Excess Female Infant Mortality and Gender Gap in Childhood Investment in Bihar, India

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ABSTRACT

This paper analyzed excess female infant mortality by age one and gender gap in childhood investment in the east-central state of Bihar, India. The female child in Bihar lies at the intersection of a web of disadvantages woven by an agrarian mode of production, an exploitative feudal system, oppressive caste system, and patriarchy. The National Family Health Surveys were used to compare female infant mortality in Bihar with thirteen major states. Females in Bihar face significant odds of excess infant mortality compared to less biased states in eastern, western, and southern regions, but do not face excess mortality compared to more biased states in northern and central regions. An estimated 23% female infant deaths in Bihar are excess. An examination of childhood investments demonstrated that gender gap in BCG vaccination is the single most important driver of excess female infant mortality, followed by DPT and measles vaccination, and illness treatment.

Keywords: Excess female infant mortality; India; Bihar; gender gap in investment; vaccination.

JEL codes: J16; O53; J13

INTRODUCTION

Biologically speaking, female infants have a survival advantage over male infants. Excess female infant mortality occurs when at the prevailing male infant mortality rate (IMR) the female IMR is higher than the biologically expected rate (Clark 2000; Hill and Upchurch 1995). In an environment of gender bias, excess female infant mortality is attributable to gender gap in childhood investment, defined as essential inputs necessary for survival, health, nourishment, and overall well-being of an infant, and ranges from breast milk to food and nutrition, to vaccination (Agnihotri et. al 2002; Bhaskar and Gupta 2007; Clark 2000; Das Gupta 1987; Dyson and Moore 1983; Hill and Upchurch 1995; Jayaraj 2009; Kishor 1993; Mishra et al. 2004; Oster 2009a; Srinivasan and Bedi 2008). Excess female infant mortality in India has received much research attention. After all, India is one of the world's most gender disparate societies, as evidenced by many forms of male favoritism and subordination of females (Rahman and Rao 2004).

Excess female infant mortality occurs in India due to human intervention: withholding of or insufficient allotment of childhood investment to female children, either deliberately or benignly neglectfully. Various studies have documented gender gap in childhood investment in India, including vaccination (Arokiasamy 2004; Oster 2009a), breast feeding (Jayachandran and Kuziemko 2011), medical care (Bhattacharya 2006), food and nutrition (milk, fats, cereals, and sugars), clothing, medical expenses (Das Gupta 1987), and illness treatment (D'Souza and Chen 1980). This gap leaves female infants at risk of adverse health consequences, including malnourishment, wasting, stunting, morbidity and mortality.

Current Study: Aims and Objectives

The objective of this paper is to analyze excess female infant mortality and gender gap in childhood investment in the east-central state of Bihar, India. The standard definition of infant mortality is used throughout the paper, defined as the number of infant deaths between ages 0-12 months for every 1000 live births.

The paper argues that Bihar is a particularly important state to pay attention to, primarily for the following reasons (a) Prior research has demonstrated a regional division in excess female infant mortality, the problem being most serious in the northern and central regions and relatively less serious in the eastern and southern regions (Dyson and Moore 1983; Rahman and Rao 2004). The regional pattern of survival disadvantage is also accompanied by a significant cultural divide. This diversity in the nature and cultural backdrop of the problem underscores the need for studies that drill down to the sub-national level. State-level analyses not only address state-specific nature of the issue, but also offer recommendations for localized policy interventions. The study of Bihar in particular is interesting because of its location at the cultural transition point from the less gender biased eastern and southern regions to the more biased central and north. (b) While son preference and female survival disadvantage are ingrained features of the Indian society in general, Bihar is characterized by extreme son preference, daughter aversion, and excess female infant mortality due to a distinctive socio-cultural landscape fraught with multiple forms of gender inequality. In particular, the notion of intersectionality of disadvantages, which is a defining feature of inequality in feminist theory (see Collins (1993) for a full discussion) applies to females in Bihar. The female child in Bihar lies at the intersection of a web of disadvantages woven by several factors including an agrarian mode of production, an exploitative feudal system, an oppressive caste system, and rigid patriarchy. (c) Economically, Bihar is one of India's least developed states and one of the most poverty stricken. In addition, the National Human Development Report's state wise ranking by Gender Disparity Index has consistently ranked Bihar as the most gender disparate states. Economic impoverishment and gender disparities are correlated with increased vulnerability of female infants to neglect and survival disadvantage (d) According to the NFHS, both male and female infants in Bihar receive substantially lower levels of childhood investment than most other states. Gender gap in investment is likely to be aggravated in an environment characterized by low overall availability of and accessibility to childhood investment, as sons get preference over daughters for a share of whatever little resources are available. Resulting denial of essential investment to daughters however makes them vulnerable to excess mortality. Given the low levels of childhood investment in Bihar, it is important to analyze gender gaps in investment and their contribution to excess female infant mortality.

This paper used three waves of the National Family Health Surveys (NFHS) to address several objectives.

(a) Compare and contrast female infant mortality in Bihar with rest of India and individually with thirteen major states covering five major regions. This analysis estimated the odds of excess female infant mortality in Bihar after controlling for socio-economic differences. [1]

(b) Use major states that are less biased than Bihar as benchmarks of comparison in order to create direct estimates of the proportion and number of female infant deaths in Bihar that are excess. This analysis is expected to inform about the magnitude of the problem in Bihar compared to other states.

(c) Examine and quantify the role of childhood investment gap in explaining excess female infant mortality in Bihar. The analysis explores whether female children in Bihar receive lower levels of childhood investment than male children. Multivariate logistic regression models were used to analyze the association between child sex and eight types of childhood investments including breast feeding, supplemental feeding, vaccination (BCG, DPT, measles, polio), and illness treatment (fever treatment, diarrhea treatment).

(d) Create estimates of the contribution of gender gap in childhood investment towards excess female infant mortality in Bihar.

Background and Profile of Bihar

This section briefly summarizes the distinctive social, economic, cultural and gendered background of Bihar in order to establish the backdrop for the rest of the paper.

Economic Development, Human Development

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[1] Throughout the paper, Bihar is compared with thirteen major states of India including West Bengal and Orissa (east), Uttar Pradesh and Madhya Pradesh (central), Punjab, Haryana, and Rajasthan (north), Maharashtra and Gujarat (west), Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu (south).

Covering an area of 174,000 sq. kms., undivided Bihar[2] shares its border with West Bengal on the east, Orissa in the south, Madhya Pradesh in the south-west, and Uttar Pradesh in the west. Despite being rich in natural resources and agricultural land, Bihar is one of the most economically impoverished states of India (Bhattacharya 2000; Clements 2005). While India embarked on the path to economic development in the year 1947 (when she became a sovereign nation state), Bihar lagged behind, failing to achieve the trajectory of economic development followed by most states. During the 1990s and 2000s, among fourteen major states, Bihar consistently had the lowest state GDP per capita income(see table 1).

[table 1 here]

During both time periods, a majority of Bihar's population lived below the official poverty line (55% in 1993-94; 41% in 2004-05). In addition, the 2001 census reported that with a population of over 83m, Bihar was the third most populous state. Bihar is also the least urbanized state, with 90% of its population living in villages that are economically dependent on agriculture (Census of India 2001; Jha 2009). Indicators of human development show that Bihar has the lowest Human Development Index (0.308 in 1991; 0.367 in 2001), the lowest literacy rate (38.5% literacy rate in 1991; 47.5% literacy rate in 2001), and one of the lowest life expectancy (around 60 years).

[2] In 2001, Bihar was bifurcated into two states: Bihar and a new state named Jharkhand, which was carved out of southern Bihar. All analysis in this paper refers to undivided Bihar. Since Jharkhand was included as a separate state in the NFHS-3, all observations on Jharkhand from this wave were recoded as Bihar.

Gender Disparity

While Bihar's economic problems are no doubt serious, there are additional dimensions of inequality in the form of wide gender gaps in human capital, social, and infant mortality indicators. Table 2 presents some comparative statistics of selected indicators of gender disparity by fourteen states. In general, central and northern regions have high levels of gender disparity. In contrast, eastern, western, and southern regions have relatively lower disparities. Although Bihar is usually categorized as an eastern state, the descriptive statistics show that gender disparity levels in Bihar are in fact more similar to central and northern regions, rather than east.

[table 2 here]

According to the National Human Development Report's Gender Disparity Index (GDI), Bihar is India's most gender disparate state with GDI of 0.469 in 1991, as opposed to the national average of 0.676 (GDI of 1.00 indicates no disparity). Among other indicators, Bihar has the second highest gender gap in literacy rate (32 pct. Pt. in 1992-93, 28 pct. Pt. in 1998-99, and 33 pct. Pt. in 2005-06), one of the highest total fertility rates (3.25 in 1992-92, 2.67 in 1998-99, 2.87 in 2005-06), and the highest self-reported rate of marital violence in India (60.8% of married women in Bihar reported physical or emotional violence according to NFHS 2005-06). Table 2 also shows statistics on son preference. Women of Bihar express high rates of son preference. In 1992-93, 56% ideally wanted more sons than daughters. In 1998-99 and 2005-06, the rates were 48% and 39% respectively, both being the highest in India.

Gender Gap in Infant Mortality Rate

Table 3 presents some descriptive statistics on infant mortality rate in Bihar from the NFHS. A comparison of sex ratio of IMR in Bihar across the three waves of the survey shows that while both male and female IMR have reduced, the male IMR has reduced more than female IMR. As a result, the sex ratio of IMR has increased steadily in Bihar, from 0.96 in 1992-93, to1.02 in 1998-99, and to 1.06 in 2005-06. Given that genetically female infants have a higher chance of survival than male children (Hill and Upchurch 1995; Clark 2000), the fact that sex ratio of infant mortality rate in Bihar has not only increased but has actually exceeded 1.00 suggests in a preliminary way that female children in Bihar may be facing discrimination and excess female infant mortality after controlling for economic variables. Any further conclusions however require the use of more formal models.

[table 3 here]

The Intersectionality of Poverty, Caste, Class and Gender: Perspectives from Bihar

While Bihar is not India's only economically impoverished and gender disparate state, Bihar's socio-economic situation stands out due to the persistence of an agrarian society characterized by a rigid caste system, a concomitant class system based on agricultural land ownership, and an exploitative *zamindari* (feudal) system dominated by upper caste landed aristocracy (Bhatia 2005; Chakrabarty 2001; Sinha 1996; Singh 2008). Taken together, these perpetuate a system of class, caste and gender inequality. In this context, Chakrabarty (2001) notes: "that caste continues to be important for structuring relations of production in agrarian Bihar marks the state as an exception to the changes Indian society is generally associated with as a consequence of British rule" (Chakrabarty 2001: pg. 1451). While the caste system was abolished in India in the year 1950 and the *Zamindari* system was statutorily abolished in the year 1952, both systems have de facto persisted in Bihar, while the rest of India has at least made various degrees of progress towards modern systems of production. The caste hierarchy in Bihar consists of the upper caste *Brahmins, Bhumihar,* and *Rajputs*, and the lower caste *dalits* (the untouchables: more than 60% of Bihar's population is *dalit* according to NFHS-3).

Alongside a rigid caste system co-exists a rigid class system based on a feudal agrarian system consisting of the landed nobility who are usually upper caste males, and the landless peasants, who are usually *dalits*. Historically, *dalits* have faced serious social and economic disadvantages. Typically, *dalits* work as landless agricultural laborers or bonded laborers in the land of the upper caste, often at below subsistence wages, facing various forms of exploitation, violence, and injustice.

Inequality in Bihar's agrarian society is further compounded by a rigid patriarchal society, where women of both lower and upper caste are subject to inferior status. This includes a patrilineal system of inheritance, patrilocal and exogamous marriage customs, (Das Gupta 1987; Dyson and Moore 1989; Jha 2004; Murthy 1996; Sudha and Rajan 1999) and the practice of dowry. While these practices are prevalent in other states of India, the inferior status of women in Bihar is exacerbated due to their de facto exclusion from the most crucial source of economic status in a society characterized by agrarian mode of production, viz. land ownership. Land reforms in Bihar that had restoration of gender equality in land ownership as an objective were a failure, doing very little in reality to reduce gender disparity in land ownership. Excluded from land ownership, Bihari women have very low economic status.

Even high socio-economic status provides no protection for women. Upper caste women have very limited opportunity for labor force participation and are instead mostly confined to the domestic sphere. Daughters of upper caste families are a monetary burden on their parents due to large dowry extractions by in-laws during her marriage. Bride torture and killing (dowry death) are alarmingly common in Bihar (Jha 2009; Srinivasan and Lee 2004). The widespread prevalence of dowry is evidenced by the fact that one of the highest reported number of dowry deaths in India (918 in 2009) is in Bihar, mostly amongst upper caste families (Ministry of Women and Child Development, GOI).

Lower caste women also are excluded from land ownership, but often work as agricultural laborers, making economic contributions to their families. However, *dalit* women not only face caste and class disadvantages, but also gendered exploitation, including wage gap and heinous forms of sexual assault and even rape in the hands of upper caste land holding men. Louis (2002) suggests in this context that lower-caste women in Bihar are considered “fair game” to any upper-caste men and that lower caste women are even afraid of going out after dark for fear of molestation or worse in the hands of upper caste men (Louis 2002; Jha 2004).

The inferior status of the Bihari girl child then is situated at the intersection of a complex web of disadvantages woven by caste, class, patriarchy and inferior status of women. The birth of a son is rejoiced because it is associated with prestige, stature, privilege, and power. The birth of a daughter in contrast is lamented because a daughter is a social burden, expensive to parents, has little or no financial prospects, and is therefore undesirable. In this context, an interview of twenty three midwives conducted by *Adithi,* a non-governmental organization based in Bihar reported that eighteen midwives desired to be reborn as males. “The benefits perceived of being male fell into five categories: material, social, religious, biological, and emotional” (Murthy 1996: pg. 20). Regarding being born as a daughter, these midwives expressed that “In all castes, the costs of daughters to parents are higher than those of sons, and the benefits lower” (Murthy 1996: pg. 22).

METHODS

Secondary Data Analysis: National Family Health Surveys

Secondary data for this study was provided by the cross-sectional and population based National Family Health Surveys (NFHS). The NFHS are nationally representative surveys designed to collect data from a sample of households on demographic and socio-economic variables. A major advantage of the NFHS is that it is the only household level survey that has information on sex, birth, mortality, and age in months at the time of death of each child, but also has several variables on child investments, including breast feeding, supplemental feeding, and vaccination.

Despite being such a rich dataset, the NFHS is not without its disadvantages. First, since the survey is based on retrospective, self-reported number and sex of children, there is always a chance of misreporting. For one, there can be a recall issue, especially in case of children who have left home. There may also be a tendency to exclude children who died, especially if they died soon after birth. Also, in India, parents tend to under-report daughters. Although researchers have contended that under enumeration due to any of these sources is less likely to be a problem in the NFHS since the interviewers were trained to probe interviewees (Bhat 1995; Griffiths et. al 2000), misreporting is still likely to lead to a small bias in the results. Clark (2000) estimates that there is a possible 6% under enumeration of female births in the NFHS, while Das Gupta et. al (2009) note that data on child mortality can suffer from underreporting of female mortality, especially if they died soon after birth due to infanticide. This could be a problem in Bihar where female infanticide is reportedly higher than other parts of the country. Given previous research that suggests a high rate of female infanticide in Bihar, this is a limitation of the NFHS and of the current study.

Sample

This study is based on data from the birth recodes of the three available waves of the NFHS (NFHS-1:1992-93, NFHS-2:1998-99, NFHS-3:2005-06).The merged dataset is a nationally representative probability sample of 777,705 children ever born to women aged 15 to 49 years. 32% of the sample was from the NFHS-1, 33% from NFHS-2, and 34% from NFHS-3. The Bihar sub-sample consists of 58,773 children, representing 7.55% of the sample. Table 4 shows additional descriptive statistics of the variables used in this study.

[table 4 here]

Variables

The first objective of this paper is to use multivariate logistic regression models to compare the odds of female infant mortality in Bihar with thirteen major states, after controlling for select socio-economic differences. Since the primary variable of interest is the probability of female infant mortality by age one, the dependent variable is based on responses from women to the question regarding their knowledge about the age (in months) at death of any deceased children. From this information, the dependent variable was created as a binary indicator variable on whether or not a child died by age one. The estimation model consists of thirteen binary logistic regressions of the association of child sex with a binary indicator variable on child mortality, with each regression based on data for Bihar and only one of the comparison states. One regression was also run using all-India data. Formally:

$$\boldsymbol{Mortality} = \alpha + \beta_1 \boldsymbol{Female} + \beta_2 \boldsymbol{Bihar} + \beta_3 (\boldsymbol{BiharXfemale}) + \beta_4 \boldsymbol{controls} \text{ --------(A)}$$

Where,

Mortality = 1 if child died in the age range 0-12 months.

= 0 if child is still alive or if dead, then died after age 12 months.

Female = 1 if child is female

= 0 if child is male

Bihar is a Bihar state fixed effect.

(Bihar X female) is an interaction term between *"Bihar"* and *"female"*. The coefficient on the interaction term *(Bihar X Female)* measures excess female infant mortality in Bihar (Oster 2009a). A positive and significant coefficient on this term demonstrates the additional probability of infant mortality faced by a female simply because she was born in Bihar, even after controlling for all socio-economic differences between Bihar and the benchmark state.

Controls

Controls include birth order, child's year of birth, mother's age, mother's education in years, dummy variable on whether mother reported an occupation, dummy variables on whether mother viewed television and listened to radio at least once a week, and a household asset index. Dummies for urban location, religion, caste and tribe, and survey years were also included. [3]

RESULTS

Estimation Results

Tables 5 – 7 show the estimation results. In comparing female infant mortality in Bihar with rest of India, table 5 shows that even after accounting for socio-cultural, economic, and overall mortality differences, just being born as a female in Bihar is associated with a significantly higher odds (11% higher odds; p <0.01) of mortality by age one. Thus a female child would face significantly higher odds of infant mortality just because she was born in Bihar instead of anywhere else in India.

Table 5 also show results from regressions comparing Bihar with eastern region. Results suggest that being born female in Bihar is associated with significant odds of excess mortality compared to both West Bengal and Orissa. If West Bengal and Bihar were a combined geographic unit, then females born in this combined unit would face significantly lower odds of mortality than males (16% lower odds; p<0.01). However, being born as female in the Bihar portion of this unit would be associated with 21% odds

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[3] Controls used in the analysis are similar to Clark (2000), Basu and DeJong (2010,) Bhat and Zavier (2003), Jayachandran and Kuziemko (2011), and Oster (2009a).

of excess infant mortality ($p < 0.01$) compared to being born as female in the West Bengal portion of the unit. Similarly, if Bihar was combined with Orissa, then females born in this unified geographic unit would have significantly lower odds of mortality than males (10% lower odds; $p<0.01$) but being female in the Bihar portion would mean a 13% odds of excess infant mortality ($p < 0.01$) than being born female in the Orissa portion.

Table 6 shows the regression coefficients comparing Bihar with western region. Results for western India also show significant odds of excess female infant mortality in Bihar compared to states of the western region. Compared to Maharashtra, being female in Bihar is associated with 15% higher odds of mortality ($p < 0.01$) while in comparison with Gujarat, being female in Bihar is associated with 18% higher odds of mortality ($p < 0.01$).

Table 6 also shows the regression coefficients comparing Bihar with southern region, and show significant excess female infant mortality in Bihar. Compared to Andhra Pradesh, being female in Bihar is associated with 19% higher odds of mortality ($p < 0.01$). Being female in Bihar is associated with 24% higher odds of mortality ($p < 0.01$) when compared to Karnataka, 50% higher odds of excess mortality when compared to Kerala, and18% higher odds of excess mortality when compared to Tamil Nadu.

Finally, table 7 shows that when Bihar is combined with any state of central or northern regions, the odds of female infant mortality for the unified geographic unit is usually between 4%-7% higher than male mortality (although not always significant), suggesting that if Bihar was combined with each state, then females born in each unified geographic unit would face excess female infant mortality. None of the interaction terms however are significant, suggesting that although each combined geographic unit overall would have excess female infant mortality, female infants in the Bihar portion would not face additional odds of mortality.

[Tables 5, 6, 7 about here]

Proportion of Excess Female Infant Mortality

Given substantial and significant odds of excess female infant mortality in Bihar compared to eastern, southern, and western regions, the second objective is to use these eight states as benchmarks of (relatively) lower levels of gender bias to estimate the proportion of female infant deaths that were excessive in Bihar. *"Excess female IMR"* occurs when the observed female IMR from ages 0 – 12 months in Bihar is greater than the expected female IMR. The expected female IMR is the female IMR that would have prevailed under the assumption that at the values of control variables prevailing in Bihar, being born as female in Bihar did not entail additional risk of infant mortality compared to the benchmark state i.e. the interaction term *"FemaleXBihar"* was zero.

For convenience, West Bengal is used as an example to illustrate the methodology that was employed. I estimated the probability of infant mortality in Bihar assuming that at the prevailing values of the control variables, being born as female in Bihar was no different than West Bengal and does not entail any additional probability of mortality i.e. the interaction term = 0.[4] The predicted probability was estimated as 73 for every 1000

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[4] Predicted probability of female IMR in Bihar is estimated as follows: Expected Pr(mortality) = $\frac{1}{1+e^{-(\alpha+\beta_1 Female+\beta_2 Bihar+\beta_4 controls)}}$. Note that tables 5-7 report odds ratios only. The coefficient βs are not reported but are available from the author upon request.

female live births. Next, to find excess female IMR, note that the observed female IMR in Bihar is 94. Hence, for every 1000 female live births, the death of 21 infants (94-73) is excess, translating into 22% (21/94)*100 = 22) of infants who die by age one as excessive. Results for remaining states are shown in table 8. Depending on the state used as benchmark, the percentage of excess female infant mortality in Bihar ranges from 18% to 36% with an eight state average of 23% excess female infant deaths.

[table 8 here]

Alternate Methodology

A reasonable criticism of this methodology of estimating excess female infant mortality is that given the high level of gender bias in India, the states used as benchmark may not completely satisfy the requirement that the benchmark of comparison should be free of bias and have low levels of gender discrimination. Most states that are used as benchmark will themselves have at least some levels of bias, albeit lower than Bihar. This could lead to an under estimation of excess female infant mortality. The opposite could be true of states such as Kerala. Although Kerala is historically known as India's most gender egalitarian state, sex ratios in Kerala tend to favor females, due to which using Kerala as the benchmark can lead to over estimation of excess female infant mortality. The wide range of excess female infant mortality percentage in table 8 hints that such a concern is well-founded.

An alternative method of estimation can address the concern. A popular option is to apply demographers' life tables, such as the Coale & Demeny Regional Model Life Tables to compare the observed male and female IMR of any country with the IMR that would prevail in countries with historically low levels of discrimination, after controlling for the life expectancy at birth (Coale 1991; Coale and Demeny 1983; Jayraj 2009). However, since this paper uses the NFHS, I prefer following the results obtained by Hill and Upchurch (1995), who also use the Demographic Health Surveys (DHS) of 35 countries to analyze sex differences in child mortality. Using data on Europe and Oceania from 1820 to 1964 as benchmarks of low discrimination, the authors fit a LOWESS regression equation between the ratio of female to male age-1 IMR and the male age-5 IMR. The results of this procedure gives the expected ratio of age-1 female to male mortality rate for any given male age-5 mortality rate for populations with same discrimination against women as Europe and Oceania. Table 1 of their paper (pg. 132) suggests that if the male age-5 IMR is 125, the expected F/M ratio of age-1 IMR should be 0.801. Since the observed male age-5 IMR in Bihar is 123, hence this is the closest basis of comparison. Now, the observed male age-1 IMR in Bihar is 92. Hence at the expected F/M ratio of age-1 IMR of 0.801, the expected female age-1 IMR is 73 (= 0.801*0.092 = 0.0736). The observed female IMR is 94. Hence, 22% of female infant deaths are excessive (= (94-73)/94). Interestingly, this estimate is exactly same as the percentage excess mortality when West Bengal is the benchmark, and is also close to the eight state average of 23% found using the methodology developed for the current study.

Gender Gap in Childhood Investment

Discrimination in providing essential childhood resources is a key factor leading to excess female infant mortality. Given the finding that anywhere between 18-36% of female deaths in Bihar could be excess, identification of key investment gender gaps is vital, as they would give crucial policy recommendations to address the problem. Previous research using nation wide data have demonstrated that gender gap in childhood investment can explain substantial proportions of excess female infant mortality in India. Oster (2009b) concludes that vaccination explains 20-30% of excess female IMR, malnutrition 20%, and lack of illness treatment (diarrhea and respiratory ailment) explains another 4%. Another study (Jayachandran and Kuziemko 2011) finds that breastfeeding could account for an additional 9% of gender gap in child mortality between ages one and five.

I fitted multivariate logistic regression models with data on Bihar only to study the association of child sex with eight types of investment in order to examine whether compared to males, being female is associated with significantly lower investment. Eight dummy variables represented whether a child was given a particular investment, including whether a child was breastfed up to age one (or if died by age one then whether child was fed up to the age of death), whether a child was given supplemental feeding from age six months, including both powdered/fresh milk and solid/mushy food, four dummy variables on whether a child received BCG (Bacillus Calmette Guerin vaccination, the direct effect of which is prevention of tuberculosis (Rajshekhar 2005), polio, DPT, measles vaccination, and two dummies on whether a child received treatment for diarrhea and fever. The key predictor variable is a dummy variable on whether a child is female. Controls used were same as in equation (A), and in addition also included four community level variables: mean years of female education, mean years of male education, proportion of females who work, and proportion of women who prefer sons.

These were created by averaging these values at the primary sampling unit (PSU) level and then matching PSU averages to individual observations (Stephenson 2009).

[table 9 here]

Results (table 9) show that females in Bihar are substantially and significantly less likely to receive four of the eight investments. Compared to male infants, females are less likely to receive the following vaccinations: BCG (22% lower odds; p <0.01), measles (19% lower odds; p <0.01) and DPT (16% lower odds; p <0.01). Female infants are also significantly less likely to receive fever treatment (29% lower odds; p <0.01). Of the remaining investments, female infants are likely to receive lower amounts of supplemental feeding (3% lower odds), polio vaccination (8% lower odds), and treatment for diarrhea (10% lower odds). None of these odds ratios however are significant. Lastly, breastfeeding is the only investment that female infants are likely to receive more of compared to males (7% higher odds), although the odds on this are not significant.

Contribution of Gender Gap in Investment to Gender Gap in IMR[5]

The contribution of gender gap in childhood investment towards excess female infant mortality was calculated for individual investments using the following formula:

[(% of males in Bihar who receive investment – % of females in Bihar who receive investment) *(IMR if denied investment – IMR if receive investment)]/ (Observed female IMR in Bihar – Expected female IMR in Bihar)

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[5] See table 10 footnote for sources of data.

= [(Gender gap in childhood investment in Bihar) X (Infant mortality risk factor for non invested infants)] / [Gender gap in infant mortality in Bihar]

For convenience, the methodology is explained using the case of BCG vaccination. First, 43% of males and 39% of females receive BCG vaccination, resulting in gender gap in BCG vaccination of 4 percentage points. Second, mortality rate by age one for infants who are given BCG vaccination (male + female) is 1.09% and 8.62% for those who are denied. From this, the implied mortality risk factor for non-BCG infants is 7.53 percentage points. So gender mortality gap *assuming lack of BCG vaccination is the only cause of mortality* = 0.04 X 7.53 = 0.30 percentage points. For the gender gap in infant mortality, note that the observed female IMR in Bihar is 94. The expected female IMR is assumed to be 73 (expected female IMR when West Bengal is benchmark, see table 8). Hence, the gender gap in IMR is 2.1 percentage points (9.4 – 7.3). Hence, lack of BCG vaccination explains 0.30/2.1 = 14.28% of overall gender gap in infant mortality. Results for remaining investments are shown in table 10.

[table 10 here]

For the types of investments that females are significantly less likely to receive than males, an estimated 14% of excess female infant mortality could be explained by gender gap in BCG vaccination, if lack of this investment only was responsible for mortality, regardless of other investments. Similarly, 6% of excess female infant mortality gender gap could be explained by gender gap in DPT, 6% by gender gap in measles vaccination, and 4% by gender gap in fever treatment. Among investments that females are less likely to receive but for which the odds ratios lacked significance, gender gap in polio vaccination could explain 6% of excess female infant mortality, and diarrhea treatment could explain 1.68%. Finally, for breastfeeding, the gender gap is reversed, resulting in a slight female infant survival advantage of 7%.

DISCUSSION

Prior literature has provided ample evidence of excess female infant mortality in India (Coale 1991; Klasen 1994; Klasen and Wink 2003; Sen 1990, 1992). It has also demonstrated substantial gender gap in childhood investment (Das Gupta 1987; D'Souza and Chen 1980; Arokiasamy 2004; Oster 2009a,b; Jayachandran and Kuziemko 2011). Research has also shown wide regional gaps in infant mortality, with the central and northern regions having relatively more serious levels of gender gaps, compared to southern and eastern regions. Given this wide regional variation, several studies have focused on regional and state level analysis (Bhat and Zavier 2003; Bose and Trent 2005; Dasgupta 1987; Miller 1981; Rajan et. al 2000; Srinivasan and Bedi 2008).

Not much attention however has been paid to the east-central state of Bihar, one of India's most impoverished state, situated at the cultural transition point from eastern to central India. From a feminist perspective however, the study of Bihar is also interesting because the female child in Bihar faces a complex intersection of oppression woven by several Bihar-specific factors including an agrarian mode of production, an exploitative feudal system, oppressive caste system, and patriarchy. The paper argues that excess female infant mortality in Bihar occurs in the backdrop of this web of oppression.

This study adds to the existing literature in several ways. While this is not the first study to do a state-level analysis, however, there is a dearth of research that use regression models to compare and contrast excess female infant mortality between states, after controlling for variations in their socio-economic profiles. This study uses multivariate regression methods to compare Bihar with thirteen major states across five regions. Hence, the first contribution of the study is that it uses several control variables to estimate the net effect of being born as female in Bihar on odds of dying in infancy, after controlling for socio-economic differences across states. The comparative analysis demonstrates that female infant mortality in Bihar follows the pattern of more biased central region consisting of Uttar Pradesh and Madhya Pradesh, and northern region consisting of Punjab, Haryana and Rajasthan. Results provide evidence of significant odds of excess female infant mortality in Bihar compared to less biased eastern region consisting of West Bengal and Orissa, southern region consisting of Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu, and western region consisting of Maharashtra and Gujarat. These findings demonstrate Bihar's situation as the dividing line in the overall regional pattern of excess female infant mortality in India.

A second contribution of the paper is that it directly quantifies infant survival disadvantage if a female is born in Bihar instead of another state that has lower level of gender bias. Results show that on an average, 23% of female infant deaths in Bihar are excessive. Given that the 2001 census reported a population of 83m in Bihar, an annual crude birth rate of 27 per 1000 population and the NFHS reported a female IMR of 94, this means that when translated to absolute numbers, roughly 48,000 annual female infant deaths in Bihar are excessive compared to other states. This estimated number enables the understanding of the magnitude of the problem. Such estimates would be of interest to policy makers, would potentially play a role in channeling resources and policies to tackle the problem, and would be beneficial in drawing much needed attention of global institutions and of the global community to this problem.

A third contribution of the paper is that it investigates gender gap in childhood investments. Previous research has established a correlation between gender gap in investment and gender gap in infant mortality (Das Gupta 1987; Griffiths et al. 2000; Borooah 2004; Pande 2003; Mishra et al. 2004; Oster 2009a). There is however a dearth of state-level studies that quantify the role of childhood investment gap in explaining excess female infant mortality. Multivariate logistic regression models were used to analyze the association between child sex and eight types of childhood investments. The study found significant gender gap in BCG, DPT, and measles vaccination in Bihar. Gender gap in BCG vaccination explains an estimated 14% of excess female infant mortality in Bihar. Gender gap in measles, DPT or polio vaccination explains 6% of excess female infant mortality.

This paper has several limitations that future research should focus on. First, a current debate surrounds whether sex selective abortion is in fact replacing excess female infant mortality (Arnold et. al 2002; Goodkind 1996; Sen 1990, 1992, 2003; Srinivasan and Bedi 2008). A parallel analysis on sex selective abortion may reveal that a substantial, if not major proportion of the manifestation of son preference may now occur before birth in Bihar, making excess female infant mortality a secondary cause of female deficit (Agnihotri 2003; Guilmoto 2007; Jha et. al 2011; Siddhanta et. al 2003). The 2001 census reported that the SRB in Bihar was 917 female births for every 1000 male births, while the Annual Health Survey of 2010-11 reported an SRB of 920 in Bihar (Annual Health Survey 2010-2011). Both figures were well below the expected SRB of 952.

However, since this paper focuses on post-birth gender bias, such an analysis is beyond the scope of analysis.

The second limitation is that the NFHS does not permit the analysis of female infanticide. Given that infanticide could well be a major source of neo-natal mortality in Bihar, future research needs to focus on this aspect of female survival disadvantage.

The third limitation is that while the focus of this study is on mortality between 0 and 12 months, some recent evidence suggests that as much as 80% of cumulative missing females from pre birth to age 100+may actually arise between ages 1 and 100+, 11% pre-birth, and only 9% between ages 0-1 years (Anderson and Ray 2010). Once again, while an age-specific analysis beyond 12 months is beyond the scope of the current study, future research should focus on this aspect of the issue.

The fourth limitation is that given that Bihar is a large state, the socio-economic, political, and cultural diversity within Bihar is also substantial. In particular, eastern and southern Bihar that borders West Bengal is likely to be less biased compared to western and northern Bihar that is closer to central India. Community level variables were used in this paper in order to do a stratified analysis. However, the community names or their locations are not disclosed by the NFHS. Since this variation within Bihar is potentially important, hence, in-depth primary data collection is a future course for further research.

Despite these limitations, findings of this paper have several important policy implications that could benefit female infants in Bihar and other states in a similar situation. First, the direct quantification of excess female infant mortality draws attention to the disturbing level of gender bias in survival in Bihar. There is an urgent need to challenge established patriarchal values and the existing intersectionalities of gender oppression in Bihar.

The second policy implication is the finding that gender gap in childhood investment makes substantial contribution to excess female infant mortality. Policy interventions to close investments gaps are needed. The paper recommends the particular interventions that would have the biggest impact. Of the eight investments analyzed, gender gap in BCG vaccination is the single most important cause of excess female infant mortality. Policy interventions aiming at closing this gap would save an estimated 14% of female infants. Interventions to close measles and DPT gap would each save an estimated 6%. This calls for increasing access to vaccination, and encouraging vaccination of all infants, and of female infants in particular as potentially effective policies to curb this problem. In contrast to Jayachandran and Kuzimko's (2011) national level study, this paper finds no evidence of significant gender gap in either breastfeeding or supplemental feeding in Bihar; hence policies that focus on these are likely to be ineffective in Bihar.

Lastly, the state-wise comparison shows that Bihar is the dividing line between the north-central regions that are more dangerous for the female child, and the east-south regions that are relatively less dangerous. The lack of significant difference in excess female infant mortality between Bihar and central and northern states suggests that similar to Bihar, female infant survival disadvantage is a reality there. These states are also likely to benefit from informed policy intervention. The analysis of this paper by extension can benefit the following five states: Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, and Rajasthan. Future research should focus on each of these states, quantifying the extent of excess female infant mortality and analyzing the role of childhood investment gaps that drives female infant survival disadvantage.

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TABLE 1: Socio-economic, Human Development, and Gender Disparity Indicators in Major States of India

Region	East				Central		North			West		South			
State	**BIHAR**	Bihar rank[a]	WB	OR	UP	MP	PJ	HR	RJ	MH	GJ	AP	KR	KE	TN
Population (million)															
1991	**64.53**	4	68.8	31.66	132	48.57	20.28	16.46	44.01	78.94	41.31	66.51	44.98	29.1	55.86
2001	**82.88**	3	80.22	36.71	166.05	60.39	24.29	21.08	56.47	96.75	50.6	75.73	52.73	31.84	62.11
Poverty Incidence (%)															
1993-94	**55**	1	35.7	48.6	40.9	42.5	11.8	25.1	27.4	36.9	24.2	22.2	33.2	25.4	35
2004-05	**41.4**	2	24.7	46.4	32.8	38.3	8.4	14	22.1	30.7	16.8	15.8	25	15	22.5
Per capita GSDP (Rupees)[b]															
1993-94 to 1995-96 Avg.	**3,349**	14	7,844	5,682	5,877	7,479	14,405	13,021	7,749	14,019	12,661	8,681	9,054	9,266	10,823
1998-99 to 2000-01 Avg.	**3,656**	14	10,236	6,236	6,500	8,495	16,848	15,716	9,569	16,865	15,779	10,665	12,619	11,304	13,859
Human Development Index															
1991	**0.308**	14	0.404	0.345	0.314	0.328	0.475	0.443	0.347	0.452	0.431	0.377	0.412	0.591	0.466
2001	**0.367**	14	0.472	0.404	0.388	0.394	0.537	0.714	0.424	0.523	0.479	0.416	0.478	0.638	0.531
Life Expectation (years)															
1992-6	**59.4**	11	62.4	56.9	57.2	55.2	67.4	63.8	59.5	65.2	61.4	62	62.9	73.1	63.7
2004	**61.6**	11	64.9	59.6	60	58	69.4	66.2	62	67.2	64.1	64.4	65.3	74	66.2
Literacy Rate (%)															
1991	**38.5**	14	57.7	49.1	41.6	44.2	58.5	55.9	38.6	64.9	61.3	44.1	56	89.8	62.7
2001	**47.5**	14	69.2	63.6	57.4	64.1	70	68.6	61	77.3	70	61.1	67	90.9	73.5

Source: India Development Report (2004-2005, 2011); India Human Development Report 2011
State names are abbreviated as follows: Bihar – BI; Punjab – PJ; Haryana -HR ; Rajasthan - RJ ; Uttar Pradesh - UP ; Madhya Pradesh - MP; West Bengal - WB; Orissa - OR; Maharashtra - MH; Gujarat - GJ; Andhra Pradesh - AP; Karnataka - KA; Kerala - KE; Tamil Nadu - TN.
[a] For all indicators, ranking is based on descending order of states by indicator value.
[b] At 1993-94 prices (Rupees)

TABLE 2: Indicators of Women's Status and Gender Disparity in Major Indian States: National Family Health Surveys (1992-93; 1998-99; 2005-06)

Region	East				Central		North			West		South			
State	BIHAR	Bihar Rank[c]	WB	OR	UP	MP	PJ	HR	RJ	MH	GJ	AP	KR	KE	TN
Gender Disparity Index (GDI)[d]															
1991	**0.469**	14	0.631	0.639	0.52	0.662	0.71	0.714	0.692	0.793	0.714	0.801	0.753	0.825	0.813
TFR															
NFHS-1	**3.25**	3	2.14	2.53	3.58	3.27	2.48	3.14	2.77	2.54	2.65	2.35	2.38	1.78	2.36
NFHS-2	**2.61**	4	1.69	2.19	2.91	2.68	1.79	2.24	2.98	2.24	2.33	2.07	1.89	1.51	2.11
NFHS-3	**2.87**	2	1.59	1.89	2.95	2.58	1.88	2.17	2.21	1.91	1.92	1.73	1.89	1.73	1.7
Literacy Rate Gap (Pct. Pt: M-F)															
NFHS-1	**31.9**	3	20.2	19.1	32.1	29.5	13.9	26.4	34.9	23.6	24.1	21.8	21.6	7.6	20.9
NFHS-2	**28.4**	2	18.6	24.7	29.1	27.6	13	21.5	34.7	21.3	23.1	20.9	18.8	7.7	21.4
NFHS-3	**33.4**	2	15.1	21.9	31.4	29.1	14.2	23	37.7	18	19.2	22.1	15.6	2.5	14.7
Marital violence rate (%)[a]															
NFHS-3	**60.8**	1	41.8	41.2	45	49.1	26.7	28	50.2	33.4	33.8	36.8	21.5	19.8	44.1
Son preferred over daughter (%)[b]															
NFHS-1	**55.9**	2	33.2	43.9	55.9	51.1	47.9	43.6	57.6	35.9	42.4	33	27	18.2	11.5
NFHS-2	**47.9**	1	20.7	37.6	53.3	42.5	29.1	37.5	47.5	27.1	33.2	19.8	13	14.6	9.6
NFHS-3	**39**	1	16.5	24.2	33.5	30.8	17.7	22	34.3	14.1	22.7	9.3	11.6	11	5.7

[a] Date not available for NFHS-1 and 2. The marital violence rate is based on whether a respondent has ever faced any form of physical violence (mild, medium, severe) from her husband.
[b] Based on the survey question on the ideal number of sons and daughters that a respondent wanted.
[c] For all indicators, ranking is based on descending order of states by indicator value.
[d] Source: National Human Development Report, 2001

TABLE 3: Male and Female Infant Mortality for Every 1000 Live Births in Fourteen Major Indian States: National Family Health Survey 1992-93, 1998-99, 2005-2006

	1992-93			1998-99			2005-06		
	Male IMR	Female IMR	Sex ratio (F/M)	Male IMR	Female IMR	Sex ratio (F/M)	Male IMR	Female IMR	Sex ratio (F/M)
Bihar	**109**	**105**	**0.96**	**82**	**84**	**1.02**	**89**	**94**	**1.06**
Bihar Rank[a]	4	3	6	8	5	4	5	4	2
Region: East									
West Bengal	109	101	0.93	87	70	0.80	76	60	0.79
Orissa	148	133	0.90	111	104	0.94	108	102	0.94
Region: Central									
Uttar Pradesh	140	152	*1.09*	126	129	1.02	101	101	*1.00*
Madhya Pradesh	121	124	*1.02*	128	125	0.98	100	92	0.92
Region: North									
Punjab	65	64	0.98	58	75	*1.29*	58	56	0.97
Haryana	92	100	*1.09*	72	79	*1.10*	62	69	*1.11*
Rajasthan	82	92	*1.12*	113	116	*1.03*	100	96	0.96
Region: West									
Maharashtra	88	76	0.86	65	62	0.95	62	50	0.81
Gujarat	96	88	0.92	95	83	0.87	79	77	0.97
Region: South									
Andhra Pradesh	104	90	0.87	96	90	0.94	65	51	0.78
Karnataka	108	95	0.88	86	74	0.86	72	55	0.76
Kerala	56	36	0.64	39	30	0.77	33	23	0.70
Tamil Nadu	108	85	0.79	80	71	0.89	61	61	*1.00*
India	98	95	0.97	91	86	0.94	78	70	0.90

[a] Rank is based on descending order of infant mortality rates and sex ratio of infant mortality rates.

TABLE 4: Sample Descriptive Statistics of Socio-economic Variables for India and Bihar: National Family Health Surveys of India (1992-93, 1998-99, 2005-2006)

	India				Bihar	
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.
Female child (Male = 0)	0.48	0.50	0	1	0.48	0.50
Bihar	0.07	0.26	0	1	---	---
Year of Birth	1987	9.19	1954	2006	1987	9.14
Birth order	2.71	1.80	1	18	2.99	1.93
Mother's education in years	3.02	4.30	0	23	1.68	3.54
Mother's age in years	35	8	15	49	34	8
Urban (Rural = 0)	0.32	0.47	0	1	0.20	0.40
Mother has occupation	0.41	0.49	0	1	0.35	0.48
Mother watches television at least once a week	0.42	0.49	0	1	0.18	0.38
Mother listens to radio at least once a week	0.34	0.47	0	1	0.20	0.40
Household asset index (0-7)	2.15	1.67	0	7	1.33	1.47
Religion: Hindu	0.75	0.43	0	1	0.80	0.40
Religion: Muslim	0.14	0.34	0	1	0.18	0.38
Religion: Other	0.11	0.31	0	1	0.03	0.16
Belongs to scheduled caste or scheduled tribe	0.30	0.46	0	1	0.23	0.42
N	777,705	---	---	---	58,936	---
NFHS-1	0.32	0.47	0	1	0.32	---
NFHS-2	0.33	0.47	0	1	0.38	---
NFHS-3	0.34	0.47	0	1	0.30	---

Household asset index was created from survey questions on whether or not a household has electricity, radio, television, refrigerator, bicycle, motorcycle, and car.

TABLE 5: Estimated odds ratios for binary logistic regression models of association of child sex (1= child is female, 0 = child is male) with probability of child mortality between ages 0-12 months in Bihar vis-à-vis India and states of Eastern Region, along with full set of controls

Predictor Variables	Comparison Region: India	Comparison Region: East	
	Bihar vis-à-vis India	Bihar vis-à-vis WB	Bihar vis-à-vis OR
	(2)	(3)	(4)
Female child	0.92***	0.84***	0.90***
	(0.008)	(0.034)	(0.031)
Bihar	0.85***	1.02	0.66***
	(0.020)	(0.04)	(0.023)
FemaleXBihar	1.11***	1.21***	1.13***
	(0.033)	(0.06)	(0.051)
Birth order	1.18***	1.16***	1.15***
	(0.005)	(0.013)	(0.013)
Mother's education in years	0.97***	0.98***	0.98***
	(0.002)	(0.006)	(0.007)
Mother's age in years	0.93***	0.93***	0.94***
	(0.001)	(0.004)	(0.004)
Urban location	0.90***	0.91**	0.89***
	(0.012)	(0.037)	(0.035)
Mother has occupation	1.00	1.09***	1.07***
	(0.010)	(0.033)	(0.031)
Mother watches television at least once a week	0.87***	0.89***	0.90***
	(0.012)	(0.041)	(0.040)
Mother listens to radio at least once a week	0.94***	1.02	1.08***
	(0.011)	(0.036)	(0.037)
Household asset index	0.91***	0.90***	0.89***
	(0.004)	(0.013)	(0.012)
Muslim	0.80***	0.93*	0.91**
	(0.012)	(0.034)	(0.041)
Other religion	0.68***	0.96	1.00
	(0.013)	(0.085)	(0.087)
scheduled caste or scheduled tribe	1.02**	1.06*	0.98
	(0.011)	(0.037)	(0.030)
Year of Birth	0.91***	0.91***	0.91***
	(0.001)	(0.004)	(0.004)
NFHS-2	1.69***	1.32***	1.31***
	(0.025)	(0.057)	(0.051)
NFHS-3	3.10***	2.86***	2.89***
	(0.076)	(0.200)	(0.188)
R^2	0.04	0.03	0.03
N	777,705	93,628	92,829

Standard errors are in parenthesis and are adjusted for clustering on mother's case identification number. * significant at 10%; ** significant at 5%; *** significant at 1%.

TABLE 6: Estimated odds ratios for binary logistic regression models of association of child sex (1= child is female, 0 = child is male) with probability of child mortality between ages 0-12 months in Bihar vis-à-vis states of western and southern regions, along with full set of controls

Predictor Variables	Comparison region: West Bihar vis-à-vis Maharashtra (1)	 Bihar vis-à-vis Gujarat (2)	Comparison region: South Bihar vis-à-vis Kerala (3)	 Bihar vis-à-vis Andhra Pradesh (4)	 Bihar vis-à-vis Karnataka (5)	 Bihar vis-à-vis Tamil Nadu (6)
Female child	0.86***	0.89***	0.68***	0.85***	0.82***	0.86***
	(0.036)	(0.038)	(0.048)	(0.035)	(0.033)	(0.037)
Bihar	1.17***	0.87***	1.54***	1.08*	1.02	0.98
	(0.049)	(0.035)	(0.097)	(0.045)	(0.041)	(0.042)
FemaleXBihar	1.18***	1.15***	1.50***	1.19***	1.24***	1.18***
	(0.060)	(0.059)	(0.115)	(0.060)	(0.061)	(0.061)
Birth order	1.16***	1.14***	1.15***	1.15***	1.17***	1.16***
	(0.014)	(0.014)	(0.016)	(0.014)	(0.014)	(0.014)
Mother’s education in years	0.97***	0.97***	0.96***	0.97***	0.98***	0.96***
	(0.006)	(0.006)	(0.007)	(0.005)	(0.007)	(0.005)
Mother’s age in years	0.93***	0.94***	0.94***	0.94***	0.93***	0.94***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)
Urban location	0.90***	0.92**	0.91**	0.81***	0.92**	0.92**
	(0.036)	(0.037)	(0.043)	(0.034)	(0.038)	(0.036)
Mother has occupation	1.13***	1.06*	1.12***	1.09***	1.12***	1.14***
	(0.035)	(0.033)	(0.040)	(0.033)	(0.034)	(0.035)
Mother watches television at least	1.01	1.00	0.97	0.98	1.02	0.98
once a week	(0.047)	(0.047)	(0.054)	(0.042)	(0.045)	(0.042)
Mother listens to radio at least once a	1.02	1.02	1.04	1.10***	1.05	1.07*
week	(0.038)	(0.039)	(0.045)	(0.038)	(0.038)	(0.038)
Household asset index	0.88***	0.89***	0.89***	0.87***	0.87***	0.90***
	(0.013)	(0.013)	(0.015)	(0.012)	(0.012)	(0.012)
Muslim	0.85***	0.89***	0.91**	0.84***	0.91**	0.90***
	(0.035)	(0.038)	(0.040)	(0.036)	(0.037)	(0.040)
Other religion	1.04	1.00	1.02	0.92	0.91	1.03
	(0.065)	(0.095)	(0.077)	(0.072)	(0.080)	(0.079)
scheduled caste or scheduled tribe	0.97	1.00	1.02	1.03	1.03	1.00
	(0.033)	(0.033)	(0.041)	(0.035)	(0.034)	(0.034)
Year of Birth	0.91***	0.91***	0.92***	0.91***	0.91***	0.91***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.002)
NFHS-2	1.39***	1.37***	1.26***	1.39***	1.33***	1.35***
	(0.060)	(0.058)	(0.061)	(0.060)	(0.056)	(0.059)
NFHS-3	3.14***	2.97***	2.81***	2.85***	2.84***	2.84***
	(0.226)	(0.210)	(0.222)	(0.201)	(0.201)	(0.202)
R^2	0.04	0.03	0.04	0.03	0.03	0.03
N	100,962	88,553	80,589	94,331	94,522	90,334

Standard errors are in parenthesis and are adjusted for clustering on mother’s case identification number. * significant at 10%; ** significant at 5%; *** significant at 1%.

TABLE 7: Estimated odds ratios for binary logistic regression models of association of child sex (1= child is female, 0 = child is male) with probability of child mortality between ages 0-12 months in Bihar vis-à-vis states of central and northern region, along with full set of controls

	Comparison Region: North			Comparison Region: Central	
Predictor Variables	Bihar vis-à-vis Rajasthan	Bihar vis-à-vis Haryana	Bihar vis-à-vis Punjab	Bihar vis-à-vis UP	Bihar vis-à-vis MP
	(1)	(2)	(3)	(5)	(6)
Female child	1.05	1.07	1.04	1.04***	0.96
	(0.032)	(0.054)	(0.059)	(0.019)	(0.024)
Bihar	0.90***	0.97	0.95	0.69***	0.77***
	(0.030)	(0.045)	(0.060)	(0.019)	(0.024)
FemaleXBihar	0.97	0.95	0.98	0.98	1.05
	(0.041)	(0.055)	(0.062)	(0.034)	(0.040)
Birth order	1.18***	1.18***	1.17***	1.17***	1.17***
	(0.012)	(0.015)	(0.016)	(0.009)	(0.011)
Mother's education in years	0.98***	0.97***	0.98**	0.97***	0.97***
	(0.006)	(0.006)	(0.008)	(0.004)	(0.006)
Mother's age in years	0.93***	0.93***	0.94***	0.93***	0.93***
	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)
Urban location	0.92**	0.89***	0.90**	0.86***	0.84***
	(0.036)	(0.039)	(0.041)	(0.025)	(0.030)
Mother has occupation	1.10***	1.11***	1.13***	1.08***	1.09***
	(0.029)	(0.035)	(0.038)	(0.022)	(0.027)
Mother watches television at least once a week	0.98	0.98	0.91*	0.89***	0.96
	(0.045)	(0.048)	(0.050)	(0.029)	(0.035)
Mother listens to radio at least once a week	1.07*	1.09	1.07*	1.02	1.00
	(0.040)	(0.044)	(0.045)	(0.026)	(0.030)
Household asset index	0.90***	0.90**	0.88	0.92***	0.90***
	(0.011)	(0.014)	(0.015)	(0.008)	(0.010)
Muslim	0.90***	0.93***	0.90**	0.85***	0.84***
	(0.036)	(0.042)	(0.043)	(0.023)	(0.034)
Other religion	0.93	0.99	0.91*	0.84**	0.96
	(0.083)	(0.079)	(0.050)	(0.065)	(0.080)
Scheduled caste or scheduled tribe	1.03	1.03	1.00	1.07***	0.97
	(0.029)	(0.036)	(0.036)	(0.024)	(0.024)
Year of Birth	0.91***	0.91***	0.91***	0.90***	0.90***
	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)
NFHS-2	1.74***	1.30***	1.36***	1.44***	1.62***
	(0.064)	(0.059)	(0.063)	(0.040)	(0.057)
NFHS-3	3.43***	2.88***	2.95***	2.90***	3.35***
	(0.215)	(0.217)	(0.223)	(0.132)	(0.20)
R^2	0.02	0.02	0.03	0.04	0.03
N	107,455	82,410	81,927	168,021	125,110

Standard errors are in parenthesis and are adjusted for clustering on mother's case identification number. * significant at 10%; ** significant at 5%; *** significant at 1%.

TABLE 8: Expected Female Infant Mortality Rate for every 1000 female live births, Estimated number of excess female deaths for every 1000 female live births, and Percentage of Female Infant Deaths that are Excess at Observed Female IMR of 94 in Bihar

Benchmark state[a]	Expected Female – IMR	Est. number of excess female deaths in Bihar for every 1000 female live births (obs. FIMR – exp. FIMR)	% of female infant deaths in Bihar that are excess
West Bengal	73	(94-73) = 21	(21/94)*100 = 22
Orissa	77	17	18
Maharashtra	74	20	21
Gujarat	77	17	18
Andhra Pradesh	74	20	21
Karnataka	71	24	24
Kerala	60	36	36
Tamil Nadu	74	21	21
State Average	---	---	23
[c] Europe and Oceania (Hill and Upchurch 1995)	73	21	22

[c]Calculated at observed male IMR by age five of 123 in Bihar, observed male age-1 IMR of 92 and expected sex ratio of age-1 IMR of 0.801 (Hill and Upchurch 1995: Table 1 pg. 132).
[a] Results shown only for states for which coefficient on *"BiharXFemale"* was positive and significant.

Table 9: Estimated odds ratios for binary logistic regression models of association of child sex (1= child is female, 0 = child is male) with probability of Receiving Various childhood Investments in Bihar, along with full set of controls

Predictor Variables	Breastfeeding	Supplemental feeding	BCG	Polio	DPT	Measles	Fever treatment[a]	Diarrhea treatment[a]
Female child	1.07	0.97	0.78***	0.92	0.84***	0.81***	0.71***	0.90
Birth order	1.00	0.98	0.84***	0.93***	0.85***	0.88***	0.92***	1.03
Mother's education in years	0.98***	1.05***	1.09***	1.06***	1.08***	1.08***	1.00	0.99
Mother's age in years	1.03***	1.02**	1.02***	1.01	1.02***	1.01	1.01	0.98
Urban location	0.76***	1.09	0.75***	1.18*	0.69***	0.83	1.03	1.07
Mother has occupation	1.25**	1.10	0.74***	0.87**	0.75***	0.94	1.12	1.04
Mother watches television at least once a week	0.90	1.20	1.43***	1.07	1.27***	1.21**	1.59***	1.14
Mother listens to radio at least once a week	0.95	1.08	1.15*	1.12	1.08	1.24***	0.95	1.25
Household asset index	0.95	1.09**	1.14***	1.16***	1.17***	1.18***	1.03	1.06
Muslim	0.81**	0.94	0.65***	0.81***	0.66***	0.70***	1.18	1.04
Other religion	0.97	0.49***	2.27***	1.31*	1.52***	2.19***	0.63*	1.44
scheduled caste or scheduled tribe	1.05	0.86*	0.90	0.82***	0.86**	0.83**	0.87	0.70***
Year of Birth	1.25***	0.98	0.97*	0.60***	0.82***	0.69***	1.00	0.96
Community var: Mean years of female education	0.99	1.10***	1.11***	0.99	1.10***	1.11***	0.99	1.00
Community var: Mean years of male education	0.97**	0.98	1.02*	1.02***	1.01	1.01	1.03	0.99
Community var: Prop. Of females who work	0.67**	0.89	0.68***	0.69***	0.59***	0.65**	0.84***	0.46***
Community var: Prop. Of women who prefer sons	1.05	1.25	0.90	1.32	1.10	1.18	2.24	0.77
R^2	0.04	0.03	0.20	0.25	0.16	0.21	0.03***	0.02
N	9,497	20,678	9,553	9,566	9,519	9,371	2,649	1,292

[a]Fever treatment/ Diarrhea treatment: Two dummy variables for each illness treatment that equals one if child received treatment from at least one of the following sources: government/municipal hospital, government dispensary, government mobile clinic, rural hospital, camp, other public medical sector, private hospital/doctor/clinic, Private paramedic, Vaidya/Hakim/Homeopath, NGO or trust hosp/clinic, other private medical, Anganwadi/ICDS Centre.

TABLE 10: Contribution of Gender Gap in Investment towards Excess Female Infant Mortality in Bihar

Investment type	Prob. of dying if recd. Investment [b]	Prob. Of dying if not received investment [b]	Mortality gap (pct. Pt.)	% males receiving investment [b]	% females receiving investment [b]	Gender gap in investment (pct. Pt.)	Prob. Of female dying due to gender gap in investment	% of gender gap in IMR explained by gender gap in this investment (unadjusted)[d]
Breastfeeding	2	17	15	0.89	0.90	-0.01	-0.15	-7.14
Supplemental feeding	8	7	1	0.83	0.83	0.00	0	0
BCG	1.09	8.62	7.53	0.43	0.39	0.04	0.04*7.53 =0.30	0.30/2.1 = 14.28
Polio	2.3	15.87	13.57	0.46	0.45	0.01	0.13	6.19
DPT	1.37	8	6.63	0.28	0.26	0.02	0.13	6.19
Measles	0.57	6.57	6	0.22	0.20	0.02	0.12	5.71
Fever treatment	Na	Na	1.03[a]	0.61	0.53	0.08	0.08	3.92
Diarrhea treatment	Na	Na	1.77[a]	0.56	0.54	0.02	0.03	1.68

Gender gap in IMR = (Observed female IMR – expected female IMR) = 9.4% – 7.3% = 2.1 percentage points. The observed female IMR is from the merged NFHS. The expected female IMR is from table 8, when West Bengal is benchmark of comparison.

[a] Sourced from Oster (2009a)

[b] Mortality rates for breastfeeding and supplemental feeding sourced from merged NFHS. Mortality by vaccination however was available only from NFHS-1. In order to use more updated figures, mortality rates by all four vaccinations were also sourced from India Human Development Survey 2005. Since the IHDS collected vaccination and mortality data for the last birth and next to last birth from each respondent, hence the mortality rates by age one for both births from the IHDS and from NFHS-1 were averaged for vaccinated and non-vaccinated children.

[d] Unadjusted figures i.e. calculations were made under the assumption that mortality is caused only by a specific investment, regardless of whether or not child was deprived of other investments.