Mortality Risks, Health Endowments, and Parental Investments in Infancy: Evidence from Rural India

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Abstract

This paper examines whether increased background mortality risks induce households to make differential health investments in their high- versus low-endowment children. We argue that increases in background mortality risks may disproportionately affect the survival of the low-endowment sibling, consequently increasing the mortality gap between the high- and low-endowment siblings. This increase in mortality gap may induce households to invest more in their high-endowment children. We test this hypothesis using nationally representative data from rural India. We use birth size as a measure of initial health endowment, immunization & breastfeeding as measures of childhood investments, and infant mortality rate in the child's village as a measure of mortality risks. We find that in villages with high mortality risks, small-at-birth children in a family are 6–17 percent less likely to be breastfed or immunized compared to their average- or large-at-birth siblings. In contrast, we find no significant within family differences in investments in villages with low mortality risks.

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1. Introduction

Both developed and less developed countries have experienced a dramatic decline in infant mortality rates over the last few decades. World infant mortality rate is estimated to have declined from 198 in 1960 to 83 per 1000 live births in 2001. However, infant mortality in less developed countries remains high – roughly 10 times the rate in the developed world. Reducing infant mortality in the less developed world is thus one of the most important development challenges. The millennium development goals have set a target to reduce infant mortality rates by two-thirds from 1990 to 2015.

The direct health benefits of reducing infant mortality are obvious. However, reductions in infant mortality might also have indirect effects that are less well understood. In particular, childhood mortality risks are a major source of risk in the returns to childhood investments. Thus, reductions in mortality risks could affect parental investments in children, consequently affecting children's long term health and economic well being. For example, Dow et al. (1999) show that the incentive to invest in child health depends inversely on the level of mortality risks. They find evidence that the reduction in mortality risks due to the Expanded Programme on Immunization of the World Health Organization increased parental health investments unrelated to immunization. [1] In recent work, Jayachandran and Lleras-Muney (2008) find that sharp declines in maternal mortality risk in Sri Lanka between 1946-1953 led to significant increases in female literacy and female years of education. In a theoretical paper, Estevan and Baland (2007) argue that high mortality risks could lead to inefficient investments in human capital. They show that the level of child labor could be inefficiently high when survival is uncertain and parents expect cash transfers from their children. This is because, given the uncertain survival of their child, parents tend to favor a certain investment, such as saving, to an uncertain one, such as human capital.

In this paper, we add to this literature by examining how mortality risks affect intra-household childhood investments in siblings with different initial health endowments. We argue that increases in background mortality risks disproportionately affect the survival of the weaker sibling. Thus, increases in mortality risk not only increase overall risks but also increase the mortality gap between siblings with high and low initial health endowments. Since mortality risks are one of the important drivers of returns to parental investments, we argue that increases in mortality risks should also increase disparities in parental

[1] In related work, Oster (2007) uses a competing mortality risks framework to examine whether lower mortality risks influence individuals' risky health behavior. She finds that individuals with longer non-HIV life expectancy (due to lower malaria prevalence or maternal mortality risk) are more likely to change their sexual behavior.

investments across high and low initial health endowment children. We empirically test this prediction using data from rural India. We use birth size as a measure of initial health endowment, immunization & breastfeeding as measures of childhood investments and infant mortality rate in the child's village as a measure of mortality risks. We find that in villages with high mortality risks, small-at-birth children in a family are less likely to be breastfed or immunized compared to their average- or large-at-birth siblings. In contrast, we find no significant within-family differences in investments in villages with low mortality risks.

This paper also makes a direct contribution to the empirical literature on the effect of endowment differences on intra-household resource allocation (Griliches, 1979; Behrman et al., 1982; Rosenzweig and Schultz, 1982; Rosenzweig and Wolpin, 1988; Pitt et al., 1990; Behrman et al., 1994; Ayalew, 2005; Datar et al., 2006; Rosenzweig and Zhang, 2006).[2] Previous work in this area has generally treated endowments as observable to parents but unobservable to researchers. Notable exceptions are the recent studies by Datar et al. (2005), and Rosenzweig and Zhang (2006) that use birth weight as a proxy for health endowment and conduct a direct test of whether variation in birth weight across siblings generates differences in parental investments. We adopt a similar approach in this paper, but in the absence of good clinical data on birth weight, we utilize birth size as reported by the mother as an indicator of child's initial endowment. Birth size is directly observable to parents, and it has also been found to be highly correlated with birth weight (Moreno and Goldman, 1990). Therefore, our measure of endowment is likely to be quite close to that used by parents in assessing the initial healthiness of a child. We acknowledge that birth outcomes are partially a consequence of prenatal investments made by parents and are therefore likely to be endogenous even after mother fixed-effects are included. However, our primary goal in this paper is to examine how changes in background mortality risks influence the relationship between birth size and parental investments. Identification of this effect relies on the assumption that sibling-specific heterogeneity does not differ across areas with high- versus low-background mortality risk. We conduct several robustness checks testing this assumption and find that our results remain unchanged.

The rest of the paper is organized as follows. In section 2, we describe the data and variables used for this analysis, and discuss our measures for birth size, parental investments, and background mortality. In section 3, we present a model of parental investments that motivates our empirical approach. Section 4 discusses our empirical strategy, and section 5 presents the main results. In section 6, we

[2] Behrman et al. (1995) and Behrman (1997) offer excellent reviews of the literature on intrahousehold resource allocation.

discuss additional results from a number of robustness checks, and section 7 concludes.

2. Data and Measures

We use data from the 1992-93 National Family Health Survey (NFHS). The NFHS surveyed a nationally representative sample of households in India's 26 major states, and the primary respondents were ever-married women in the 13-49 age group. Structured interviews were conducted with the women and the household in which they resided. Detailed information on the survey is available at http://www.nfhsindia.org. We use the rural sample of NFHS for our analysis and focus on women who had at least 2 live births within the previous 4 years of the survey. We have detailed information on the 16,404 children born to 7,951 women.

We exploit 5 key features of the NFHS for the purposes of this paper. First, the NFHS collected detailed information on each child born to an interviewed woman during the four years prior to the survey. Information was collected on children even if they had died by the time of the survey. This allows us to examine outcomes for all children born to a mother within the previous 4 years of the survey, and not only children living at the time of the survey, thereby avoiding any selection issues induced by mortality. For women who had more than one live birth during this 4 year period (1988-89 to 1992-93), information was obtained on the 3 most recent live births.

Second, we have information on birth size for almost all surveyed children, and use this as a proxy for a child's initial endowment. As mentioned before, we would have liked to utilize birth weight information for children as the measure of initial health endowment. However, birth weight is available for less than 8% of the children in our sample[3], whereas information on birth size (small, average, large) is available for more than 98% of the children.[4] Dow et al. (1999) also use birth size information from Demographic and Health Surveys to proxy birth weight. Birth size may be a better measure of initial health endowment for our analysis compared to actual birth weight since it is mother-reported and, therefore, captures the perceived "healthiness" of the child. Ultimately, it is this perception that is likely to influence parent's decisions, regardless of what the child's actual endowment may be. In rural households, where the majority of

[3] Missing data on birth weight for a large part of our rural sample is mainly due to the fact that most deliveries in rural India take place outside of health facilities and are done by traditional mid-wives who typically do not measure the newborn's weight at birth.

[4] Moreno and Goldman (1990) report that relative size at birth as reported in the Demographic and Health Surveys (DHS) was of reasonably high quality, and was well correlated with measured birth weights.

births take place outside the formal health care system, birth size may be the only indicator of the live infant's healthiness to the parent.

Third, the NFHS collected information on two key health investments that parents make in their children during infancy and early childhood – breastfeeding and immunizations. This information was collected for a maximum of 3 children in the family who were born within the last 4 years, allowing us to estimate mother fixed-effect models.

Fourth, the availability of information on maternal and child characteristics, as well as on prenatal investments at the time of each child's birth allows us to control for observable difference across siblings that may be correlated with birth outcomes as well as parental investments.

Finally, the birth history information obtained from each mother allows us to construct a village level measure of infant mortality that captures the background mortality risk for infants in each village.

The main outcomes of interest in our study are health investments that parents make in their children during infancy. In particular, we focus on immunizations and breastfeeding:

1. Whether the child received all age appropriate doses of Polio vaccination.
2. Whether the child received all age appropriate doses of non-Polio, i.e., BCG and DPT vaccinations.
3. Whether the child was breastfed for at least 6 months.

Health investments such as immunizations and breastfeeding during a child's first year are highly recommended by the World Health Organization (WHO) and are also included as objectives in the various child health programs of the Department of Family Welfare in India (Ministry of Health and Family Welfare, 2006). In order to increase immunization coverage, the Government of India started the Universal Immunization Program (UIP) in 1985-86, which aimed to vaccinate at least 85% of all infants by 1990 against the 6 vaccine-preventable diseases or VPDs (tuberculosis, diphtheria, pertussis, tetanus, poliomyelitis, and measles). We distinguish between 2 types of immunization coverage – Polio and non-Polio – because vaccination against Polio has historically received greater public health attention in India. For example, under the Expanded Programme on Immunization (EPI) started by the Government of India in 1978, immunization against Polio was introduced early in 1979-80.[5] Further, previous research shows a stronger connection between improvement in rural health infrastructure and immunization against non-Polio diseases than against Polio (Datar et al., 2006).

[5] More recently, the Government of India initiated the Pulse Polio Initiative (PPI) Campaign in 1995, which sought to proactively engage the public through media awareness campaigns and set up additional infrastructure for dispensing polio vaccines.

This in turn suggests different delivery mechanisms and coverage strategies for Polio and non-Polio vaccines. In the case of breastfeeding, the Innocenti Declaration on the Protection, Promotion, and Support of Breastfeeding (1990), and the WHO Working Group on Infant Feeding (WHO, 1991) made several recommendations, which state that infants should be exclusively breastfed for 4 to 6 months. Also, previous research has shown that breastfeeding protects children from a number of diseases including gastrointestinal tract infections, and atopic eczema (Kramer et al., 2001). A systematic review of evidence by the WHO on the optimal duration of exclusive breastfeeding finds that exclusive breastfeeding for at least 6 months can reduce child morbidity from gastrointestinal infections (Kramer and Kakuma, 2002).

Data on immunization were collected in the NFHS through the mother questionnaire for children in the age group of 2-35 months. Mothers were asked about the immunizations received by each of her eligible children, and where possible, this information was verified by cross-checking against the child's vaccination card. Specifically, the survey asked whether the child had received BCG, DPT (all doses), Polio (all doses) and Measles vaccinations.

Since both the timing as well as completeness of vaccinations are important, we follow Datar et al.'s (2006) approach and denote a child as having "full age appropriate coverage" for polio or non-polio vaccinations using Government of India's Recommended Immunization Schedule (Table 1). Thus, for example, a child who is 3 months old, and has BCG, DPT1 and 2, and Polio1 vaccines would be classified as having "fully age appropriate coverage" under the non-Polio vaccine category, but would be classified as not having "fully age appropriate coverage" for the Polio vaccine. This approach allows us to distinguish between children who receive age appropriate coverage and children who are immunized at an older (or younger) age and therefore are exposed to the risk of VPDs for a longer duration of time (or are physiologically not ready for vaccination). Also, as mentioned before, these outcomes are observed for children even if they were not alive at the time of the survey. Hence, by using information on current age for living children and age at death for children who died before the survey, we are able to define "fully age appropriate coverage" for both groups of children.

Mothers were asked about their breastfeeding behavior for each of their 3 most recent live births in the past 4 years. The survey questions did not ask about exclusive breastfeeding, but instead focused on any breastfeeding, including when it was initiated and how for long it was done. Following the WHO guidelines, our breastfeeding measure captures whether the child was breastfed for at least 6 months. For the breastfeeding analysis, we restrict our sample to children 6 months and older, and once again use information on both children who are living

at the time of the survey and those who survived for at least 6 months after birth, but died before the survey.

For the purpose of our analysis, we first restrict our sample to mothers with at least 2 children for whom birth size information is available. Next, we only keep children for whom there is information on at least one of the parental investments examined in the paper. This reduces our sample size to 16,088 children born to 7,891 mothers. Later, we show that the final sample used in our analysis looks fairly similar to the original sample of mothers with at least 2 live births in the 4 years prior to the survey. The exact sample sizes in our regressions drop further when we exclude observations with missing values for the particular parental investment being examined, and/or with missing values for any of the other variables in our analysis, and once again ensure that there are at least two children for every mother in each of the regressions.

The means and standard deviations of the parental investment variables and other explanatory variables are reported in panels A and B of table 2 – for children in our analysis sample, and the original sample of children respectively (those with at least one sibling). These suggest that children in our analysis sample are quite similar to those in the original sample with respect to parental investments as well as other attributes. Based on the summary statistics for our analysis sample (panel A), we find that only about 35% of the children were fully immunized against polio, while only a quarter were fully immunized against non-polio diseases. In contrast, 85% of children aged 6 months and older were breastfed for at least 6 months. This suggests that breastfeeding was fairly widespread in rural India, compared to immunization.

Birth size information for each child in the NFHS was reported by the mother retrospectively. Specifically, mothers were asked to report whether a particular child was "large", "average", or "small" when he/she was born, for each of her 3 most recent live births within the 4 years preceding the survey. The median number of months between the child's birth and the mother's report of that child's birth size, or the "recall" period in our sample is 22 months or about 2 years.[6] Nearly a quarter of all children in our sample were smaller than average size at birth (hereafter small-at-birth). Additionally, the median age of the mother at birth was 22 years, the median birth order was 3, and exactly half the children were male.

[6] This is comparable to the median recall period for birth weight in Datar et al.'s (2006) study that used the National Longitudinal Study of Youth 1979 – Child Data. Parental recall of birth weight has been found to be fairly accurate in a number of studies (Walton et al., 2000; O'Sullivan et al., 2000). Maternal recall of whether the child was born bigger or smaller than average is likely to be more accurate relative to a numerical birth weight.

There exists a substantial amount of within-family variation in birth size and parental investments in our data. Table 3 reports the percentage of families with intra-family variation in birth size and health investments i.e. at least one sibling had a different birth size or investment compared to the other siblings. More than 26% of the families in this sample have across-sibling variation in birth size and in age-appropriate polio coverage, and 22% of the families have variation across siblings in age-appropriate non-polio coverage. About 41% of the families have variation across siblings in whether they were breastfed for 6 or more months.

Finally, we measure background mortality risk by constructing a village level infant mortality rate. Using retrospective birth history data, we aggregate the number of children born in a village within the previous 4 years across all women who were interviewed in that village, and also the number of children who died before the age of one to construct an infant mortality rate for each village in our sample. We classify a village as having high background mortality risk if the infant mortality rate for that village exceeds the median infant mortality rate in the distribution, which is 7% (same as the mean).

3. Theoretical Framework

In this section, we outline a simple one-period model of parental investments in children's health when child survival is uncertain. We follow the approach of consensus parental preference models (Behrman, 1997) and assume that altruistic parents maximize their consensus utility function

(1) $U[V(h_1, h_2, \ldots, h_n), Y]$

where V(.) is a parental welfare function that has as its arguments the adult health of each child (h_i), and Y is the parents' consumption.

Parents maximize their utility function subject to two constraints: the health production function for each child and the household's budget constraint. The health production function shows the adult health of child i and is increasing in health and educational investments that parents make in the child (x_i) and the child's endowment (e_i), but is decreasing in the background mortality risk (m) that the child faces. m refers to the underlying risk of dying due to factors exogenous to the household.

(2) $h_i = h(x_i, e_i, m) \qquad i= 1, 2, \ldots, n$

The budget constraint requires that parental expenditures on their own consumption and investments in their children's health not exceed their total resources (M).

$$(3) \qquad \sum_{i=1}^{n} x_i v + Y = M$$

where *v* is the relative price of parental inputs.

First order conditions from the above model can be written as follows.

$$(4) \qquad V'_{h_i} h'_{x_i} = V'_{h_j} h'_{x_j} \quad \forall\, i \neq j$$

The above equation shows that the marginal benefit from investing in each child should be equal at the optimum. The first term on the left hand side captures the marginal utility to the parent from an increase in child *i*'s health. The second term on the left hand side captures the marginal returns in terms of health from an increase in parental inputs into child *i*.

The optimal level of parental investment in each child (x_i*) is a function of the child's endowment, background mortality risk, price of parental inputs, and income:

$$(5) \qquad x_i^* = x_i^*(e_i, m, v, M)$$

In this paper, we are specifically interested in two comparative statics – (a) how parental investments change as the child's endowment increases i.e. dx_i^* / de_i , and (b) how parental responsiveness to child endowment changes as background mortality risk increases i.e. $d^2 x_i^* / de_i dm$.

From the first order condition, it can be seen that x_H*- x_L*, which is the difference in parental investments between a high (H) endowment and a low (L) endowment child, depends upon two quantities – (a) the ratio of the marginal utility of health for the two children (V'_{h_L} / V'_{h_H}), and (b) the ratio of the marginal returns to parental investments for the two children (h'_{x_L} / h'_{x_H}). The first quantity depends upon the properties of the parental welfare function V(.) i.e. parental preferences for equity versus efficiency and whether parents have "equal concern"

for all their children[7]. For example, all else equal, x_H*- x_L* is likely to be smaller for parents who exhibit a higher preference for equity or who have greater concern for their low endowment child. The second quantity depends upon the properties of the health production function h(.), in particular, whether the returns to parental investments are higher for the high or low endowment child. For example, x_H*- x_L* is likely to be larger if returns to parental investments increase with endowments. Therefore, it is a priori unclear whether x_H*- x_L* is positive, negative or zero.

The second comparative static examines how x_H*- x_L* changes as background mortality risk increases. In general, this effect would depend upon how the ratios V'_{h_L} / V'_{h_H} and h'_{x_L} / h'_{x_H} vary with background mortality risk. An increase in background mortality risk would reduce the probability of surviving to adulthood, and therefore returns to parental investments, for all children. However, the magnitude of reduction in these returns might critically depend on the endowment of the child. For example, an increase in background mortality risk might affect the survival probability of the low endowment child more than that of her high endowment sibling. This is because lower endowment children might be less resilient and more susceptible to disease. Consequently, the returns to parental investment in the low endowment child reduce more compared to the returns to investment in the high endowment sibling. This change in relative returns implies that an increase in background mortality risk will increase x_H*- x_L*. Changes in background mortality risk, however, might also be related to changes in parental preferences. For example, parents with a high preference for equity might choose to live in areas with low mortality risks. Therefore, it is a priori unclear how changes in mortality risk affect x_H*- x_L*. Ultimately, how changes in background mortality risk affect investments in children is an empirical question which we test in the subsequent sections.

4. Empirical Strategy

An econometric model for the demand function shown in equation (5) can be written as follows:

$$(6) \qquad I_{if} = \beta_1 small_{if} + \beta_2 small_{if} * highmortality_f + \beta_3 X_{if} + \gamma_f + \phi_i + \varepsilon_{if}$$

where "*i*" indexes child, and "*f*" indexes family. The dependent variable, *I*, is an indicator for whether a child received a specific parental investment or not. A

[7] "Equal concern" refers to whether the parental preference indifference curves are symmetric around the 45 degree line. Parental preferences for equity versus efficiency are captured by the shape of the indifference curves (e.g. L-shaped or straight lines).

child's own endowment is captured by the variable *small*, which is an indicator for whether the child was smaller than average birth size. The variable *highmortality* is a village level indicator for whether the infant mortality rate in that village was greater than the median mortality rate (7%). The vector X_{if} includes other child- and family- specific characteristics that may influence parental investment, child survival and birth outcomes (e.g. gender, income, price of health inputs). In addition to these "observed" characteristics are a set of unobservable factors that affect parental investments – γ_f represents unobserved endowments and environmental influences (pre- and post-natal) common to all siblings in a family and ϕ_i represents unobserved child-specific factors that are correlated with parental investments and birth outcomes. Finally, ε_{if} is an idiosyncratic error term.

The key parameters of interest in equation (6) are β_1 and β_2. β_1 captures the effect of own-endowment on parental investment. β_2 captures the additional effect of own-endowment in areas where the background mortality risk is high.[8] The model that we estimate, however, is the following:

$$(7) \qquad I_{if} = \alpha_1 small_{if} + \alpha_2 small_{if} * highmortality_f + \alpha_3 X_{if} + \gamma_f + \nu_{if}$$

where, $\nu_{if} = \phi_i + \varepsilon_{if}$. While the mother fixed-effect γ_f controls for the influence of all unobserved family specific factors correlated with parental investment and birth outcomes, one might be concerned that the error term may still include sibling-specific factors that are correlated with parental investment and birth outcomes. Below, we discuss 3 reasons why such concerns are minimized. First, we include a number of sibling-specific controls in X_{if} such as gender, birth month, birth order, mother's age at birth, and a host of prenatal investments in child *i* such as whether the mother received iron folic tablets during pregnancy, whether she was given tetanus injections before birth, and the trimester of her first antenatal visit. Inclusion of these covariates will absorb a lot of the important sibling-specific heterogeneity contained in the error term. Second, the siblings within a family are all born within a relatively short time period. This significantly reduces the likelihood that aspects of family circumstance, not already captured by our covariates, changed enough between the birth of the 2 siblings to affect their birth size and parental investments. Third, if the bias from sibling-specific heterogeneity remains the same across high- and low-infant mortality villages, then the estimated α_2 will be unbiased, because α_2 captures the

[8] The direct effect of *highmortality*, which does not vary across siblings within a family, cannot be estimated in this model due to the inclusion of the family fixed effect.

differential effect of being small in high mortality areas.[9] In section 6, we test whether the bias from sibling-specific heterogeneity is the same across high and low mortality villages.

We estimate equation (7) using linear probability models and adjust the standard errors for clustering at the family level (Bertrand et al. 2004).

5. Results

We begin by reporting estimates from a special case of the model in equation (7) that assumes there are no differences in parental response to birth size across high- and low-infant mortality areas i.e. $\alpha_2 = 0$. Panel A in Table 4 reports the estimated effects of being smaller-than-average birth size on the likelihood of receiving age-appropriate polio and non-polio immunizations and breastfeeding for at least 6 months. We find that children with smaller birth size are significantly less likely to be immunized against both polio and non-polio diseases relative to their larger birth size siblings; smaller birth size siblings have a 4 and 3 percentage point lower likelihood of being immunized against polio and non-polio diseases, respectively, and both these effects are significant at the 1% level. However, a child's relative birth size does not significantly affect her chances of being breastfed for at least 6 months. Among other covariates in the model, gender, maternal age and prenatal investments are associated with immunizations, but not with breastfeeding. Boys[10] and siblings born when the mother is younger and when she took tetanus injections and iron folic tablets during pregnancy have a significantly greater likelihood of receiving polio and non-polio immunizations. For breastfeeding, first borns are less likely to be breastfed for 6 months and younger mothers are less likely to breastfeed for 6 months or more.

Panel B in Table 4 reports estimates from the model in equation (7). The interaction term tests whether parents residing in villages with a high infant

[9] To see this, let δ_1 and δ_2 be the estimated coefficients on *small* from 2 separate regressions that estimate equation (7) using the low mortality and high mortality subsamples, respectively. The difference $\delta_2 - \delta_1$ is equal to the estimate α_2 from equation (7). If $\delta_1 = \beta_1 + \text{bias}$ and $\delta_2 = \beta_1 + \beta_2 + \text{bias}$ then $\delta_2 - \delta_1 = \beta_2$. This argument obviously assumes that the "bias" would be the same in high mortality and low mortality areas. This assumption is tested using several robustness checks in section 6.

[10] To examine the hypothesis that parental response to birth size differences between their children might depend upon whether the small birth size child is a boy or girl, we tested for the interaction between birth size and gender in an alternate specification (results available from the authors upon request). The interaction effect was not statistically significant, and all other estimated parameters were same as before.

mortality rate are more likely to adopt a reinforcing strategy compared to parents in villages with lower background mortality. Our results confirm this hypothesis. In high infant mortality villages, a small birth size child is about 6 and 4 percentage points less likely to be immunized with polio and non-polio vaccines, respectively, compared to her better endowed siblings. However, there is no significant effect of a child's birth size on immunizations in low infant mortality villages. Further, the same reinforcing pattern in parental investments is now observed for breastfeeding as well. In high mortality villages, a small birth size child is about 4 percentage points less likely to be breastfed for at least 6 months compared to her larger birth size siblings. As in the case of immunizations, there is no significant effect of birth size on breastfeeding in low mortality villages.

We also estimated equation (7) with a continuous measure of infant mortality at the village level instead of the indicator for high mortality. The results were similar to those reported above. Additionally, we compared villages above the 75th percentile in the distribution of the infant mortality rate with those below the 25th percentile, instead of looking at villages above and below the median. Once again, results were similar suggesting a stronger reinforcing pattern in villages with high background mortality risk.

6. Robustness Checks

The primary goal of this paper is to examine how changes in background mortality risks influence parental responses to children's endowment differences. Identification of this effect relies on the assumption that sibling-specific heterogeneity does not differ across areas with high- and low-background mortality risk. However, there is some concern that infant mortality rate is not an exogenous measure of background mortality risks. Thus, it is possible that our results might be driven by observed or unobserved differences across high- and low-mortality villages that correlated with parental investments and birth outcomes. To address this concern we discuss results from several robustness checks in this section.

6.1. Do preferences for discrimination explain the stronger reinforcing effects in high mortality villages?

As discussed in section 3, it may be possible that villages that have a high background mortality risk are also those that have generally higher parental preferences for discrimination. If this were true, the evidence of stronger reinforcing effects in high mortality villages might be the result of such parental preferences rather than the result of background mortality *per se*. To test this

alternate explanation, we examine intra-household gender differences in parental investments across high- and low- infant mortality villages. If the stronger reinforcing effects in high mortality villages are driven purely by parental preferences for discrimination then we should find that parents in high mortality villages are more likely to discriminate between their sons and daughters.

Table 5 reports estimates from models that include an additional interaction term for male child and high background mortality. There are 3 notable results from this analysis. First, our main finding that parents in high mortality villages are more likely to reinforce birth size differences remains unchanged. Second, consistent with the prior literature, we also find that parents are significantly more likely to immunize their sons compared to daughters. And finally, the insignificant coefficient on the male-high mortality interaction suggests that parents in high mortality villages do not have any different preferences for gender discrimination compared to parents in low mortality villages.

6.2. Do high mortality villages also exhibit stronger reinforcing patterns for prenatal investments?

The main finding of this paper is that parents in high mortality villages are more likely to reinforce birth size differences by making more postnatal investments in high endowment children. It is possible that this stronger reinforcing pattern in high mortality areas is driven by unobserved sibling-specific heterogeneity that increases pre- and post-natal investments as well as birth outcomes in some children relative to others. If this were true, we should expect to see a similar pattern of results with respect to prenatal investments too i.e. a stronger positive association between birth size and prenatal investments in high mortality areas relative to low mortality areas.

The results from this test are reported in Table 6. The upper panel of Table 6 reports estimates from a model without mother fixed effects. Here, we simply check whether prenatal investments in general differ across high versus low mortality areas. We find that, as one would expect, high infant mortality in a village is associated with significantly lower prenatal investments. Specifically, high mortality risk leads to significantly lower probabilities of iron and folic acid supplementation, tetanus toxoid vaccination, and antenatal visit in the first trimester. The estimates in the lower panel of Table 6 are from models with mother fixed effects, and these results clearly show that there is no significant difference in the relationship between birth size and prenatal investments in high versus low mortality areas. In other words, it is unlikely that the stronger reinforcing pattern in high mortality villages is driven by unobserved sibling-

specific factors that differ by mortality risk since that would have also led to a stronger reinforcing pattern in prenatal investments.

6.3. Does controlling for sibling-specific observed heterogeneity matter?

As discussed in section 5, there may be concern that our results are partly driven by unobserved sibling level economic shocks correlated with birth size and parental investments that vary across high- and low-mortality villages. In other words, the bias from sibling-specific heterogeneity may differ across high- and low-infant mortality villages. To address this concern, we estimate models without child level covariates (Table 7). The estimates are similar to those reported in Panel B of Table 4 and show that our results are virtually unchanged when we add sibling-specific covariates, including prenatal investments. Therefore, if controlling for observed sibling-specific heterogeneity leaves our results unchanged it is less likely that unobserved sibling-specific heterogeneity will bias our results.[11]

6.4. Does differential availability of health infrastructure explain the stronger reinforcing effects in high mortality villages?

One might be concerned that villages with high infant mortality also have inadequate health infrastructure. If this were true, the evidence of stronger reinforcing effects in high mortality villages might be the result of differential health infrastructure availability rather than the effect of background mortality *per se* (Oster, 2006). To address this concern, we examine whether the interaction between *small* and *highmortality* is significantly different in villages that have at least a Primary Health Center (PHC) compared to villages that do not have a PHC. [12]

Table 8 reports estimates from models that include a triple interaction term for *small*, *highmortality*, and an indicator for whether there is a PHC or bigger health facility in the village. Two main results stand out from this analysis. First, parents' response to differences in their children's birth size is not influenced by whether there is a PHC present in the village. And second, the triple interaction term is statistically insignificant for all investments suggesting that the stronger

[11] In analyses not reported here, we also estimated our models using births spaced within 2 years of each other. The assumption here is that family circumstances are likely to change slowly over time and therefore sibling-specific heterogeneity is likely to be minimal. The point estimates from this test are also similar to those from the full sample, although the standard errors are larger as we drop more than 75% of the observations due to the restriction of closer spaced births.

[12] Using NFHS data, Datar et al (2007) found that presence of a PHC or bigger health facility in the village had a significant impact on immunizations, but smaller size facilities had no effect.

reinforcing effect found in high mortality villages is not explained by differences in health infrastructure availability.

6.5. Controlling for the presence of other small-at-birth siblings in the household

As pointed out in Datar et al. (2006), other siblings' endowments could also impact the amount of investment parents make in child *i*. Presence of other less-endowed siblings in the household might increase or decrease the level of parental investment in a child because, first, the realization of a low endowment child might raise parental concern for all children and therefore increase the levels of all subsequent investments, and second, parents' *ability* to either reinforce or compensate for endowment differences would depend upon the endowments of other children in the household who compete for the same limited family resources. Since a child's endowment is likely to be correlated with that of his or her siblings, failure to control for siblings' endowment may lead to biased estimates of the effect of birth size on parental investments. In addition, it is likely that presence of other small-at-birth siblings is correlated with background mortality i.e. families living in high mortality villages may be more likely to have multiple low birth weight children. Therefore, omission of this variable may bias the estimate of α_2.

To check the robustness of our results, we re-estimate equation (7) with the inclusion of another dummy variable that captures whether the child has any siblings who were also small-at-birth and are currently alive (results reported in Table 9). This variable is measured during the first year of child *i*'s life, when majority of the immunization and breastfeeding investments are made. The value of this variable varies across siblings. We find that the presence of other small-at-birth siblings does not have any significant effect on parental investments in a child – as shown by the estimated coefficients on "any small-at-birth siblings present". Moreover, the effect of birth size on immunizations remains virtually unchanged – both in terms of magnitude and the direction of effects.

7. Conclusions

In this paper, we examined the relationship between children's initial health endowment, measured by birth size, and parental investments that promote child health, when infants' survival is uncertain. Using data from rural Indian households, we estimated mother fixed-effects models to examine whether there were any systematic differences in health investments such as immunizations and breastfeeding across children who were relatively large-at-birth compared to their small-at-birth siblings. We found that parents in villages with a high infant

mortality rate adopted a reinforcing strategy of investments in child health whereby larger-at-birth children were significantly more likely to be immunized and breastfed compared to their small-at-birth siblings. For example, in villages with high infant mortality, small-at-birth children in a family were 4-6 percentage points less likely to receive these health investments compared to their large-at-birth siblings. In percentage terms, these amount to a 17 percent, 16 percent, and 6 percent reduction in the probabilities of polio vaccination, non-polio vaccination, and breastfeeding respectively. In contrast, we found no significant differences in breastfeeding and immunization rates between small-at-birth and large-at-birth siblings in low infant mortality villages.

These results show that children's endowment differences as well as background mortality risks can have sizeable impacts on intra-household resource allocations in a developing country. They also show that reductions in mortality can not only improve overall population health but also reduce health disparities. Reductions in mortality affect less endowed and weaker children more than healthy children. Thus, they create unique incentives for parents to invest in weaker children, consequently reducing health disparities.

The results also highlight that public health investments do not crowd out private investments in child health. In fact, they are complements. For example, public health interventions that improve birth weight are likely to encourage parental investments such as immunizations and breast feeding. Dow et al. (1999) make a similar argument in their study that showed that women were more likely to increase inputs into birth weight when the United Nation's Expanded Programme of Immunization (EPI) was implemented. By decreasing the probability of child mortality from any of the 6 vaccine preventable diseases, the EPI increased mothers' incentives for improving birth outcomes.

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Appendix

Table 1: Government of India's Recommended Immunization Schedule

Age (weeks)	Age (months)	BCG	DPT	Polio	Measles	Age Appropriate Coverage for all India
Birth	0	X		X[1]		BCG
6 weeks	1.5		X	X		BCG + DPT1 + Polio1
10 weeks	2.5		X	X		BCG + DPT1-2 + Polio1-2
14 weeks	3.5		X	X		BCG + DPT1-3 + Polio1-3
36 weeks	9.0				X	BCG + DPT1-3 + Polio1-3 + Measles

[1] Polio vaccination at birth is recommended in all institutional deliveries and in all endemic areas.
Source: Universal Immunization Program Division, Department of Family Welfare, Min. of Health & Family Welfare http://cbhidghs.nic.in/hii2003/12.01.htm

Table 2: Summary Statistics

	Panel A: Analysis sample				Panel B: Full sample			
Variable	Mean	Median	Std. Dev.	Obs	Mean	Median	Std. Dev.	Obs
Parental investments								
Age appropriate Polio coverage	0.35	0	0.48	16015	0.34	0	0.48	16329
Age appropriate non-Polio coverage	0.25	0	0.43	15757	0.24	0	0.43	16066
Breastfed for at least 6 months	0.85	1	0.36	13528	0.85	1	0.36	13698
Explanatory variables								
Small-at-birth	0.23	0	0.42	16088	0.23	0	0.42	16090
Sex of child (Male =1)	0.50	1	0.50	16088	0.50	1	0.50	16404
Birth order	2.71	3	1.11	16088	2.71	3	1.11	16404
Month of birth	6.82	7	3.39	16088	6.82	7	3.39	16404
Age of Child if alive (months)	22.90	22	15.15	14348	22.91	22	15.15	14529
Any small-at-birth siblings present in household	0.08	0	0.27	16088	0.08	0	0.27	16404
Mother's age at birth (years)	23.37	22	5.26	16088	23.36	22	5.26	16404
Given iron folic tablets during pregnancy	0.44	0	0.50	16082	0.43	0	0.50	16278
Tetanus injections bef. birth	1.20	1	1.22	15996	1.20	1	1.21	16187
First antenatal visit in 1st trimester	0.18	0	0.38	16088	0.18	0	0.38	16404
First antenatal visit in 2nd trimester	0.27	0	0.44	16088	0.26	0	0.44	16404
First antenatal visit in 3rd trimester	0.11	0	0.31	16088	0.11	0	0.31	16404
Background variables								
High infant mortality in village	0.56	1	0.50	16088	0.56	1	0.50	16404
Health infrastructure (at least PHC) in village	0.16	0	0.36	16088	0.16	0	0.36	16404

Source: National Family Health Survey – Wave I (1992-93)
Note: Summary statistics have been adjusted with sampling weights

Table 3: Within family Variation in Birth size, Parental Investments, and Other Variables

Continuous Variables	Percent of total variance explained by within-family variation
Number of Tetanus injections before birth	29.05%
Mother's age at birth (years)	9.40%
Birth order	33.14%
Month of birth	87.44%
Age of Child if alive (months)	100.00%
Dichotomous variables	Percent of families with within variation
Age appropriate Polio coverage	26.47%
Age appropriate non-Polio coverage	22.00%
Breastfed for at least 6 months	40.81%
Small-at-birth	26.49%
Any small-at-birth siblings present in household	15.52%
Given iron folic tablets during pregnancy	14.54%
First antenatal visit in 1st trimester	15.60%
First antenatal visit in 2nd trimester	24.53%
First antenatal visit in 3rd trimester	12.72%
Sex of child (Male =1)	51.32%

Table 4: Effect of Birth Size and Background Mortality on Parental Investments

	Age appropriate polio coverage	Age appropriate non-polio coverage	Breastfed for 6 months
	(1)	(2)	(3)
PANEL A			
Small-at-birth	-0.038***	-0.032***	-0.01
	(0.01)	(0.01)	(0.01)
Observations	15679	15269	8571
Number of mothers	7,616	7,418	4,240
PANEL B			
Small-at-birth	-0.006	-0.009	0.009
	(0.02)	(0.02)	(0.01)
Small-at-birth * High IMR in village	-0.057***	-0.042**	-0.041**
	(0.02)	(0.02)	(0.02)
Observations	15,679	15,269	8,571
Number of mothers	7,616	7,418	4,240

Notes: Estimates are from mother fixed-effects models that include the following covariates: mother's age at birth, whether the mother received iron folic tablets during pregnancy, number of tetanus injections received by the mother during pregnancy, dummies for the trimester of first antenatal care visit, and dummies for gender, birth order and birth month. Figures in parentheses are standard errors. * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Table 5: Effect of Background Mortality Risk on Gender Differences in Parental Investments

	Age appropriate polio coverage	Age appropriate non-polio coverage	Breastfed for 6 months
	(1)	(2)	(3)
Small-at-birth	-0.006	-0.009	0.009
	(0.02)	(0.02)	(0.01)
Small-at-birth * High IMR in village	-0.060**	-0.038	-0.042**
	(0.03)	(0.02)	(0.02)
Male child	0.046***	0.036***	0.009
	(0.01)	(0.01)	(0.01)
Male * High IMR in village	-0.012	-0.02	0.00
	(0.02)	(0.02)	(0.01)
Observations	15,679	15,269	8,571
Number of mothers	7,616	7,418	4,240

Notes: Estimates are from mother fixed-effects models that include the following covariates: mother's age at birth, whether the mother received iron folic tablets during pregnancy, number of tetanus injections received by the mother during pregnancy, dummies for the trimester of first antenatal care visit, and dummies for gender, birth order and birth month. Figures in parentheses are standard errors. * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Table 6: Effect of Background Mortality Risk and Birth Size on Prenatal Investments

	Given iron & folic acid tablets during pregnancy	Received any tetanus shot	First antenatal visit in 1st trimester
	(1)	(2)	(3)
PANEL A			
High IMR in village	-0.088***	-0.090***	-0.040***
	[0.010]	[0.010]	[0.008]
Observations	15924	15936	12953
Number of mothers	7731	7737	6367
PANEL B			
Small-at-birth	-0.004	-0.012	0.001
	[0.012]	[0.013]	[0.015]
Small-at-birth * High IMR in village	-0.007	-0.006	-0.002
	[0.017]	[0.018]	[0.020]
Observations	15924	15936	12953
Number of mothers	7731	7737	6367

Notes: Estimates are from models that include the following covariates: mother's age at birth, and dummies for gender, birth order and birth month. Estimates in Panel B are from models that also include mother fixed-effects. Figures in parentheses are standard errors. * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Table 7: Effect of Birth Size and Background Mortality on Parental Investments: Estimates from Models without Sibling-Specific Covariates

	Age appropriate polio coverage	Age appropriate non-polio coverage	Breastfed for 6 months
	(1)	(3)	(5)
Small-at-birth	-0.022	-0.019	0.011
	[0.017]	[0.016]	[0.013]
Small-at-birth * High IMR in village	-0.061***	-0.045**	-0.039**
	[0.022]	[0.021]	[0.019]
Observations	15,679	15,269	8,571
Number of mothers	7,616	7,418	4,240

Notes: Estimates are from mother fixed-effects models without additional control variables. * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Table 8: Effect of Health Infrastructure Availability on Parental Investments

	Age appropriate polio coverage	Age appropriate non-polio coverage	Breastfed for 6 months
	(1)	(2)	(3)
Small-at-birth	-0.003	-0.007	0.013
	(0.018)	(0.017)	(0.014)
Small-at-birth * High IMR in village	-0.056**	-0.037*	-0.037*
	(0.024)	(0.022)	(0.020)
Small-at-birth * at least PHC in village	-0.017	-0.007	-0.014
	(0.038)	(0.039)	(0.032)
Small-at-birth * at least PHC * High IMR	-0.012	-0.03	-0.021
	(0.055)	(0.057)	(0.048)
Observations	15,679	15,269	8,571
Number of mothers	7,616	7,418	4,240

Notes: Estimates are from mother fixed-effects models that include the following covariates: mother's age at birth, whether the mother received iron folic tablets during pregnancy, number of tetanus injections received by the mother during pregnancy, dummies for the trimester of first antenatal care visit, and dummies for gender, birth order and birth month. Figures in parentheses are standard errors. * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Table 9: Sensitivity of Birth Size Effects to Presence of Other Small-at-Birth Siblings in the Household

	(1)	(2)	(3)
	Age appropriate polio coverage	Age appropriate non-polio coverage	Whether breastfed for six months
Small-at-birth	-0.014	-0.012	0.013
	(0.017)	(0.017)	(0.014)
Small-at-birth * High IMR in village	-0.056***	-0.041**	-0.041**
	(0.021)	(0.020)	(0.018)
Any small-at-birth siblings present	-0.021	-0.011	0.007
	(0.017)	(0.017)	(0.014)
Observations	15,679	15,269	8,571
Number of mothers	7,616	7,418	4,240

Notes: Estimates are from mother fixed-effects models that include the following covariates: mother's age at birth, whether the mother received iron folic tablets during pregnancy, number of tetanus injections received by the mother during pregnancy, dummies for the trimester of first antenatal care visit, and dummies for gender, birth order and birth month. Figures in parentheses are standard errors. * Significant at 10%, ** Significant at 5%, *** Significant at 1%.