **	-0.000
	(1.775)	(0.001)	(0.001)	**(0.009)**	(0.001)
Observations	406,063	406,063	396,613	403,954	383,541

Note: Each regression is separated by a horizontal line. All regressions also include municipality of birth fixed effects, month of birth fixed effects and year of birth fixed effects. Clustered standard errors at the municipality level in parentheses. *** p<0.01, **p<0.05.

Table 5. Effect of temperature and rainfall shocks during pregnancy on birth outcomes: a test of the validity of the identification strategy

	Weight	Weight normal	Full term	Length	Healthy Apgar
A. Excluding child and maternal characteristics					
Cold	0.593	-0.000	0.002	0.000	**0.005*****
	(2.388)	(0.002)	(0.002)	(0.014)	**(0.001)**
Hot	-3.531	0.000	**-0.005*****	-0.018	**-0.004*****
	(2.015)	(0.001)	**(0.002)**	(0.012)	**(0.001)**
Drought	-2.014	**0.004*****	0.002	-0.010	**0.004*****
	(2.378)	**(0.002)**	(0.002)	(0.013)	**(0.001)**
Flood	5.061	0.001	0.004	-0.024	0.002
	(3.319)	(0.002)	(0.002)	(0.019)	(0.001)
B. Including child and maternal characteristics					
Cold	-0.096	-0.000	0.002	-0.003	**0.005*****
	(2.347)	(0.002)	(0.002)	(0.014)	**(0.001)**
Hot	-3.498	-0.000	**-0.005*****	-0.018	**-0.004*****
	(1.970)	(0.001)	**(0.002)**	(0.012)	**(0.001)**
Drought	-1.450	**0.005*****	0.002	-0.007	**0.004*****
	(2.307)	**(0.001)**	(0.002)	(0.013)	**(0.001)**
Flood	5.586	0.002	0.005	-0.022	0.002
	(3.293)	(0.002)	(0.002)	(0.019)	(0.001)
Observations	406,063	406,063	396,613	403,954	383,541

Note: Each cell corresponds to a different regression. All regressions also include municipality of birth fixed effects, month of birth fixed effects and year of birth fixed effects. Regressions in panel b include mother's age and education levels (primary*, secondary or high school, tertiary) and indicators for wether the child is a boy or was born in a multiple births. Clustered standard errors at the municipality level in parentheses. ******* $p<0.01$, ******$p<0.05$.

Table 6. Comparison of the effects of weather shocks and extreme weather shocks on birth outcomes

	Weight	Weight normal	Full term	Length	Healthy Apgar
A. Weather shocks					
Cold	0.593	-0.000	0.002	0.000	**0.005*** **
	(2.388)	(0.002)	(0.002)	(0.014)	**(0.001)**
Hot	-3.531	0.000	**-0.005*** **	-0.018	**-0.004*** **
	(2.015)	(0.001)	**(0.002)**	(0.012)	**(0.001)**
Drought	-2.014	**0.004*** **	0.002	-0.010	**0.004*** **
	(2.378)	**(0.002)**	(0.002)	(0.013)	**(0.001)**
Flood	5.061	0.001	0.004	-0.024	0.002
	(3.319)	(0.002)	(0.002)	(0.019)	(0.001)
B. Extreme weather shocks					
Extremely cold	-0.897	-0.000	**0.004** **	0.026	0.001
	(2.461)	(0.002)	**(0.002)**	(0.014)	(0.001)
Extremely hot	-1.793	-0.001	**-0.003** **	-0.016	**-0.005*** **
	(2.008)	(0.001)	**(0.002)**	(0.012)	**(0.001)**
Extreme drought	1.127	**0.004*** **	0.001	0.013	**0.003*** **
	(2.043)	**(0.001)**	(0.001)	(0.012)	**(0.001)**
Extreme flood	2.823	0.000	0.003	-0.004	0.001
	(2.512)	(0.002)	(0.002)	(0.015)	(0.001)
Observations	406,063	406,063	396,613	403,954	383,541

Note: Each cell corresponds to a different regression. All regressions also include municipality of birth fixed effects, month of birth fixed effects and year of birth fixed effects. Weather shocks in panel *a* are based on a cutoff of +/-0.7 sd with respect to the historic mean. Extreme weather shocks in panel *b* are based on a cutoff of +/- 1 sd with respect to the historic mean. Clustered standard errors at the municipality level in parentheses. ******* p<0.01, ******p<0.05.