The Impact of Climatic shocks on children's health in India

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Abstract: While there is little evidence of discrimination against girls in the allocation of resources within a household under normal circumstances, it would be worthwhile to explore the effect of extreme conditions such as rainfall shocks on the outcomes of surviving girls and boys. I explore two channels through which rainfall affects child health: by affecting time spent by mothers in childcare particularly breastfeeding (as rainfall affects demand for mother's labour on the farm) and through income (as rainfall generates variation in income through its effect on agricultural output). In this paper, I estimate the impact of rainfall shocks around the time of birth on the probability of being breastfed as well as anthropometric outcomes of girls and boys aged 13-35 months in rural India. I find that adverse negative rainfall shocks negatively impact height for age and weight for age for both girls and boys. On the other hand, above average rainfall increases the risk of termination of breastfeeding.

Keywords: breastfeeding, anthropometric outcomes, rainfall shock, India

1 Introduction

The relative status of women in the developing world is poor, compared to developed countries. The literature has highlighted the existence of gender inequalities in South Asia, attributed to strong preferences for male offspring stemming from cultural and traditional customs. Further, households in India, as in much of the developing world, face substantial risk - an inevitable consequence of engaging in rain-fed agriculture in a drought-prone environment. This further affects the ability of households to provide for their families and invest in children. Investments in children and human capital are central to enhance the well being of households, break the inter-generational transmission of poverty and finally lead to the growth and development of a country.

One of the most important forms of risk arises from rainfall. In an influential paper, Duflo (2005) concludes that "even in the countries where the preference for boys is strongest, it is hard to find evidence that girls receive less care than boys under normal circumstances". But what happens under abnormal circumstances like shocks faced by households? I seek to address this question by looking at the impact of rainfall shocks in infancy on children's health in rural India.

Even though it has been well established that rainfall shocks in developing countries may have important impacts on child health, the channels through which this effect operates remain unclear. In this paper, I focus on these channels by looking at the impact of rainfall shocks during infancy on anthropometric outcomes (through income) as well on time spend in childcare particularly

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breastfeeding (as rainfall affects demand for mother's labour on the farm). Breastfeeding further could affect the nutritional status of children which might be reflected in the anthropometric data. I will further check whether there exists any gender bias in household's reaction to rainfall shocks.

1.1 Literature Review

1.1.1 Gender bias in South Asia

The phenomenon of "missing women", a term coined by Amartya Sen, was used to describe that the gender ratio is much lower than would be expected if women and men were subject to similar allocation of resources in a household. The comparative neglect of female health and nutrition, especially - but not exclusively – during childhood is largely responsible for such a phenomenon.

Indeed, the most striking evidence on twisted sex ratios and gender bias in mortality comes from South Asia in general and India in particular. According to the gender statistics of the Census of India in 2001, out of the total population of India, 532 million or 52 percent are males and 497 million are females constituting the remaining 48 percent in the population. In sheer numbers, males outnumber females by 35 million in the population. These sex differentials can potentially be attributed to differences in mortality rate, migration, sex ratio at birth and at times the undercounting of women at the time of population enumeration.

Further, child sex ratio (0-6 years) of the population has been registered as 914 in the 2011 Census (refer to Figure 1). This ratio has been continually declining from 927 in 2001, 945 in 1991 and 962 in 1981 (refer to Figure 2). Another notable feature is that the child sex ratio has fallen below the sex ratio at birth according to the Census of India 2001. Prior to 2001, the child sex ratio was close to sex ratio at birth. The magnitude of the decline can be seen from the fact that 31 States / union territories have registered a decline in Child Sex Ratio according to Census 2001 as compared to Census 1991. This reflects a grim picture of the status of the girl child in the country and further points towards investigating the existence and causes of gender bias during infancy and early childhood among surviving children. That said, evidence on the existence of gender bias in nutritional status in India is limited empirically (Basu (1989, 1993), Pelletier (1998) and Mishra *et al*. (1999)). However under abnormal circumstances such as income shocks, the story might change. Thus, it would be worthwhile to explore if female children bear the excess burden in the face of shocks when households are unable to smooth consumption. This is the question I seek to address.

A large number of studies have found an excess mortality of girls relative to boys in South Asia (Sen 1981, 1984; Dréze and Sen 1989). These include largely descriptive accounts like the one by D'Souza and Chen's (1980) which provide conclusive documentation of higher female over male mortality shortly after birth through the childbearing ages in rural areas in Bangladesh. Another influential account has been provided by Dasgupta (1987) who argues that in Punjab, gender bias in mortality is more severe for daughters who are born into families with other surviving female children. This is more pronounced in the case of families with mothers who are younger and, even more, if they are educated.

While gender bias in mortality is shown to exist, it is less obvious when we compare the anthropometric outcomes of surviving girls and boys. On the one hand, Sen and Sengupta (1983) provide a descriptive account of malnutrition among children less than 5 years of age in two villages of the Birbhum district of West Bengal in India. The sex bias is reflected both in (i) the greater prevalence of undernourishment of various degrees among girls than among boys (ii) in the lower growth dynamics of girls vis-a-vis boys. They also found that the village with the better over-all nutritional record has much sharper sex discrimination. Following the same line, Sain (1994) also examines the problem of nutrition and hunger in three villages of Birbhum district in India. There exist many children who suffer from grade II (moderate) degree of malnutrition and grade III (acute) malnutrition which requires immediate medical attention and there exist gender disparities. On the other hand, Ryan et al. (1984) found no significant variation in anthropometric indices using data on six ICRISAT villages of Maharashtra and Andhra Pradesh in India.

Thinking about high mortality and poor anthropometric outcomes among girls in infancy and early childhood, the key suspects would seem to be less food or nutrient intake and/ or less medical care. In some earlier studies, authors found gender bias against girls in nutrition intake like Ryan et al. (1984) for south- west India. Similarly, Dasgupta (1987) found that for children aged 0-2 years, boys receive food that is superior nutritionally and more valued socially in India. Considerably more is spent on clothing for boys than girls, reflecting more general differences in caring for boys and girls. A novel approach was developed by Subramanian and Deaton (1990) who used data on Maharashtra and estimated the expenditure elasticity by running a regression of budget share of different food groups on the household budget. They find that for only two foodstuffs – non-alcoholic beverages and processed food- is there a gender effect indicating higher male consumption. Importantly, no gender bias was found in the distribution of milk. Deolalikar and Rose (1998) use ICRISAT data and find increases in consumption of medicines and edible oils and fats for male children which are consistent with the substitution effect/preference explanation: boys consume higher quality foods and are more likely to receive health care than girls, resulting in better health and increased survival probabilities for boys relative to girls than would exist if allocations were identical.

Pitt, Rosenzweig and Hassan (1990) incorporate controls for activity level and body weight in the data analysis and do not find gender bias in nutrient consumption. They used the 1981-82 Nutrition Survey of Rural Bangladesh and found that adult males (aged 12 years and above) and male and female children (aged 6 to 12) were found to receive calorie reinforcement with respect to their health endowments. Thus, taking into account the health endowments and productivity, along with the activities undertaken by Bangladeshi women appear to account for part for the differences in the average consumption of nutrients.

Results on healthcare and medical care also diverge. Subramanian and Deaton (1990) found no gender bias for medical expenses in Maharashtra, India. On the other hand, Deolalikar and Rose (1998) found higher expenditure on medicines and healthcare for male Indian children. Dasgupta (1987) also found much wider sex differentials among children in medical care than in food allocation. The expenditure on medical care for sons was found to be 2.34 times higher than that for daughters in Punjab, India.

In summary, the literature on gender bias in South Asia has explored several questions in the past. There exists a plethora of descriptive evidence on twisted sex ratios and excess female mortality in this region. However, it is largely unclear when one focuses on gender bias in 1) anthropometric outcomes and 2) medical care. Regarding nutrient intake and food allocation, results point out gender differences. However taking into account activity levels and endowments appear to account for part for the differences in the average consumption of nutrients pointing to the idea that enough food is being allocated to girls. A notable study by Deaton (1989) in which he reviews the gender discrimination using the adult goods method, finds no evidence that parents spend more on boys than on girls. Further, there exists little evidence on gender bias in breastfeeding (which is one of the most important sources of nutrients) in India. A part of the divergent results could be attributed to the specificities of the data used and the particular regions in which these studies are conducted. For example, it is well documented that gender bias in India is a more acute problem in the northern states as compared to the south.

1.1.1 Effect of income shocks on child health

The first channel through which rainfall affects children is income. An important characteristic of developing countries is the exposure of its people to various kinds of risks and volatilities in incomes both within a given year and from year to year. One of the important sources of income volatility stems from poor rainfall, due to the dependence of a large proportion of population on agriculture and related activities. There do exist some local market and non-market mechanisms to smooth the impact of shocks across time and states of nature. But shocks are still hard to insure because of the commonality of shocks to all in a given region. The literature points that households can partially, but not completely smooth consumption. (Besley (1995); Murdoch (1995) and Townsend (1995))

Rainfall and other agricultural shocks may negatively affect children's nutrition through the effect on agricultural output and thus income. Some studies explore the links between shocks that affect child health at time period t and health states measured subsequently at period t+1. Some of these studies do find that the burden of shocks is borne disproportionately by women in South Asia.

For example, Behrman and Deolalikar (1989) found an allocation of nutrients away from girls in response to changes in relative food prices. Using ICRISAT data in India, Behrman J. (1988b) found that during the lean season, parents weigh a given health-related outcome for boys almost 5% more heavily than the identical health-related outcome for girls. This result suggests that when faced with lean season, parents exhibit male preference. Rose (1999) also examines the connection between gender bias in mortality and shocks. She uses rainfall shock data for India and links to the mortality among girls, checking for consumption smoothing at the time of shock: a favourable rainfall shock increases the likelihood-relative to that of a boy- that a girl survives until school age.

One can also draw from other similar studies have also been conducted for Africa, with largely no evidence of gender bias. For example, Jensen (2000) uses data from the Cote d'Ivoire and examines whether children living in areas which experiences adverse climatic shocks, had lower investments in education and health. He compares the differences in height for weight Z score, children enrolled in school and the use of medical services in regions which had an adverse shock as compared to regions which experienced normal rainfall. He found an increase in the percentage of boys and girls who were malnourished and a decline in enrolment for children in shock regions. No girl-boy differences were found. Hoddinott and Kinsey (2001) examine the impact of drought (in 1995) on the growth in the heights of very young children; those aged 12 to 24 months. They use a panel data set in Zimbabwe and are thus able to measure the growth of children over time as opposed to estimating a level equation. They refer to children aged 12 to 24 months in 1995 as the "drought cohort" and find that this cohort grew, on an average, about 2 cm more slowly than other children, when measured 12 months later.

It is important to examine the effect of shocks in infancy as the consequences of underinvestment in female children during drought/ rainfall shock are likely to be high if such faltering has permanent effects. Children that experience slow height growth are found to perform less well in school, score poorly on tests of cognitive function, and have fine motor skills (Dercon and Hoddinott (2003); Alderman, Hoddinott, and Kinsey (2006)). Finally, Maccini and Yang (2009) find that higher deviation (of this early-life rainfall from the mean rainfall in one's district) has positive effects on the adult outcomes of women, but not of men.

1.1.1 Effect of time spent in breastfeeding on child health

The second channel which I seek to explore is the time spent in childcare by mothers in response to good rainfall. It is conceivable that good rainfall is accompanied by an increase in labour demand thereby increasing the parent's opportunity cost of time spent in childcare. This may alter parental behaviour and finally child health outcomes. One of the most important parental behaviour that could respond to changes in rainfall is breastfeeding, which is what I focus on in this paper. Not only is it time demanding but it also has a direct impact on child's health. Literature capturing the impact of rainfall on women's time spent in breastfeeding is largely limited for developing countries. However, some studies point that the most prominent reasons for breast milk weaning seem to be mother's return to work (Roe et al. 1999; Baker and Milligan 2008).

The World Health Organization (2003, pp. 7-8) recommends that infants should be exclusively breastfed throughout the first six months of their life. It also recommends mothers should continue to breastfeed children after 6 months upto two years or more even while other foods are being introduced into their diet. There are other health benefits associated with breastfeeding as recognized by other papers including improved cognitive development (Kramer et al. 2008) and reduced risk of obesity (Kramer 2010). In addition, Jayachandran (2010) finds that not only are girls breastfed less than boys in India, but the gender of older siblings also affects how long a child is breastfed.

To measure the impact of rainfall on child health, I use data from the second round of the Demographic and Health Surveys conducted in 1998-99, and link it to the district level historical rainfall data for India. I examine the effect of weather shocks around the time of birth on anthropometric outcomes and breastfeeding outcomes of children aged 1-3 years.

The underlying assumption is that rainfall shortage reduces agricultural output and thus income available to the farmers which might negatively impact the health of children; however this is more likely to be so in early childhood. Children are particularly sensitive to nutritional shocks from 6-12 months of age because weaning from breast milk typically occurs in that period (Adair and Guilkey, 1997). While I cannot directly observe historical variation in crop yields or household income, existing evidence indicates that local rainfall in India positively covaries with output (Parthasarthy et al. 1988, Krishna et al 2004). Evidence from West Africa also points out that droughts lead to a decline in production of foodgrains as well as lower consumption (Fafchamps, Udry and Czukas 1998; Kazianga and Udry 2006). Further, I would examine the impact of rainfall in other years before birth year on health outcomes to see whether the coefficient on birth year rainfall changes substantially when rainfall variables for other years are added to the regression.

For the second channel, evidence shows that that good rainfall is accompanied by an increase in labour demand on women. This further increases the women's opportunity cost of time spent in childcare particularly breastfeeding. Since breastfeeding has an impact on child's health, rainfall variation across space and time should generate corresponding variation in maternal labour demand and thus children's health.

The paper is organized as follows. Section 2 briefly discusses the context of India. In Section 3, I describe the data and variables. Estimation results are reported in Section 4 and Section 5 concludes.

2 The Indian Context

2.1 Rainfall and agriculture

The monsoon plays a critical role in Indian agriculture and in determining whether the harvest will be bountiful, average, or poor in any given year. The agricultural season in India is divided into two prominent seasons- Kharif and Rabi. During the kharif season, crops are sown at the beginning of the south-west monsoon from May- July and harvested at the end of the south-west monsoon, that is, September- October. During the rabi season, crops need relatively cool climate during the period of growth but warm climate during the germination of their seed and maturation. The sowing thus is between October and December and the harvesting season is from February to April. Table 1 provides trends of production in kharif and rabi season for India. Not only the kharif crops have higher production in million tonnes but they also occupy more land in India. To start with the analysis it is worthwhile to mention that there is considerable variation in rainfall across the country (refer to Figure 3).

3 Data Sources and Variable Definitions

3.1 Rainfall Data

In the absence of station rainfall data for India, I use a gridded rainfall dataset called 'Terrestrial Precipitation: 1900-2008 Gridded Monthly Time Series (Version 2.01)' interpolated and documented by Kenji Matsuura and Cort J. Willmott (with support from IGES and NASA)[2] as the source for rainfall data. This published dataset consists of interpolated (on a 0.5 degree latitude-longitude grid) global monthly rainfall data, from 1901 to 2008. I used Mapinfo software to merge the rainfall data from 1122 weather stations spread throughout India to calculate monthly level rainfall for Indian districts.

Using the latitude and longitude information, I assigned weather stations to each of the 436 districts in DHS data. The idea was to assign to each district –weather stations in the 50 mile radius from the centroid of the district. Thereafter, I used the Inverse Distance Weighting (please refer to the appendix at the end for more on this) to interpolate monthly rainfall values for 436 districts.

For the regression analysis, I consider rainfall data corresponding to children in the age group of 13-36 months at the time of the survey. I identify the months from May- October as the wet (Kharif) season and consequently November- April as the dry (Rabi) season as these should be most closely related to agricultural cycles. So if a child is born in August 1994, the first wet season for the child would be May to October 1994 and the first dry season would be November 1994 to April 1995. I use two different measures of rainfall as defined below.

The first measure of rainfall that I use is categorical. I calculate for each district -the 40 year wet season mean, one standard deviation less than the 40 year wet season mean, one standard deviation more than the 40 year wet season mean. Then, I assigned rainfall shock to each child equal: 0 if wet season rainfall around his/her birth is 1 standard deviation less than 40 year wet season mean, 1 (normal rainfall) if it is between '1 standard deviation less than 40 year wet season mean' and '1 standard deviation greater than 40 year wet season mean', 2 if it is greater than '1 standard deviation more than 40 year wet season mean'.

[2] The dataset is provided by Center for Climatic Research, Department of Geography, University of Delaware. Terrestrial Precipitation: 1900-2008 Gridded Monthly Time Series - Version 2.01, interpolated and documented by Kenji Matsuura and Cort J. Willmott (with support from IGES and NASA). For further information about this dataset, please refer to Legates and Willmott (1990)

The second rainfall variable captures the deviation of rainfall in the first wet season (and also separately dry season) around birth in the district in which the child is born from the district's 40 year historical wet season (and dry season) mean, normalized in terms of standard deviation. The above variable could be positive (positive rainfall deviation from historical mean) or negative (negative rainfall deviation from historical mean). I distinguish between positive and negative rainfall shocks and introduce them as two separate variables in my equation of interest to capture asymmetry. For example, if the variable is negative in the wet season, I keep it but 0 if it is positive – I call this variable as negative wet rainfall deviation. Similarly, I define the positive wet rainfall deviation, negative dry season deviation and positive dry season deviation.

The 'seasonal rainfall in the year around birth' variable is graphed in figure 4 by gender. It ranges from -1.93 to 2.66. The distribution shows that the probability of being born in a district with negative (or positive) rainfall deviation is the same for boys and girls. It also shows that there were no "big" droughts during this time period (in the districts that are covered by DHS 1998-99) biasing the estimates.

3.2 Outcome variables

The data for the analysis of health outcomes among children is sourced from the second round of Demographic and Health Surveys conducted in 1998-99[3]. DHS is a nationally representative household survey with large sample sizes. These surveys provide data for a wide range of indicators in the areas of population, health, and nutrition. The survey was administered nationwide to ever-married females aged 15–49 years. The rural sample in each state, which we use in the study, was selected by selecting primary sampling units (PSUs) with a probability proportional to the population. Thereafter the households were randomly selected within each PSU.

I observe the height and weight for children in the age group of 0-36 months at the time of the interview, born to mothers in the age group of 15- 49 years. However I restrict my analysis to children aged 13-36 months as I'm interested in capturing the impact of rainfall in the year around birth which is likely to show effects on children aged 1 and older. Another reason is the concern raised about the accuracy of measuring height and weight for children less than 1.

The outcomes that I'm interested in are height for age Z scores (HAZ) and weight for age Z scores (WAZ). There is evidence that these two outcomes reflect the nutritional status of children well (Waterlow *et al*. 1997). HAZ and WAZ are expressed as standard deviations from US National Center for Health Statistics (NCHS) standard of mean, used by the World Health Organisation (WHO), standardized by gender and age. While weight is a measure of short-term health status, height on the other hand is a stock variable and can be considered to be a long term predictor of nutrition.

All eligible children had their height and weight measured, with some exceptions. These are listed in Table 2. Out of the total 27250 children, anthropometric data was measured for 24855 children out of which 18044 live in rural areas. After accounting for missing observations and restricting my sample to children only above 12 months of age, my final sample comprises of 5004 girls and 5455 boys.

Figure 5 demonstrates separately the HAZ and WAZ of girls and boys. The Kolmogorov–Smirnov test for the equality of Distributions does not reject the equality of distributions of both HAZ and WAZ by gender. Figure 6 illustrates the distribution of HAZ for girls and boys when rainfall in the wet season

[3] I do not use the first round of DHS because there are a lot of missing observations for height and weight.

around the time of birth is 1 standard deviation below the historical mean (than when it is not). The Kolmogorov-Smirnov test for the equality of Distributions rejects the equality of distributions for girls at 5% significance but not that of boys. This provides further credence to the hypothesis that girls might be more negatively affected as a result of negative rainfall shocks.

For the set of breastfeeding outcomes, we have information on the number of months the child has been breastfed and whether he/ she is still being breastfed. The best possible outcome is the duration of breastfeeding to understand whether rainfall shocks induce mothers to stop breastfeeding their children. Out of the 27250 children, we drop children living in urban areas, some outliers and restrict the sample to children aged 13-36 months. This leaves us with a sample of 12996 children.

3.3 Explanatory variables

As far as the explanatory variables are concerned, I use various maternal, household and individual level characteristics. Household characteristics include wealth index, sex and age of household head and dummies for caste and religion. I also include the number of sisters and brothers under 13 years of age, born to the mother and to other adult women in the household. Individual characteristics comprise the birth order of the child, whether he/ she possesses a health card, season of birth and dummies for year of birth. I also included a variable where the interviewee recalls the size of the child at birth, categorized as larger than average, average, smaller than average and small.

Parental characteristics include variables such as height and weight of mother (included only for anthropometric outcomes), the age and number of years of completed schooling of the mother and father and dummies for the occupation of father. It is likely that taller and thinner mothers would have taller and thinner children respectively, all else being same. Hoddinott and Kinsey (2001) find a well defined relationship between child growth and maternal height. Further, many studies have pointed to the impact of mother's education on child health, though the precise pathways through which this works remain unclear (Strauss and Thomas 1995). Finally, I have included the age and the square of age of mother as explanatory variables. The age of the mother has an ambiguous effect on the child's health-- older mothers might be expected to have more children thus putting a strain on the amount of time that is dedicated to the well being of each child. However, it might be that older mothers have extensive experience in childcare which might make them more knowledgeable about child health practices. For breastfeeding outcome, I include a binary variable of whether the mother works on the farm or not.

Village level variables include distance from the nearest all weather road, whether the village is electrified, population of the village, the number of households in the village, presence of a traditional attendant in the village, distance to health sub-centre, distance to community health centre and distance to private clinic.

Tables 3 and 4 provides descriptive statistics on all outcome and explanatory variables for children, mothers and households along with the children's outcome variables. The anthropometric outcomes that I'm interested in are height for age Z score (HAZ) and weight for age Z score (WAZ) for children in the ages of 13-36 months. The value of these variables lies between -6 and 6. The height for age Z score for children averages around -2.5 for girls and boys whereas the weight for age Z score averages around -1.9 for both groups. The children whose height (weight) for age z-score is between –2.0 and –2.99 standard deviations (SD) below the mean on the WHO international references standard are classified as moderately stunted (underweight). This sheds some light on the general status of underperformance on anthropometric outcomes in the country.

The birth order of the children in the sample averages around 2.86 and 2.91 for girls and boys. On an average, boys have 0.84 sisters and 0.68 brothers whereas the girls have 0.79 sisters and 0.74 brothers. Regarding the household characteristics, the household head is a man in 94% of the households with an average age around 43.84 for girls and 43.49 for boys. The wealth score calculated using principal component analysis indicates that girls and boys are from equally wealthy households. Mother's height and weight averages around 151.65cm and 44.7 kg respectively. The average age of the mother is 25.77 for girls and 25.89 for boys, with boy's mothers being more educated that girl's mothers. The fathers tend to be more educated than the mothers with average number of years of schooling being 5.69 years for girls and 5.88 years for boys. The caste and religion variables are also are described as well along with village level characteristics.

The duration of breastfeeding (which includes children still being breastfed) is a little more 19 months for boys and 18.5 months for girls—observed to be about 3/4 of a month higher for boys. It seems that women continue to breastfeed children for a long time in India—more than that recommended by WHO.

3.4 Econometric specification

In examining the relationship between early-life rainfall and subsequent health outcomes for children, I use the child's height for age Z score and weight for age Z scores of the child at the time of the interview. I run all the regressions separately for boys and girls.

I estimate the relationship between rainfall shock and outcome for each gender as follows:

$$Y_{ihrt} = \beta_0 + \beta_1 * R_{rt} + \beta_2 X_i + \beta_3 A_h + \beta_4 C + \delta_r + \mu_{ihrt} \qquad (1)$$

Where Y_{ihrt} is the health outcome for child 'i' in household 'h' in district 'r' for cohort 't'. R_{rt} is an indicator of rainfall shock in district 'r' in cohort/year 't'. X_{ir} is a vector of control variables at the level of the child. A_h is vector of household level and maternal control variables which might have a direct bearing on child's health outcomes. C captures indicators at the village level. District fixed effects (δ_r) capture time invariant features of districts, including determinants of quality of care that do not change over time and accounts for unobserved heterogeneity across districts. Further, I include year fixed effects. Finally, μ_{ihrt} is the individual specific standard error term.

Equation (1) is a reduced form equation to estimate the impact of variability in rainfall on child health. The identification is driven by the variation of rainfall across clusters after accounting for other differences across clusters. For the impact of rainfall through income, I am assuming that rainfall shortage reduces agricultural output and thus income available to the farmers which might negatively impact the health of children. However, it would be more interesting to check the impact of rainfall shocks on income to make the link from shock to income to health clearer. Lack of data on income prevents me from identifying the exact channel through which rainfall affects child outcome. However, evidence discussed earlier in this paper suggests that there is a clear link between weather and agricultural output and thus income.

4 Results

I estimate equation (1) regressing rainfall on child outcomes. The results for the impact of rainfall shock on anthropometric outcomes are given in Table 5. I present the results for each gender separately. Standard errors are robust to heteroskedasticity and clustered at the district level. Clustering standard errors at the level of the DHS district allows for an arbitrary variance-covariance structure within birth districts to account for possible correlation of errors within the same sampling cluster. I restrict my sample to all eligible children in rural areas as the effect of the lack/ abundance of rainfall is likely to be highest here.

4.1 Anthropometric outcomes

The measure of rainfall that I use in Table 5 (Columns 1-4) is a categorical variable explained in Section 3.1. Taking negative rainfall deviation as the base, children born in areas which received normal or more than average rainfall around the time of birth have better outcomes. The magnitudes are large and significant and do not differ for girls and boys. This is in line with what we hypothesized.

The birth order is also an important determinant: the higher the birth order, the poorer are the outcomes. Further, the more the number of sisters, the lower is the HAZ of girls. This is in line with much of the literature on India which suggests that girls tend to have more siblings on an average as compared to boys, thus fewer resources allocated to every child. Children living in wealthier households and born to more educated mothers have better outcomes, irrespective of gender. Girls born to more educated fathers also tend to have better outcomes but the same is not observed for boys. As expected, mother's height and weight is significant for all outcomes and across both genders. Interestingly, girls born in households where the household head is male have better HAZ as well. Age of the mother is seen to have no effect on outcomes.

Season of birth is defined as birth during wet or dry season. Girls born in the Dry season (November-April) tend to have worse outcomes as compared to girls born in the wet season. The subjective measure of size of the child at birth has the anticipated impact on both outcomes, however the effect is less pronounced for boys indicating some sort of catching up. The effect is more in magnitude; the lower is the size of girls at the time of birth. Interestingly, it is found that girls have lower HAZ if they are from Muslim households and boys have better WAZ if they are from the General caste.

In Columns 1-4, I have run regressions separately for girls and boys. Thus, currently, I'm comparing girls who experienced low rainfall around birth with girls who received good rainfall around birth, and similarly for boys. However, it would be interesting to see if negative rainfall deviation affects girls more than boys. To capture this effect, I introduce an interaction between gender and the deviation of rainfall (column 5) and find that the variable to be not statistically significant. Thus, from my results, it is not clearly evident that girls bear a disproportionate burden from negative rainfall shocks.

In Table 6, I summarize the estimates using the two different measures of rainfall shocks. For the second measure, instead of introducing rainfall shock variable symmetrically, I distinguish between positive and negative rainfall shocks and introduce them as two separate variables in my equation of interest to capture asymmetry. If the effect is symmetrical, then one would get a positive and significant impact of "positive deviation of rainfall in wet season t", and a negative and significant impact of "negative deviation of rainfall in wet season t". Table 6 shows OLS estimates of the impact of rainfall. 'Negative deviation of rainfall in the wet season around birth' has a negative effect on HAZ and WAZ of girls and boys however the effect is insignificant for boy's HAZ. The result suggests that an increase in the negative rainfall by 1 standard deviation leads to a decrease in the HAZ of girls by 13%. This is much in line with the literature that has been discussed earlier in this paper.

Using different measures of rainfall shocks, it is clear that negative rainfall shocks have a significant deterring effect on HAZ and WAZ of both girls and boys and that the magnitude of this effects does not differ by gender.

Finally, it is important to assess the impact of rainfall shocks in years other than the year around birth to check for robustness. Since I'm examining children in the age group of 13-36 months, I would not be able to check the impact of rainfall on years subsequent to birth year. However, it is possible that a rainfall shock at the time the child is in the mother's womb has some impact on outcomes. To check for this, I included the categorical measure of rainfall during wet season for 2 consecutive years (the season around birth and the one before)-- the OLS estimates are given in Table 6.

The results for the categorical rainfall variables increase in magnitude as a result of including rainfall deviation during gestation period. As compared to negative rainfall deviation, children born in areas which received normal rainfall (both during gestation and time around birth) have better HAZ and WAZ. Interestingly, the impact of positive rainfall deviation is significant only for girl's HAZ and higher in magnitude than that of boys'. The impact of low rainfall in the wet season is robust irrespective of the measure used and to the inclusion/ exclusion of variables.

Lastly, Rose (1999) examines the connection between gender bias in mortality and shocks for India. She uses rainfall shock data at the district level and links to the mortality among girls, checking for consumption smoothing at the time of shock: a favourable rainfall shock increases the likelihood-relative to that of a boy that a girl survives until school age. In such a case, one can argue that the weaker girls have already died and we are left with a healthier sample of girls thus introducing selection. Further, Maitra and Rammohan (2011) analyze the same dataset that I'm using and find differences between HAZ and WAZ of boys and girls, after controlling for probability of surviving the first year of life. Thus, it would be worthwhile to mention that our impact of rainfall on nutritional outcomes is a lower bound estimate.

4.2 Breastfeeding outcomes

Survival and duration models originated in biomedical sciences; where the interest lies in observing time to death of patients or laboratory animals or until the relapse of an illness. In the recent past however, these techniques have increasingly become popular in social sciences. Here, we use Cox proportional hazard model to analyze the impact of rainfall shocks on breastfeeding duration.

A detailed discussion of the Cox models can be found in Hosmer and Lemeshow (2003). Let the random variable T denote survival time. The distribution function of T is defined by the following equation and indicates the probability of death up until time t

$$F(t) = P(T < t)$$

Because T is a continuous random variable, its density function f (t) can be computed as the first derivative of the distribution function. The survival function S(t) denotes the probability of surviving until time t or longer and is given by

$$S(t) = P(T >= t) = 1-F(t)$$

The limit of S(t) represents the risk or proneness to death at time t. This limit is usually called the hazard function which measures the death rate given survival until time t. In our case, the hazard function measures the risk of stoppage of being breastfed.

In our data, we have children for whom breastfeeding has finished and for whom it is still ongoing. Since our data is censored, it is important to use Cox's proportional hazards in our case because this technique adjusts for truncation bias by incorporating both complete and incomplete segments of histories in the analysis of breastfeeding-related data. It is a semi-parametric method for analyzing the effects of covariates on the hazard function. The regression coefficients give the proportional change that can be expected in the hazard (risk of stoppage of being breastfed), related to changes in the explanatory variables. They are estimated by a maximum likelihood.

Table 7 shows the coefficients of the impact of rainfall shock (categorical rainfall variable) on the hazard of stoppage of breastfeeding. Columns 1 and 2 show the coefficients for girls and boys separately. E^b, the exponentiated coefficient, gives the hazard ratio: effect of explanatory variables in the multiplicative form of the model. A hazard ratio lower than 1 indicates decreased risk whereas a ratio higher than 1 indicates increased risk. For example, the hazard ratio for girls who faced average rainfall in wet season around birth is $e^{0.34}$= 1.4049. Thus, taking negative rainfall shock as the base while holding all other variables constant, the risk of stoppage of breastfeeding increases by a factor of 40.49% for girls who experienced average rainfall. The corresponding hazard ratios are given in columns 4 and 5. The impact is found to be highly significant for both girls and boys and is similar in magnitude.

Higher birth order is associated with higher risk of stoppage of breastfeeding while we do not find any impact of the number of siblings on breastfeeding. Education of the mother is likely to increase the opportunity cost of time spent breastfeeding. Hence more educated women are more likely to be employed and spend less time breastfeeding—we find evidence in support of this hypothesis. The risk of cessation of breastfeeding is found to be increasing with increasing maternal education. Age of the mother, wealth and education of the father has no impact on outcomes. Children born in dry season have a lower risk of termination of breastfeeding compared to children born in wet season. This is much in line with what is hypothesized—mothers have less demand on their time in dry season and hence can continue to breastfeed their children longer. Scheduled tribe households have 11.31% (100-88.69) less likelihood of terminating breastfeeding than schedule caste households.

It would be interesting to see if negative rainfall deviation affects girls more than boys. To capture this effect, I introduce an interaction between gender and the categorical rainfall deviation– the results are given in column 3 and 6 of table 7. I find the interaction variable as not significant implying that girls do not bear a disproportionate higher risk of the cessation of breastfeeding in face of good rainfall.

Table 8 presents a summary of the estimates using two rainfall measures. The coefficients are presented in columns 1 and 2 and the corresponding hazard ratios are presented in columns 3 and 4. Using the continuous seasonal rainfall measure, we find evidence that rainfall has an impact on the risk of stoppage of breastfeeding. As rainfall becomes more negatively deviated from mean in the wet season, the risk of stoppage of breastfeeding decreases by a factor of (100% - 85.21%) = 14.79% for girls. On the other hand, as rainfall becomes more positively deviated from mean in wet season, the risk of stoppage of breastfeeding increases for boys by a factor of 20.92%.

5 Conclusion

While the finding that girls do not experience negative allocation of resources as compared to boys under normal circumstances is now well founded, evidence regarding the disproportionate allocation of resources under harder circumstances is still scarce. At the same time, it is found that the child sex ratio (0-6 years) has dropped below sex ratio at birth between Census of India 1991 and Census of India 2001, suggesting that more girls are dying in the ages of 0-6 years. However it could be that the girls that are alive are undernourished as compared to boys that are alive. It is under this context that I check the impact of rainfall shocks around birth on health outcomes of children aged 13-36 months.

There are three potential channels through which rainfall affects the health of children. First, when households suffer a shock on their income, they may allocate resources among boys and girls differently leading to different anthropometric outcomes. Secondly, the amount of rainfall could determine the time spent by mother in childcare particularly breastfeeding and thus impact child's health. Lastly, enough/ excess rainfall could negatively affect health through the spread of water-borne diseases such as malaria. In this paper, I explore the first two of these three channels.

Good rainfall implies higher income and availability of more/better resources for children, which in turn positively affects their HAZ and WAZ. It could also be that more income might allow the mother to spend more time in leisure including breastfeeding. Thus, the effect of positive rainfall on HAZ and WAZ is speculated to be positive. The results reveal that children who experience negative rainfall shocks in the wet season around birth have worse height for age Z scores and weight for age Z scores as compared to children who experienced no or positive rainfall shock. The results are similar in magnitude for boys and girls, irrespective of the measure of rainfall deviation used. Even after controlling for rainfall deviation in the wet season one year before birth (gestation period), the estimates stay significant although they increase in magnitude. However, I do not find any evidence of gender bias. Taking the interaction between rainfall deviation and gender for each of the above outcomes, I do not find that girls bear a disproportionate burden from these shocks.

On the other hand, good rainfall could also provide economic incentives for the mother to work on the farm and hence spend less time breastfeeding, negatively impacting child's health. But at the same time more rainfall (and thus income) might allow the mother to spend more time in leisure including breastfeeding. Our results indicate that the former effect outweighs the latter –good rainfall is seen to increase the risk of termination of breastfeeding for both boys and girls and the estimates are similar in magnitude.

These results have important policy implications. Over the past years, there has been an increased interest in weather based index insurance wherein farmers are insured against bad weather. This program has also been tested in some parts of India using experimentation. Our results suggest a negative impact of bad rainfall on the height and weight for children. Since these negative effects determine the long-run attainment of good health, weather based insurance programs could help to improve outcomes by providing a way to smooth consumption. One possible suggestion that stems out of this paper is thus to document children's health outcomes in response to weather based index insurance both in early childhood and in the long run.

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Figure 1[4]: Rural Child Sex Ratio for Indian states, 2011

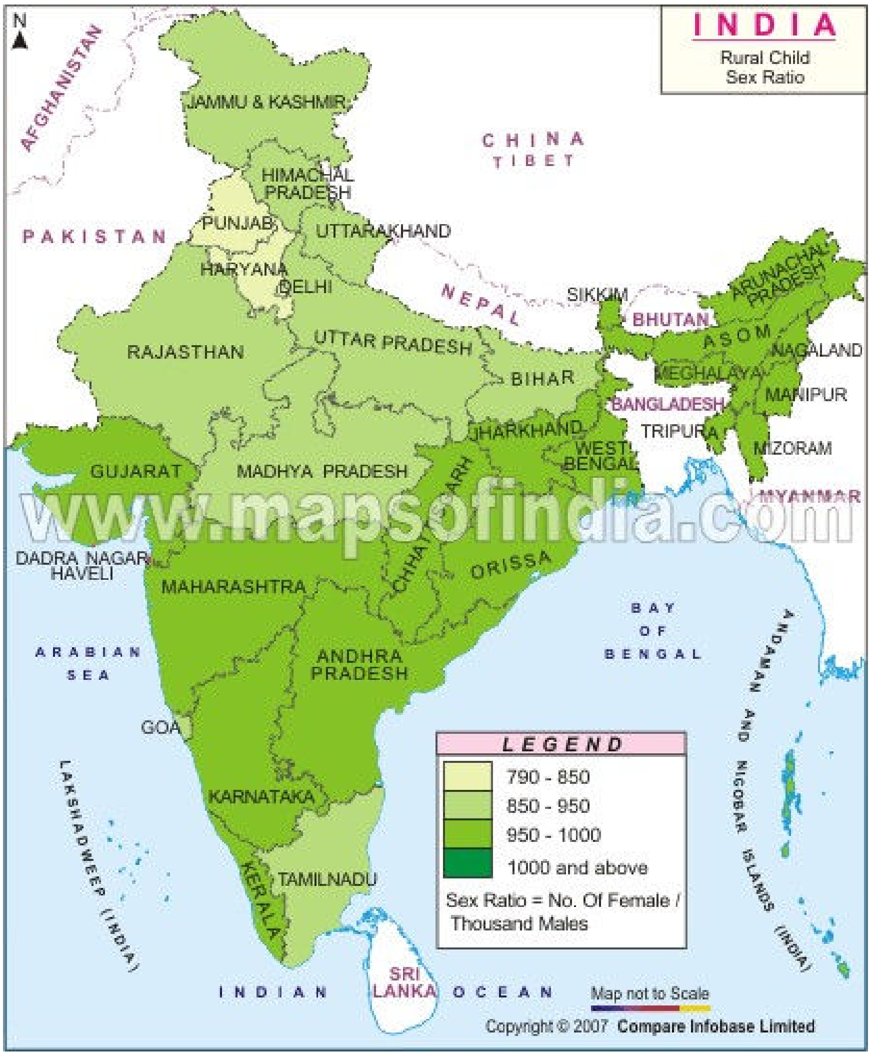
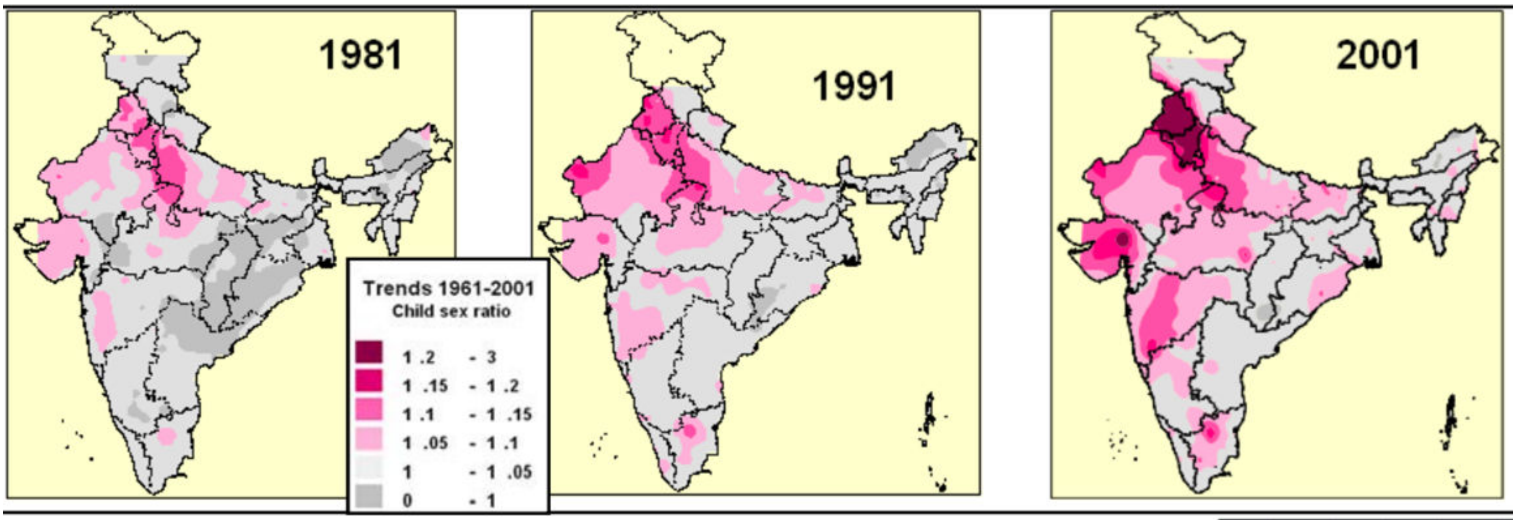


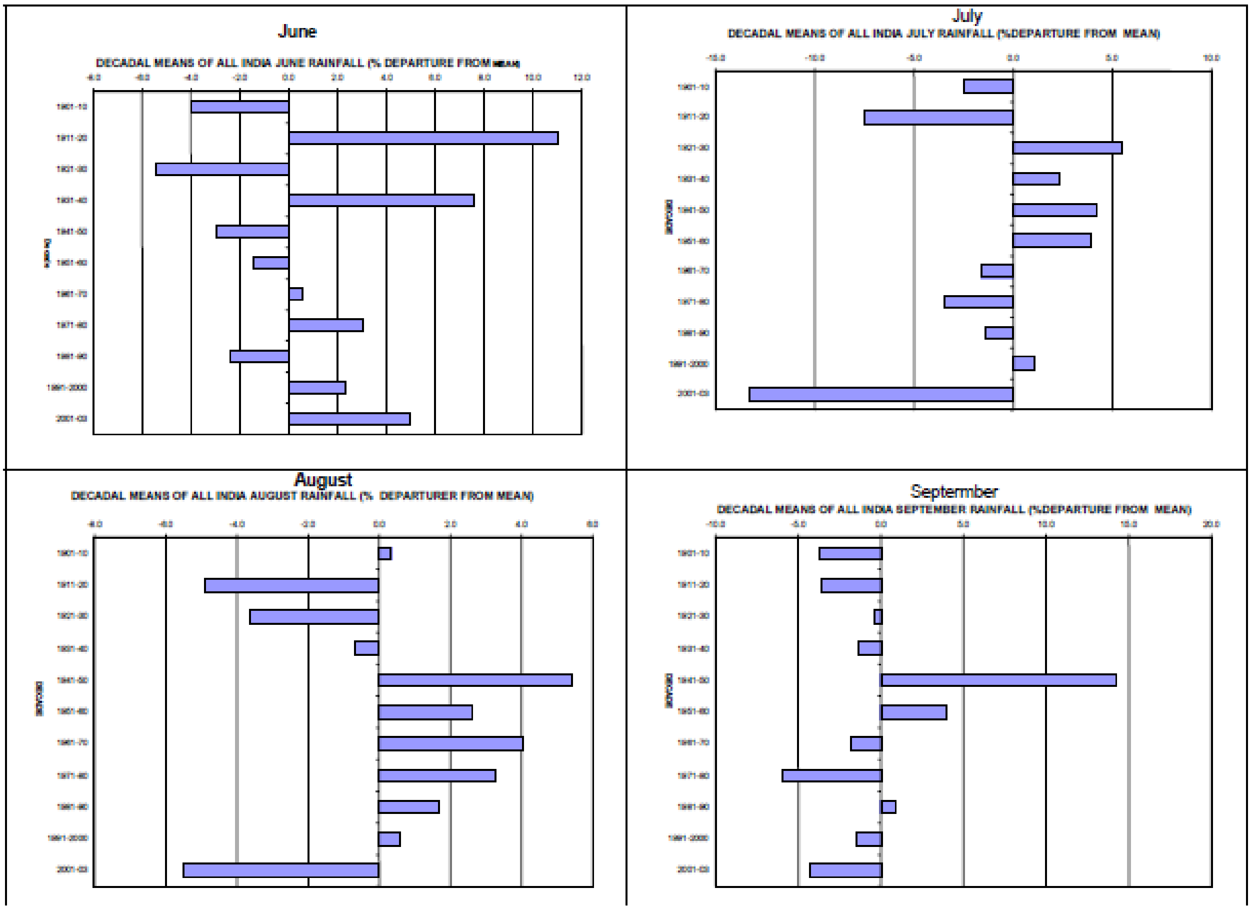
Figure 2[5]: Evolution of child (0-4 years) sex ratio in India at the district level



[4] http://www.mapsofindia.com/census/rural-clild-sex-ratio.html

[5] Source : "Characteristics of Sex-Ratio Imbalance in India, and Future Scenarios" Christophe Z Guilimoto

Figure 3: Decadal means of all India summer monsoon rainfall (% departure from mean)



Source: "Trends in rainfall patterns over India" by P. Guhathakurta and M. Rajeevan, National Climate Centre

Figure 4: Log of rainfall in the year around birth by gender and year of birth

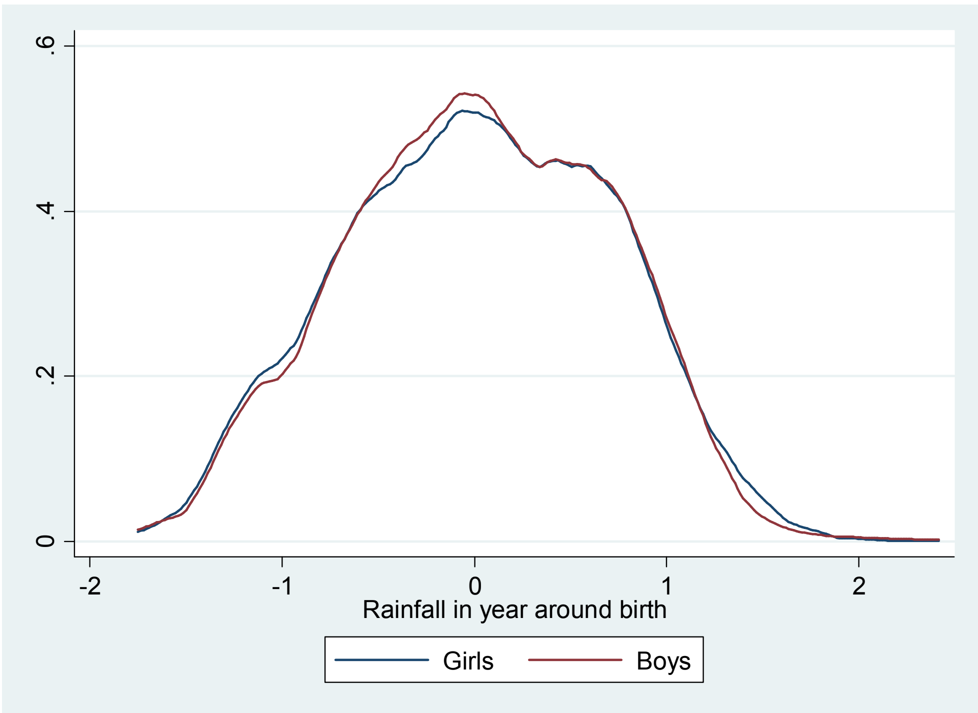
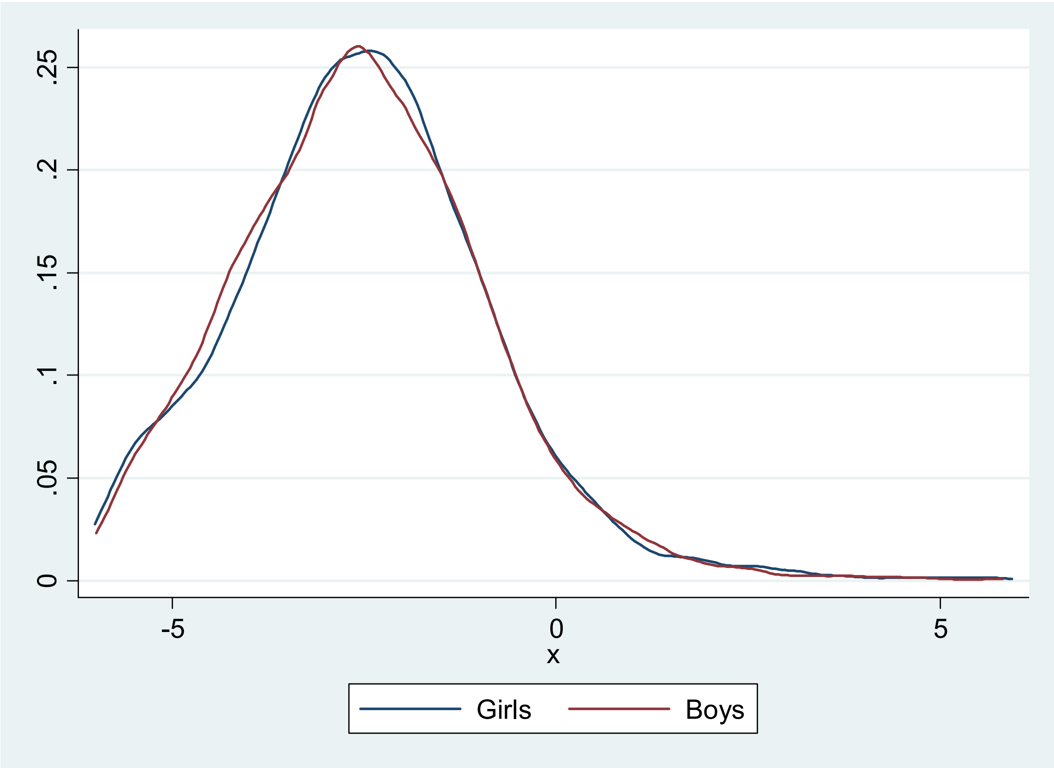


Figure 5: HAZ and WAZ by gender

HAZ by gender



WAZ by gender

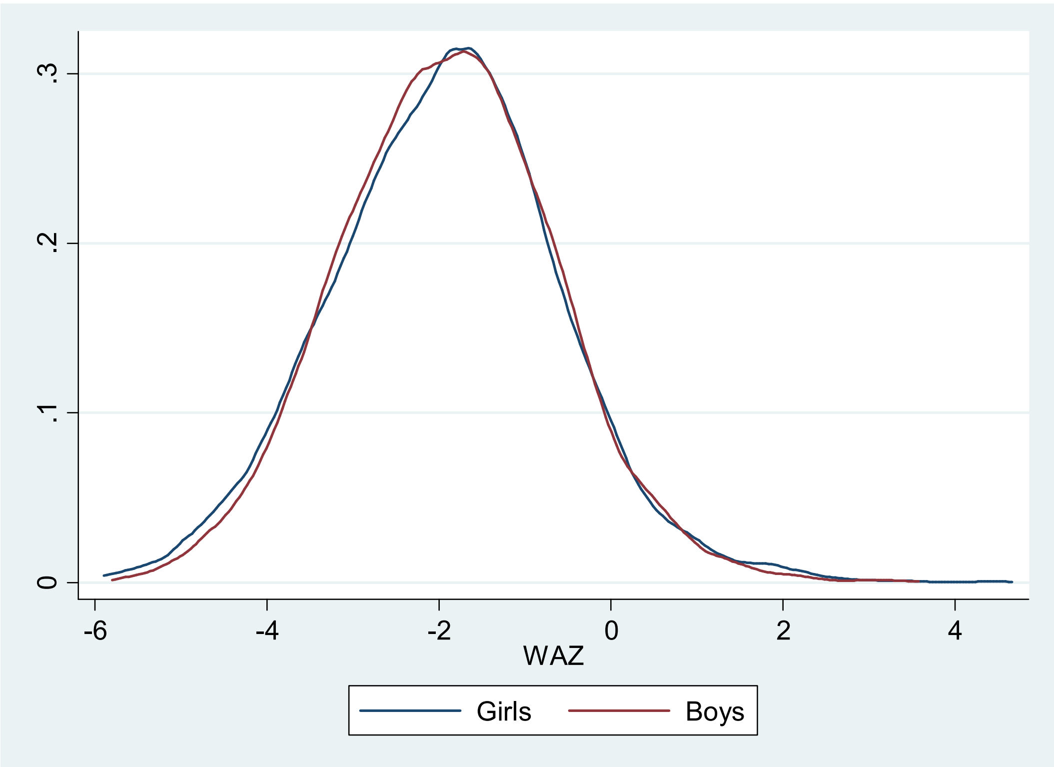
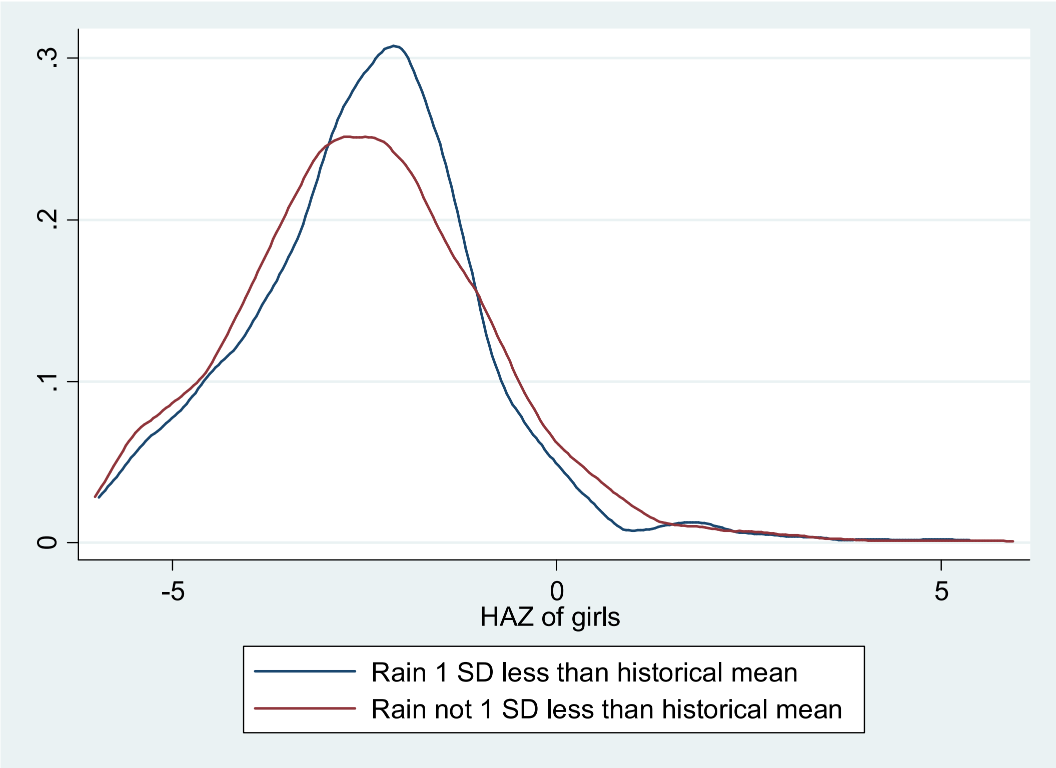


Figure 6: HAZ in response to rainfall being 1 SD less than 40 year wet season mean by gender



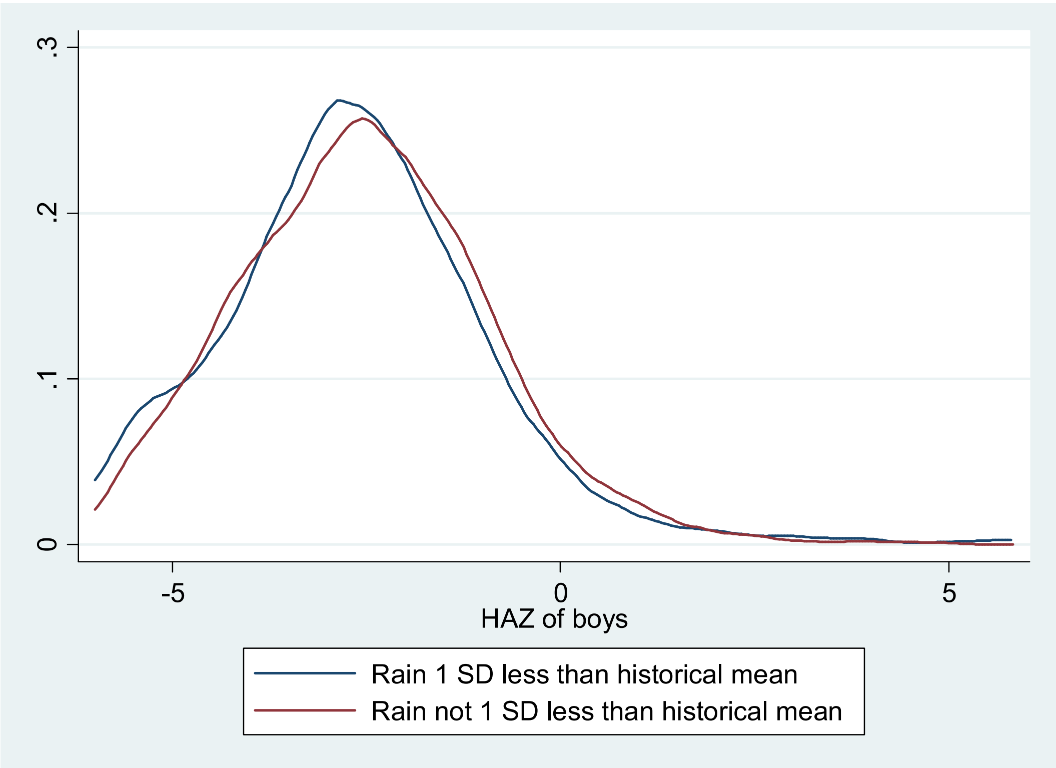


Table 1: Season-wise Area, Production and Yield of Foodgrains from1991-92 to 2005-06

	Kharif			Rabi			Total	
Year	Area	Prod.	%	Area	Prod.	%	Area	Prod.
1991-92	78.02	91.59	54.39	43.85	76.79	45.61	121.87	168.38
1992-93	77.92	101.47	56.54	45.23	78.01	43.46	123.15	179.48
1993-94	75.81	100.40	54.49	46.94	83.86	45.51	122.75	184.26
1994-95	75.19	101.09	52.79	48.67	90.41	47.21	123.86	191.50
1995-96	73.60	95.12	52.72	47.42	85.30	47.28	121.02	180.42
1996-97	75.34	103.92	52.11	48.24	95.52	47.89	123.58	199.44
1997-98	74.15	101.58	52.83	49.70	90.68	47.17	123.85	192.26
1998-99	73.99	102.91	50.55	51.18	100.69	49.45	125.17	203.60
1999-00	73.24	105.51	50.29	49.87	104.29	49.71	123.11	209.80
2000-01	75.22	102.09	51.87	45.83	94.73	48.13	121.05	196.81
2001-02	74.23	112.07	52.65	48.55	100.78	47.35	122.78	212.85
2002-03	68.56	87.22	49.91	45.30	87.55	50.09	113.86	174.77
2003-04	75.44	117.00	54.88	48.01	96.19	45.12	123.45	213.19
2004-05	72.26	103.31	52.08	47.82	95.05	47.92	120.08	198.36
2005-06	72.72	109.87	52.67	48.88	98.73	47.33	121.60	208.60

**Area in million hectares, production in million tonnes*

Source: http://dacnet.nic.in/eands/At_A_Glance/pcrops.html

Directorate of Economics and Statistics, Ministry of Agriculture, Government of India

Table 2: Reason for not taking anthropometric info for children

	Freq.	Percent	Cum.
Measured	27,250	82.49	82.49
Dead	2,090	6.33	88.82
Sick	128	0.39	89.21
Not present	465	1.41	90.62
Refused	158	0.48	91.09
Mother refused	359	1.09	92.18
Other	2,583	7.82	100
Total	33033		100

Table 3: Descriptive Statistics for girls and boys born to families in rural areas, age 13-35 months

	Girls	**Boys**
Height for age	-2.5	-2.52
	(1.66)	(1.64)
Weight for age	-1.92	-1.9
	(-1.33)	(-1.26)
Positive rain in Dry season	0.7	0.68
	(-0.82)	(-0.81)
Negative rain in Dry season	0.21	0.2
	(-0.41)	(-0.39)
Positive rain in Wet season	0.28	0.28
	(-0.42)	(-0.41)
Negative rain in Wet season	0.39	0.38
	(-0.51)	(-0.5)
Categorical measure of rainfall	0.97	0.97
	(-0.47)	(-0.45)
Birth Order	2.86	2.91
	(-1.9)	(-1.91)
Brothers under 13 years in family	0.74	0.68
	(-0.85)	(-0.83)
Brothers under 13 years in HH	2.51	2.48
	(-2.3)	(-2.29)
Sisters under 13 years in family	0.79	0.84
	(-0.92)	(-0.97)
Sisters under 13 years in HH	2.4	2.49
	(-2.24)	(-2.32)
Sex of HH Head	0.94	0.94
	(-0.25)	(-0.24)
Age of HH Head	43.84	43.49
	(-15.41)	(-15.22)
Wealth Score	-0.44	-0.39
	(-0.71)	(-0.73)
Age of mother	25.77	25.89
	(-5.43)	(-5.44)
Education of mother	2.98	3.22
	(-3.99)	(-4.19)
Mother's weight	151.63	151.69
	(-5.55)	(-5.51)
Mother's height	44.75	44.74
	(-6.6)	(-6.57)
Education of father	5.69	5.88
	(-4.76)	(-4.86)
Duration of breastfeeding	18.56	19.27
	(7.36)	(7.66)
Observations	***5004***	***5455***

Standard deviation in brackets

Table 4: Descriptive Statistics for girls and boys born to families in rural areas, age 13-35 months

	Girls	Boys
% Hindu	76.46	75.40
% Muslim	11.69	12.06
% Christian	6.69	7.00
% Sikh	2.32	2.58
% Scheduled caste	19.24	19.23
% Scheduled tribe	17.43	16.99
% Other backward caste	30.24	29.15
% General caste	33.09	34.63
% Average sized at birth (subjective measure)	60.01	61.25
% Father: agriculture as occupation	46.56	45.76
% not electrified	15.91	16.04
% Presence of traditional attendant in village	58.29	57.29
Average population of the village	3972.48	4094.47
Number of households in village	631.21	624.20
Average distance to all-weather road	14.50	14.20
Average distance to health sub-centre	4.82	5.32
Average distance to community health centre	17.90	18.11
Average distance to private clinic	10.81	10.87
Observations	***5004***	***5455***

**Distance variables in kilometres*

Table 5: Impact of categorical measure of rain on HAZ & WAZ of boys & girls aged 13-35 months

VARIABLES	(1) HAZ Girls	(2) HAZ Boys	(3) WAZ Girls	(4) WAZ Boys	(5) HAZ	(6) WAZ
Base: Rainfall less than 1 SD						
Average rainfall (1 SD around	0.19*	0.18*	0.17**	0.15**	0.12	0.13**
mean)	(0.10)	(0.10)	(0.08)	(0.07)	(0.08)	(0.06)
Rainfall more than 1 SD	0.28**	0.22*	0.17*	0.21**	0.22*	0.11
	(0.14)	(0.13)	(0.10)	(0.10)	(0.11)	(0.09)
Gender					-0.15	-0.05
					(0.10)	(0.07)
Base: Gender* Rainfall less than 1 SD					0.13	0.04
Gender* Average rainfall					(0.10)	(0.07)
Gender* Rainfall more than 1 SD					0.03	0.10
					(0.14)	(0.10)
Birth Order	-0.02	-0.04	-0.06**	-0.06***	-0.04*	-0.05***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)
Nb of girls under 13 to mother	-0.12***	0.05	-0.05	0.03	-0.03	-0.01
	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.02)
Nb of boys under 13 to mother	-0.05	-0.01	0.00	0.01	-0.02	0.00
	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.02)
Sex of HH Head	0.17**	-0.17*	0.09	0.00	-0.01	0.03
	(0.08)	(0.10)	(0.07)	(0.07)	(0.06)	(0.05)
Wealth Score	0.19***	0.18***	0.14***	0.17***	0.19***	0.16***
	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.03)
Education of mother (in years)	0.02**	0.04***	0.02***	0.03***	0.03***	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Mother's height	0.01***	0.02***	0.03***	0.03***	0.01***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Mother's weight	0.04***	0.04***	0.02***	0.02***	0.04***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Education of father (in years)	0.02**	0.00	0.01**	0.01	0.01**	0.01***
	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)
Season of birth	-0.15***	-0.05	-0.12***	-0.05	-0.11***	-0.08***
	(0.05)	(0.05)	(0.04)	(0.03)	(0.04)	(0.03)
Size of child at birth	-0.16**	-0.07	-0.15***	-0.17***	-0.12***	-0.17***
Average	(0.07)	(0.06)	(0.06)	(0.05)	(0.04)	(0.04)
Smaller than average	-0.31***	-0.28***	-0.36***	-0.40***	-0.30***	-0.40***
	(0.07)	(0.08)	(0.06)	(0.06)	(0.05)	(0.04)
Small	-0.59***	-0.12	-0.63***	-0.41***	-0.37***	-0.55***
	(0.13)	(0.12)	(0.11)	(0.09)	(0.09)	(0.07)
Religion: Hindu is base	-0.25**	0.07	-0.21**	-0.05	-0.09	-0.13**
Muslim	(0.11)	(0.10)	(0.09)	(0.07)	(0.07)	(0.05)
Christian	-0.26*	0.33**	0.17	0.19	0.06	0.17**
	(0.14)	(0.16)	(0.13)	(0.15)	(0.10)	(0.09)
Sikh	0.02	0.19	0.18	0.07	0.08	0.13
	(0.11)	(0.24)	(0.15)	(0.13)	(0.15)	(0.10)
Other	-0.05	0.09	0.16	0.14	0.02	0.16**
	(0.22)	(0.16)	(0.12)	(0.11)	(0.13)	(0.08)
Caste: Scheduled caste is base	0.01	-0.00	-0.13	0.05	0.00	-0.04
Scheduled tribe	(0.11)	(0.10)	(0.10)	(0.07)	(0.08)	(0.06)
Other backward caste	-0.08	0.08	-0.05	0.07	0.02	0.01
	(0.08)	(0.06)	(0.06)	(0.05)	(0.05)	(0.04)
None/ General caste	0.06	0.16**	0.04	0.15***	0.13**	0.11***
	(0.08)	(0.07)	(0.06)	(0.05)	(0.05)	(0.04)
Constant	-12.33***	-9.41***	-7.18***	-6.48***	-10.57***	-6.80***
	(1.02)	(1.05)	(0.87)	(0.87)	(0.82)	(0.69)
Observations	*5004*	*5455*	*5004*	*5455*	*10,459*	*10,459*
R-squared	0.26	0.23	0.31	0.29	0.21	0.27

All results are based on OLS regressions models with year of birth and district fixed effects. Estimates of standard errors (in parenthesis) are

robust and adjusted for the clustering at the district level. *** p<0.01, ** p<0.05, * p<0.1
Other controls include number of girls and boys under 13 in the household, age of HH head, age of mother, age of mother², owns a health card, dummies for husband's occupation, population, presence of traditional attendant, number of households in village, distance from all-weather road, distance to health sub-centre, distance to community health centre, distance to private clinic.

Table 6: Impact of different measures of rainfall on HAZ and WAZ of boys & girls 13-35 months

VARIABLES	(5) HAZ Girls	(6) HAZ Boys	(7) WAZ Girls	(8) WAZ Boys
Seasonal rainfall measure				
Positive rainfall in Dry season	0.04	0.06	0.02	-0.00
	(0.05)	(0.04)	(0.03)	(0.03)
Negative rainfall in Dry season	-0.08	-0.04	-0.05	-0.03
	(0.08)	(0.06)	(0.07)	(0.05)
Positive rainfall in Wet season	0.11	0.04	0.04	0.04
	(0.08)	(0.08)	(0.06)	(0.06)
Negative rainfall in Wet season	-0.13*	-0.11	-0.11*	-0.11**
	(0.08)	(0.08)	(0.06)	(0.05)
Categorical measure of rainfall				
Base: Rainfall less than 1 SD	0.19*	0.18*	0.17**	0.15**
Average rainfall (1 SD around	(0.10)	(0.10)	(0.08)	(0.07)
mean)	0.28**	0.22*	0.17*	0.21**
Rainfall more than 1 SD	(0.14)	(0.13)	(0.10)	(0.10)
Categorical measure of rainfall				
Including gestation period				
Base: Rainfall less than 1 SD	0.29**	0.29**	0.23***	0.20**
Average rainfall (1 SD around	(0.12)	(0.12)	(0.08)	(0.08)
Mean)	0.37**	0.25	0.23**	0.22*
Rainfall more than 1 SD	(0.15)	(0.16)	(0.10)	(0.12)
Base: Rainfall less than 1 SD during gestation	0.22*	0.21*	0.14*	0.08
Average rainfall (1 SD around	(0.12)	(0.12)	(0.08)	(0.08)
Mean in gestation)	0.22	-0.00	0.16*	0.01
Rainfall more than 1 SD in gestation	(0.13)	(0.15)	(0.09)	(0.11)
Observations	*5004*	*5455*	*5004*	*5455*

All results are based on OLS regressions models with year of birth and district fixed effects. Estimates of standard errors (in parenthesis) are robust and adjusted for the clustering at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Impact of categorical measure of rainfall on the hazard of stoppage of breastfeeding for children aged 13-35 months

VARIABLES	(1) Girls	(2) Boys	(3)	(4) Girls	(5) Boys	(6)
		Coefficient			Hazard Ratio	
Base: Rainfall less than 1 SD						
Average rainfall (1 SD around mean)	0.34*** (0.10)	0.27*** (0.07)	0.32*** (0.08)	1.4049	1.3100	1.3771
Rainfall more than 1 SD	0.37** (0.16)	0.41*** (0.13)	0.44*** (0.14)	1.4477	1.5068	1.5527
Gender			0.04 (0.06)			1.0408
Base: gender* Rainfall less than 1 SD Gender*average Rainfall			-0.06 (0.06)			0.9418
Gender* Rainfall more than 1 SD			-0.06 (0.09)			0.9418
Birth Order	0.03* (0.02)	0.02 (0.02)	0.02* (0.01)	1.0305	1.0202	1.0202
Nb of girls under 13 to mother	0.01 (0.03)	0.01 (0.02)	0.01 (0.02)	1.0101	1.0101	1.0101
Nb of boys under 13 to mother	0.01 (0.03)	0.00 (0.03)	0.01 (0.02)	1.0101	1.0000	1.0101
Wealth Score	0.00 (0.04)	0.03 (0.04)	0.01 (0.03)	1.0000	1.0305	1.0101
Age of mother	-0.04 (0.02)	-0.04* (0.02)	-0.03** (0.01)	0.9608	0.9608	0.9704
Age of mother²	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.0000	1.0000	1.0000
Education of mother (in years)	-0.01 (0.01)	0.01** (0.00)	0.00 (0.00)	0.9900	1.0101	1.0000
Mother engages in farm work (y=1, n=0)	-0.04 (0.04)	-0.06 (0.04)	-0.04 (0.03)	0.9608	0.9418	0.9608
Season of birth	-0.85*** (0.06)	-0.93*** (0.05)	-0.90*** (0.04)	0.4274	0.3946	0.4066
Religion: Hindu is base Muslim	-0.02 (0.07)	-0.01 (0.06)	-0.00 (0.04)	0.9802	0.9900	1.0000
Christian	0.01 (0.12)	-0.14 (0.17)	-0.11 (0.12)	1.0101	0.8694	0.8958
Sikh	-0.14 (0.26)	0.02 (0.14)	-0.04 (0.10)	0.8694	1.0202	0.9608
Other	-0.11 (0.14)	-0.17 (0.13)	-0.16 (0.11)	0.8958	0.8437	0.8521
Caste: Scheduled caste is base Scheduled tribe	-0.12* (0.06)	-0.07 (0.06)	-0.07* (0.04)	0.8869	0.9324	0.9324
Other backward caste	-0.06 (0.05)	0.01 (0.04)	-0.01 (0.03)	0.9418	1.0101	0.9900
None/ General caste	-0.01 (0.06)	-0.01 (0.04)	-0.01 (0.03)	0.9900	0.9900	0.9900
Observations	*6207*	*6789*	*12996*	*6207*	*6789*	*12996*

All results are based on Cox proportional hazard model regressions models with year of birth and district fixed effects. Estimates of standard errors (in parenthesis) are robust and adjusted for the clustering at the district level. *** p<0.01, ** p<0.05, * p<0.1
Other controls include number of girls and boys under 13 in the household, age and gender of HH head, father's education, owns a health card, dummies for husband's occupation, population, presence of traditional attendant, number of households in village, distance from all-weather road, distance to health sub-centre, distance to community health centre, distance to private clinic.

Table 8: Impact of different measures of rainfall shock on the hazard of stoppage of breastfeeding for children aged 13-35 months

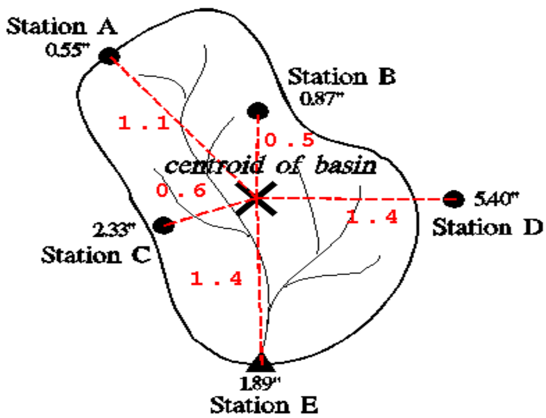
VARIABLES	(1) Girls	(2) Boys	(3) Girls	(4) Boys
	Coefficient		Hazard ratio	
Seasonal rainfall measure				
Positive rainfall in dry season	0.22***	0.21***	1.2461	1.2337
	(0.07)	(0.05)		
Negative rainfall in dry season	-0.08	-0.06	0.9231	0.9418
	(0.08)	(0.07)		
Positive rainfall in Wet season	0.16	0.19*	1.1735	1.2092
	(0.14)	(0.11)		
Negative rainfall in Wet season	-0.16**	-0.09	0.8521	0.9139
	(0.07)	(0.06)		
Categorical measure of rainfall				
Base: Rainfall less than 1 SD	0.32***	0.27***	1.3771	1.3100
Average rainfall (1 SD around	(0.10)	(0.07)		
mean)	0.36**	0.41***	1.4333	1.5068
Rainfall more than 1 SD	(0.16)	(0.13)		
Observations	*6207*	*6789*	*6207*	*6789*

All results are based on Cox proportional hazard model regressions models with year of birth and district fixed effects. Estimates of standard errors (in parenthesis) are robust and adjusted for the clustering at the district level. *** p<0.01, ** p<0.05, * p<0.1

Appendix

Inverse Distance Weighting

This is a popular measure of calculating the point precipitation of a district from multiple weather stations. Each observed weather station value is given a unique weight based on the distance from the centroid of the district in question. The district precipitation value is then calculated based on the sum of the individual weather station weight multiplied by observed weather station precipitation value.[6] Below is a diagrammatic illustration from the National Weather Service website:



[6] National Weather Service website