International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

Address: IIASA, Schlossplatz 1, A-2361 Laxenburg, Austria
Email: permissions@iiasa.ac.at

Working paper

The Role of Maternal Education in Reducing Excess Deaths among Girls in India

Moradhvaj Dhakad,[1,2,3,4*] (moradhvaj@iiasa.ac.at, moradhvajiips@gmail.com)
Dilek Yildiz,[1,2,3] (yildiz@iiasa.ac.at)
Samir KC,[1,3,5] (kc@iiasa.ac.at)

WP-23-006

[1]Population and Just Societies (POPJUS) Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria. *Corresponding author
[2] Vienna Institute of Demography of the Austrian Academy of Sciences (OeAW), Vienna Austria
[3] Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID/OAW, WU), Vienna, Austria
[4] University of Vienna, Vienna, Austria
[5] Asian Demographic Research Institute (ADRI), Shanghai University, China

Approved by:

Name Anne Goujon
Program: Program Director, Population and Just Societies Program
Date: 23 May 2023

ZVR 524808900

The authors gratefully acknowledge funding from Austrian Academy of Sciences (ÖAW) „Innovation Fund Research, Science and Society" for the research project 'Bayesian reconstruction of populations and vital rates by educational attainment' (IF_2019_29_BayesEdu).

Table of contents

Abstract 4
Introduction 5
Maternal education relation to under-five mortality 6
Education, gender equality, and child mortality nexus 7
Data and Methods 8
Outcome variable 9
Explanatory variables 9
Methods 10
Results 11
Cox-proportional hazard models 14
Discussion 19
Acknowledgments 22
References 23
Appendix 30

Abstract

Background: India's skewed child–sex ratio (fewer girls than boys) results from excessive female child mortality due to postnatal discrimination against girls and sex-selective abortions. The positive effect of maternal education on child survival is well documented; however, its impact on protecting girls from higher mortality than boys is under-explored in the case of children under five. This study hypothesizes that educated mothers treat their children equally without gender discrimination, which reduces the unduly higher mortality of girls in India.

Data and Methods: Using five rounds of the National Family Health Surveys (NFHS) between 1992–1993 and 2019–2021, this study compared mortality for boys and girls in their first five years (0–59 months, under-five mortality) with respect to their mothers' educational attainment. This was disaggregated by ages 0–1 month (neonatal mortality), 1-11 months (post-neonatal mortality), and 12-59 months (child mortality). A mixed-effects Cox proportional hazard (MECPH) model was employed to compare the hazard of death for boys and girls by mothers' education.

Results and conclusion: The mortality rate for boys and girls under the age of five differs significantly by mothers' educational attainment. In NFHS 1992–1993, 9 more girls (per 1000 live births) died than boys to mothers with below-primary education; this contrasts with 20 fewer girls dying than boys to mothers with secondary education. This implies that India could have saved 0.27 million girls per year during the NFHS 1992-1993 if the girls born to below-primary-educated mothers had a similar sex difference as those born to secondary-educated mothers. Recent surveys have indicated that girls born to mothers with primary education or lower continued to experience higher mortality than boys aged 12-59 months. MECPH model results based on pooled data from 1992-2021 indicate that girls have an 8% and 18% lower mortality risk than boys during under-five years of age born to primary and secondary educated mothers, respectively, than those born to below-primarily educated mothers.

The survival advantage for girls born to secondary educated mothers is closer to the prevailing biological survival advantage of girls in Western European countries where gender discrimination is negligible. The impact of mothers' education is stronger at ages when girls are more disadvantaged (i.e., at ages 1-11 months and 12-59 months). Our results show that maternal education significantly protects girls from a higher risk of death, leading to achieving the biological survival advantage for girls in India. There is thus a need to increase focus on women's secondary school education to improve both under-five mortality and the child–sex ratio in India

Keywords:

Maternal education, under-five mortality, gender discrimination, excess female death, sex ratio, India

Introduction

India and Nigeria, with their huge population size and higher than average mortality rate, account for almost one-third of global deaths in children under the age of five (UNICEF, 2021). According to UNICEF (2021), in India, 8.3% more girls die than boys in the first five years of life, although the death rate for boys worldwide in the under-fives is 14% higher. India's recent (2019–2021) National Family Health Survey (NFHS) suggests that about 7% more girls die than boys in the 1–4-year age group (4q1[1]) (IIPS and ICF, 2021). As a result of the higher girls' mortality rate combined with a skewed sex ratio at birth, India has a female deficit in early ages, which contributes to a skewed child-sex ratio (Arnold et al., 1998; Arokiasamy and Goli, 2012; Coale and Banister, 1994; Das Gupta and Mari Bhat, 1997; D'Souza and Chen, 1980; Guilmoto et al., 2018; Kumari and Goli, 2022; Sudha and Rajan, 1999; Visaria, 1971). While it is well established that maternal education strongly increases the survival status of all children (Caldwell, 1979; Lutz and Kebede, 2018; Pamuk et al., 2011a), the role of maternal educational attainment in protecting female children from excess mortality conditions is under-explored. This study investigates whether maternal education shields female children during under-five ages (0-59 months, 0 month, 1-11 months, 12-59 months) against their survival disadvantages in India.

In most populations, where girls and boys have the same levels of access to healthcare and nutrition, girls are more likely than boys to survive in childhood due to boys' greater biological frailty (United Nations, 2011; Waldron, 1998). However, in a society where females encounter greater social disadvantages than males, a higher female under-five mortality rate (U5MR) can be observed (Alkema et al., 2014). This feature of mortality is especially striking in India. According to UN IGEM (2023), in 2022, more girls continued to die before the age of five in India than boys. In India, the U5MR declined from 127 per 1,000 live births (male=123, girls=130) in 1990 to 31 per 1000 live births (boys=30, girls=31). Despite the fast improvement in under-five mortality, India continues to experience one of the highest levels of excess female under-five mortality worldwide (Alkema et al., 2014; Guilmoto et al., 2018; Kashyap, 2019; Kashyap and Behrman, 2020; UNICEF, 2021).

Despite India's fairly rapid economic growth, the country's progress toward gender equality has been limited (World Economic Forum, 2022). The status of women in Indian society continues to be lower than that of men, as evidenced by women's low socioeconomic status and political participation. Discrimination against girls and women in India is a pervasive and long-running phenomenon, as reflected in the recent gender gap report, which ranks India among the least gender-equal countries, endangering the lives of female children (World Economic Forum, 2022). The survival disadvantage for a girl is attributed to the entrenched preference for sons over daughters (Arnold et al., 1998). A variety of socioeconomic and cultural factors influence that preference. For instance, in India, daughters are often seen as an economic liability due to the dowry system, which obliges the bride's family to give durable assets to the groom as a condition of marriage (Chowdhury, 2010). After

[1] 4q1 denotes the probability of dying between the exact ages of 1 and 4.

marriage, any socioeconomic contributions made by the brides belong to their husband's families, which causes parents to invest less in their daughters than in their sons (Moradhvaj and Saikia, 2019; Rashmi et al., 2022). Sons, however, perpetuate patrilineage, contribute to the household economy, provide old-age security, and do not incur high dowry costs (Croll, 2000; Vlassoff and Vlassoff, 1980).

India is one of the world’s most populous countries, after China, with a higher sex ratio (fewer females than males) compared to Western countries. The child sex ratio (0–6 years) in India has long favoured males (Arokiasamy, 2007; Arokiasamy and Goli, 2012; Bhat and Zavier, 2007; ORGI, 2011; Premi, 2001). According to the most recent Indian census in 2011, the child sex ratio was 109 males for every 100 females (ORGI, 2011). More worrisome is the fact that the child sex ratio increased from 106 in 1991 to 108 in 2001 and then to 109 in 2011. Proximally, these high child-sex ratios are attributable to the combination of high sex ratio at birth and excess female mortality during childhood (Alkema et al., 2014; Arnold et al., 2002; Das Gupta and Mari Bhat, 1997; Diamond-Smith et al., 2020; Guilmoto et al., 2018; Sudha and Rajan, 1999; Visaria, 1971).

Maternal education relation to under-five mortality

Almost universally, maternal education is considered one of the most potent factors in reducing under-five mortality (Balaj et al., 2021; Lutz and Kebede, 2018; Wu, 2022). Gakidou et al. (2010) reported a more than 50% decline in global under-five deaths due to improvements in women's education between 1970 and 2009. Similarly, Balaj et al. (2021) showed that an additional year of schooling is associated with a 3% reduction in under-five mortality in Demographic and Health Survey (DHS) countries. Analyzing a series of DHS surveys conducted in Zimbabwe, Grépin and Bharadwaj (2015) further showed that an additional year of maternal secondary education contributed to a 21% reduction in child mortality. Furthermore, each additional year of maternal schooling reduced the risk of death among under-five children in Malawi and Uganda by 10% and 16%, respectively (Andriano and Monden, 2019). Monden & Smits (2013) found that maternal education reduces under-five mortality in sub-Saharan Africa and southern Asia. Similarly, studies in India showed a clear association between mothers' educational attainment and child mortality (Choudhury, 2015; Kravdal, 2004). A recent study by Moradhvaj and KC (2023) found that there is lower under-five mortality among educated Indian women in both rural and urban areas.

Children of educated mothers benefit from a survival advantage through many direct and indirect factors. These factors can be treated under three headings: fertility decision, prenatal care, and postnatal care. First, higher-educated women are better informed about modern contraceptive methods and their efficient use for birth spacing, which translates to better child health status (Rosenzweig and Schultz, 1989). Studies show that the risk of death is very high for girls with higher-order sisters (Arnold et al., 1998), and education leads to smaller family sizes; consequently, parents can invest more when they have fewer children without gender-based discrimination coming into the picture (McCrary and Royer, 2011). Additionally, higher-educated mothers are more likely to obtain employment, resulting in fewer children. Second, the use of prenatal care positively correlates with maternal education level (Wang et al., 2021). The mother’s education positively affects the timely utilization of antenatal care, with secondary-educated mothers having at least four checkups before the child's birth (Wang et al., 2021; Yadav et al., 2021). Third, these differences persist after birth; better-educated women are more likely to seek medical care when needed and are better informed about healthcare and nutrition practices. Children of more educated women are more likely to be immunized and to receive vitamin A supplements to prevent blindness, diarrhea, and measles (Desai and Alva, 1998; Keats, 2018). In the same vein, a mother's education may affect child mortality, as she may adopt good environmental practices regarding sanitation and hygienic practices in the home. For instance, it was found that children whose mothers had a higher educational level had a lower risk of diarrhea (Hatt and Waters, 2006; Hobcraft, 1993). Moreover, education helps women to access gainful employment and empowers them to make healthcare decisions about themselves and their children (Badaoui and Rebière, 2013; Caldwell, 1979; Jejeebhoy, 1992; Keats, 2018; Thomas, 1990).

Education, gender equality, and child mortality nexus

Education has been recognized as one of the keys to achieving a gender-equal society (Karam, 2014; Parsons et al., 2015; Peppen, 2016). Under the United Nations development agenda, both the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) aimed to achieve gender equality and empower women through education (United Nations, 2016, 2015). There is a wider consensus that education fosters the achievement of equal human rights, such as access to healthcare, food, and employment, leading to an improved status of women in society (Karam, 2014; Saikia et al., 2016). Education is key to changes in attitudes and practices that cause gender-based discrimination. Maternal education, for example, reduces the preference for having a son over a daughter (Nguyen and Le, 2022). As a result, it may thus also reduce gender-based discrimination in providing healthcare and nutrition to children. Evidence from India shows that education reduces gender-based discrimination in providing healthcare facilities and spending money on healthcare (Saikia et al. 2016).

Few studies, however, have examined whether maternal education is equally effective at reducing child mortality among boys and girls. Monden and Smits (2013) found that among women with a higher educational level, the male–female under-five-mortality ratio is closer to biological sex differences than it is among women with little or no education in sub-Saharan Africa and southern Asia. Bourne and Walker (1991) demonstrated that a mother's education level influences a daughter's survival more than a son's in India. In Bangladesh, there is evidence of only a small difference in the impact of mothers' educational attainment on the mortality of male and female children (Muhuri and Preston, 1991; Wu, 2022). Other studies have not observed a differential impact of maternal education on children's mortality between boys and girls (Caldwell et al., 1989; Chen et al., 1981; Sen and Sengupta, 1983).

The results of some studies are inconsistent. For instance, Gupta (1987) found that in the Ludhiana district of India, girls born to women with some education have a greater risk of dying than those born to women without education. The author argued that more educated women are better positioned to "keep the mortality of undesired children high by withholding the requisite care." The conclusion reached was based on a relatively small sample size. Another explanation by Das Gupta and Mari Bhat (1997) is that more educated mothers have lower fertility rates, accompanied by a greater degree of gender bias. In a study conducted in rural Bangladesh, the association between mother's education and the survival rate of their 6- to 36-month-old children were found to be higher for boys than girls (Bhuiya and Streatfield, 1991).

Historically, studies have shown that the relationship between education and imbalances in child mortality differs according to several characteristics. For example, a study based on the 1981 Indian census showed that the impact on boys' and girls' mortality of maternal education varies by age and region. In the northern region, a more positive effect was recorded for the girl child, while southern states showed a higher positive impact for boys aged under five. Furthermore, maternal education has a stronger influence on boys' survival in infancy (0-1 age), while it is more favorable for girls after infancy (Bourne and Walker, 1991). Amin (1990) showed that maternal education has a positive impact in the case of the first daughter but a negative effect on the higher parity daughters.

To summarize, the research examining the differential effect of mothers' education on boys' and girls' mortality is limited. In the existing studies, there is mixed evidence regarding the impact of mothers' education on boys and girls. It is noted that the majority of studies conducted on this subject are either very old in terms of their period of study or are based on early surveys, which have a limited sample size. At present, there is no systematic investigation of the differential effects of maternal education on boys' and girls' survival during childhood in India based on nationally representative household data.

As mentioned earlier, maternal educational attainment is a primary factor in improving under-five mortality across countries. In addition, education has influenced attitudes and behavior regarding gender norms, thereby fostering greater gender equality. In India, girls are more likely to die than boys due to gender discrimination, despite the fact that biologically, boys have a higher mortality rate. This study explores whether maternal education helps to reduce female children's mortality disadvantage in India. We hypothesize that maternal education improves the survival rate of their children by ensuring that they are cared for without gender-based discrimination. Reducing the sex differences in child mortality among educated women would lead to biological sex differences in mortality (female advantage over male). Thus, this research compared the mortality levels between boys and girls by their mother's education in the first five years (0–59 months) of their life, disaggregated by age in the neonatal period (0 months), post-neonatal period (1-11 months) and child age group (12-59 months).

Data and Methods

This study uses five rounds of the National Family Health Survey (NFHS) of India conducted in 1992–1993 and 2019–2021 (IIPS, 1995; IIPS and ICF, 2021, 2017; IIPS and Macro International, 2007; IIPS and ORC Macro, 2000). The NFHS is a repeated cross-sectional nationally representative survey. The first NFHS survey was conducted in 1992–1993 (NFHS–1), the second survey in 1998–1999 (NFHS-2), the third in 2005–2006 (NFHS-3), the fourth in 2015–2016 (NFHS-4), the fifth and most recent in 2019–2021 (NFHS-5) (IIPS, 1995; IIPS and ICF, 2021, 2017; IIPS and Macro International, 2007; IIPS and ORC Macro, 2000).

The NFHS provides unit-level information on a wide range of health, demographic, family welfare, and maternal and child health indicators, including fertility, infant and child mortality, reproductive health, anaemia, nutrition, and utilization and quality of health and family planning services. The women's questionnaire collects detailed information about background characteristics such as age, education, religion, caste, reproductive behaviors, number of ever-born and surviving children, birth history, and other maternal and child health information. The birth history data provides the key data for the measurement of under-five mortality, such as date of birth, survival status of each live birth, and age at death of each deceased live birth.

Outcome variable

The outcome variable in this analysis is mortality among children below the age of five (0–59 months), defined as the probability of the child dying between birth and their fifth birthday. We analyzed the mortality among under-fives at different ages separately due to different biological and sociocultural risk factors across the age groups (Benjamin et al. 2021; WHO; 2021). We analyzed: i) under-five mortality (0–59 months); ii) neonatal mortality, defined as the probability of dying within the first month of life (0–1 months); iii) post-neonatal mortality, defined as the probability of death between one month and before the first birthday (1-11 months); iv) child mortality, defined as the probability of dying between age one and before fifth birthday (12-59 months). We also analyzed mortality at different ages for children born during the five years preceding the survey in each of the five NFHS rounds.

Explanatory variables

This study considers a range of demographic, socioeconomic, and community characteristics as explanatory variables that have been recognized as important predictors of under-five mortality in previous studies (Gupta, 1997; Hosseinpoor et al., 2006; Kravdal, 2004; Moradhvaj and Samir, 2023; Mosley and Chen, 1984; Saikia et al., 2013). The main explanatory variables in this study are the mother's educational attainment and the sex of the child (male or female). Maternal educational attainment is grouped into three categories: mothers with below primary, with completed primary, and with completed secondary education. Other explanatory variables considered in our study include the place of residence (rural or urban) and the household's wealth status (poorest, poorer, middle, richer, richest). We also considered the social affiliation of the household caste categorized as Scheduled Caste/Scheduled Tribe (SC/ST)—namely socially disadvantaged; non-SC/ST); and religion (Hindu, Muslim, others). Finally, we accounted for maternal characteristics such as the birth order (first birth, 2–4, 5 and above), birth interval as a short interval (less than 24 months), medium interval (25–48 months), and large interval (49 and more months). Previous studies showed that community characteristics also impact child mortality (Kravdal, 2004; Lutz and Kebede, 2018; Meitei et al., 2022). In this regard, the correlation between the survival status of the children and the community is investigated by controlling for the community-level characteristics, including education and economic status. The community-level education is calculated by taking the average of years of schooling of women residing in the community; similarly, community-level economic status is taken as the average household wealth status of the community. The number of children by women characteristics analyzed in this study is presented in Appendix Table 1A.

Methods

The synthetic cohort life table approach was used to estimate the mortality rates for different age segments by sex of the child and mother's educational attainment under the age of five (Croft et al. 2018). We estimated the under-five mortality rate (U5MR, 0–59 months), the neonatal mortality rate (NNMR, 0 month), the post-neonatal mortality rate (PNNMR, 1-11 months), and the child mortality rate (CMR, 12-59 months). Further, the survival analysis used to compare the effect of maternal educational attainment on the mortality of boys and girls. In data, the survival status of the child was measured for the duration given in days (if the child died in the first month) and months (after the first month) from birth until the age of five; this is time-to-event data or time-to-death data. The time-to-death data has censored cases. For under-five mortality, children who died before reaching their fifth birthday were considered as an event. The children who were still alive, had not yet reached their fifth birthday, and were event-free at the end of the study were considered the censored cases in the analysis (Austin, 2017). For the post-neonatal period, children from the age of one month who died before reaching their first birthday were considered an event; the children who were still alive and had not yet reached their first birthday were considered as censored cases.

The time-to-death data consist of i) whether or not the event has occurred and ii) the time at which it occurred. Conventional regression is limited to accounting for information about whether or not the event has occurred. It does not consider the time at which an event occurred and thus fails to consider the censorship problem. The Cox proportional hazards model is recommended to account for the censoring issue, as the outcome specifies the time until the event of interest occurs (Cox and Oakes, 2018). However, when the units of analysis are dependent, the Cox proportional hazard model does not provide unbiased estimates. The NFHS data is presented in a hierarchical structure. The children and their mothers are nested in clusters and are assumed to be correlated with one another. It is assumed that unobserved cluster characteristics may induce within-cluster homogeneity (e.g., community environment). This may affect the outcome variable at the subject level, as subjects have similar characteristics within the same cluster. Because of the correlation of within-cluster units, the parameter estimates of the Cox proportional hazards model are considered biased and inconsistent (Trussell et al., 1990). Mixed-effects Cox proportional hazards (MECPH), which allows the inclusion of random effects in the Cox proportional hazard model, can account for such cluster homogeneity. The MECPH has recently become more popular for studying child mortality because it uses hierarchically structured data (Alotaibi et al., 2020; Meitei et al., 2022; Moradhvaj and Samir, 2023). As the MECPH can account for the cluster-level variations in outcome variables within the community with information on time-to-event data, we used the MECPH model.

To understand the differential impact of maternal education on boy's and girls' mortality, the model includes the interaction term of these two predictors in addition to other predictors.

$$h(t_{ji}) = h_0(t_{ji}) \times \exp\left(\beta_{sex_{jik}} + \beta_{education_{jil}} + \beta_{sex_{jik} \times education_{jil}} + \beta x_{ji} + u_j\right)$$

Where $h(t_{ji})$ is the conditional hazard of the child's death at time t in cluster j (1, ...,m), i denotes the observations (child) with in a cluster; $h_0(t_{ji})$ is the baseline hazard (k=0 and l=0). $\beta_{education_{jil}}$ and $\beta_{sex_{jik} \times education_{jil}}$ are, respectively, the coefficients for the sex = k and education = l, and the interaction (sex = k × education = l). Here, x_{ji} is a vector of covariates with the associated vector of fixed parameters β. Random effects uj are realisations of a multivariate normal distribution with mean 0 and q × q variance matrix Σ.

For example, when the sex is male (k=0), the hazard function is

$$h(t_{ji} \mid \text{sex} = 0, \text{education} = l, \text{cluster} = j) = h_0(t_{ji}) \times \exp\left(\beta_{education_{jil}} + \_\text{cons} + u_j\right)$$

Where $\beta_{education_{ji0}}$ is equal to 0 for the base category (below-primary). This indicate that for a given cluster j,

$$\frac{h(t_{ji} \mid sex_{ji} = 0, education_{ji} = l, cluster = j)}{h(t_{ji} \mid sex_{ji} = 0, education_{ji} = 0, cluster = j)} = \exp\left(\beta_{education_{jil}}\right)$$

We also calculated the intraclass correlation coefficient (ICC) to determine the degree of clustering in the data. The ICC measures the correlation between the hazard ratios for children who live in the same cluster. The details regarding the calculation of the ICC for a MECPH model have been provided in other studies (Rodríguez, 2010; Canette, 2016). We fitted the model using the pooled data from NFHS 1992–1993 to NFHS 2019–2021. For each age segment (0–59 months, 0–1 month, 1-11 months, 12-59 months) of the under-five age-group, two models are fitted separately to examine the risk of deaths in each age group. The first model controlled only for the child's sex and mother's educational attainment and for their interaction effect; the second model included other determinants of child mortality at the individual and community levels to control for their impact.

Results

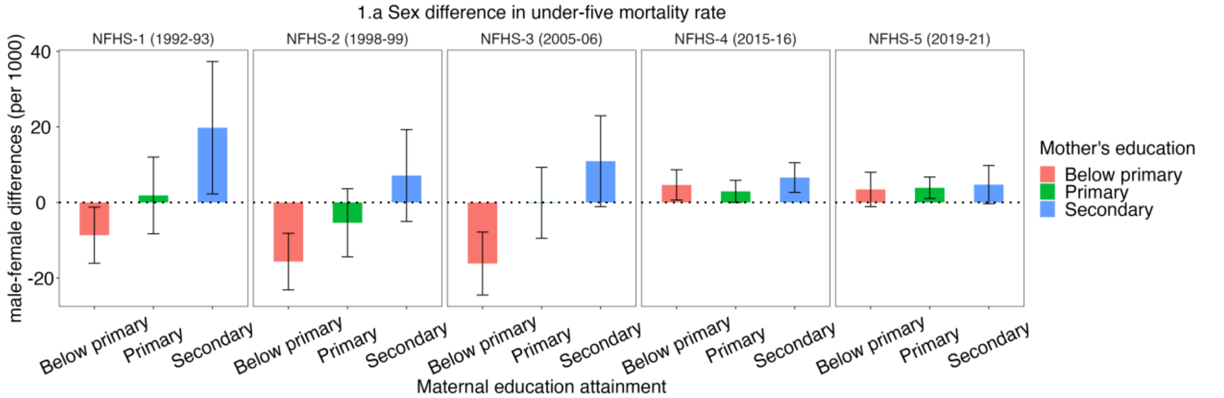
In this section, we first present the trends of female and male mortality in the age 0–59 months and disaggregated into the age 0 month, 1-11-months and 12–50 months. Then, we further investigate the sex differences in these rates by maternal educational attainment. Finally, we discuss the results of the Cox proportional hazard models. It is worth noting here that all the values reflect the five years preceding the survey dates.

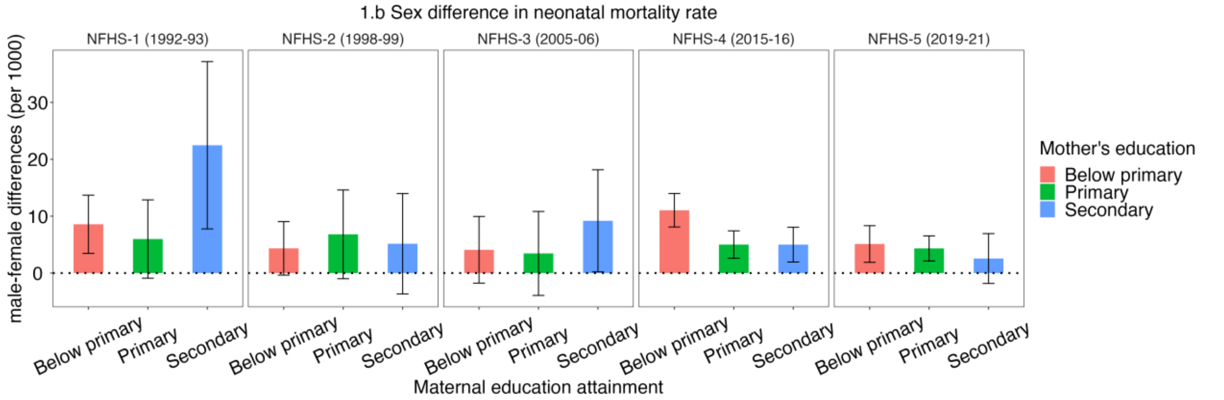
The trends analysis of mortality by age and sex in 0–59 months shows that prior to the 2015–2016 survey, the U5MR was higher for girls than boys. Conversely, after the 2015–2016 survey, the U5MR became lower for females than for males. When the sex differences in mortality are disaggregated by the child's age, it is apparent that sex differences in the risk of death vary at different ages of the child during the under-five age period. All surveys show that boys are more likely to die in 0 month of age than girls. Girls' mortality rates were higher during the 1-11 months and 12-59 months periods; however, in the recent survey, girls' mortality in the 1-11-month period was reported to be lower than that of boys. Notably, mortality rates among girls stayed higher in the 12-59 months of age period. Appendix A.1 provides details of mortality trends by age and sex.

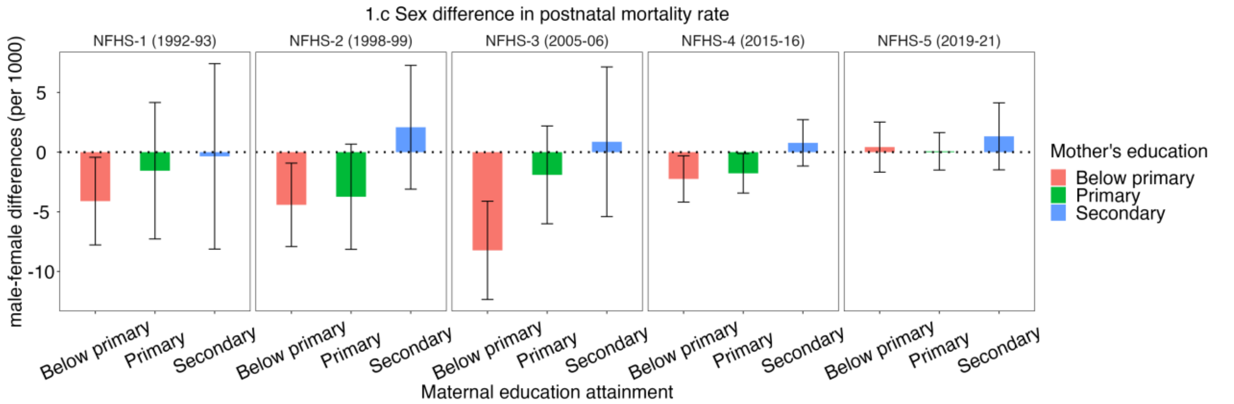
Figure 1 shows the trends of sex differences in age of 0–59 months (Figure 1a), 0 month (Figure 1b), 1-11 months (Figure 1c), and 12-59 months (Figure 1d**)** per 1000 live births by mother's educational attainment in India between NFHS 1992–1993 and NFHS 2019–2021. The figures indicate male and female under-five mortality differentials by maternal educational attainment. Negative values indicate higher female mortality and positive values indicate higher male mortality. In a gender-equal society, positive values are expected in all segments, as the probability of dying is higher for male children than for their female counterparts.

Figure 1a (0–59 months) shows the results from NFHS 1992–1993; about 9 more girls died (per 1000 live births) compared to boys among the mothers with below-primary education, whereas fewer girls than boys died among the mothers who had completed either primary or secondary education. Thus, compared to the males, there were two fewer female deaths (per 1000 live births) among the mothers who had completed primary education. Further, the sex differences increased in favor of girls among the secondary-educated women, where there were about 20 fewer female deaths (per 1000) compared to the male deaths in this age group. This implies that there were 29 more deaths (per 1000 live births) among girls whose mothers had below-primary education than those whose mothers had completed secondary education. The female survival disadvantage continued to remain high: according to the surveys conducted in 1998–1999 and 2015–2016, respectively, 23 and 27 more girls died than boys whose mothers had below-primary education than those whose mothers had completed secondary education. It is noteworthy that the pattern has changed in the recent rounds of NFHS surveys in 2015–2016 and 2020–2021, with the U5MR decreasing among girls across all education groups. However, the male–female differential in 0–59 months mortality continued to differ by the mother's educational attainment. This shows a lower survival advantage among girls born to below-primary-educated mothers compared to those born to secondary-educated mothers. In recent years, girls born to secondary-educated mothers continue to have more survival advantages than those born to below-primary-educated mothers.

The next panel, Figure 1b, presents the sex differential in mortality during the age of 0 month; it shows that the mortality rate was lower among girls across the survey years.


1.a Sex difference in under-five mortality rate
NFHS-1 (1992-93)
NFHS-2 (1998-99)
NFHS-3 (2005-06)
NFHS-4 (2015-16)
NFHS-5 (2019-21)
male-female differences (per 1000)
40
20
0
-20
Below primary
Primary
Secondary
Maternal education attainment
Mother's education
Below primary
Primary
Secondary


1.b Sex difference in neonatal mortality rate
NFHS-1 (1992-93)
NFHS-2 (1998-99)
NFHS-3 (2005-06)
NFHS-4 (2015-16)
NFHS-5 (2019-21)
male-female differences (per 1000)
30
20
10
0
Below primary
Primary
Secondary
Maternal education attainment
Mother's education
Below primary
Primary
Secondary


1.c Sex difference in postnatal mortality rate
NFHS-1 (1992-93)
NFHS-2 (1998-99)
NFHS-3 (2005-06)
NFHS-4 (2015-16)
NFHS-5 (2019-21)
male-female differences (per 1000)
5
0
-5
-10
Below primary
Primary
Secondary
Maternal education attainment
Mother's education
Below primary
Primary
Secondary

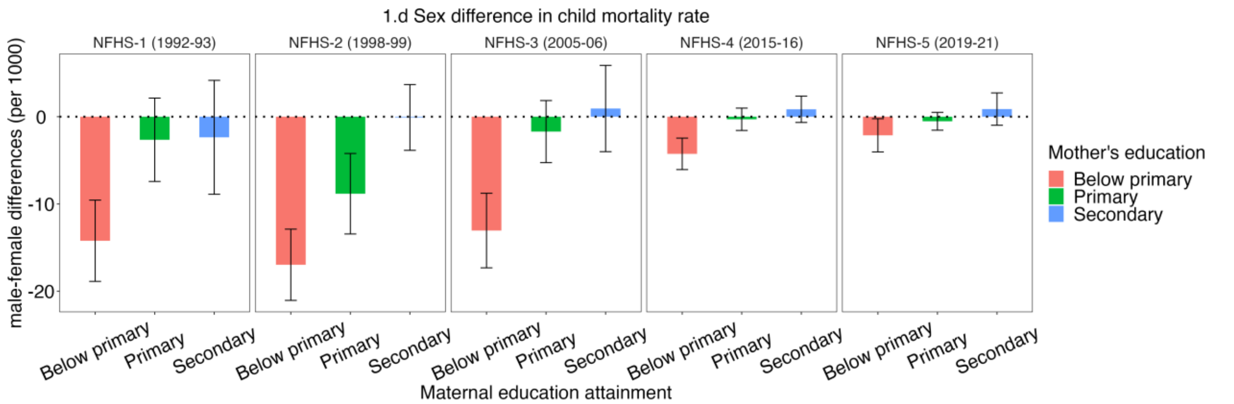

1.d Sex difference in child mortality rate
NFHS-1 (1992-93)
NFHS-2 (1998-99)
NFHS-3 (2005-06)
NFHS-4 (2015-16)
NFHS-5 (2019-21)
male-female differences (per 1000)
0
-10
-20
Below primary
Primary
Secondary
Maternal education attainment
Mother's education
Below primary
Primary
Secondary

Figure 1. Sex differences in mortality rates during the age of 0–59 months, 0 month, 1-11 months, and 12-59 months.

We also estimated sex differences in mortality during the 1-11 months of age. Figure 1c shows apparent sex differences in mortality. Using NFHS 1992–1993 survey data, we measured that i) more girls died than boys, regardless of their mothers' education level, but that ii) similar to other age segments, the degree of girls' disadvantage reduced with increases in maternal education level. This shows that mortality during the 1-11 months age was 4.1 per 1000 higher for girls (12 times higher) and 1.5 per 1000 (three times higher) for girls than boys born to mothers with, respectively, below-primary and primary education. In girls born to secondary-educated mothers, the rate was measured as only 0.3 per 1000, higher for girls. This indicates that the girls born to primary-educated mothers are less disadvantaged than those born to below-primary educated mothers. Overall, the sex differences in the 1-11 months of age were reduced in recent surveys, but the sex differences continued to vary by maternal educational attainment. The most recent survey (2019–2021) estimated that girls also have a survival advantage in 1-11 months of age and that the level of advantage continues to vary by maternal educational attainment. It shows that girls born to secondary educated mothers have more survival advantages than boys compared to those born to below-primary and primary educated mothers.

The next panel of Figure 1 (Figure 1d) shows the sex differences in mortality at 12-59 months of age across surveys by maternal educational attainment. Similar to the other mortality rates, it shows that the sex differences in child mortality differ by the mother's educational attainment. During the five years preceding the NFHS 1992–1993, about 14 more girls (than boys) died among those born to below-primary-educated mothers, whereas only three and two more girls (than boys), respectively, died those born to primary- and secondary-educated mothers. Even though the survival disadvantage for girls has decreased in recent years, more girls than boys died among mothers with below-primary and primary education. In the 2019–2021 survey, we measured that two and one more girls, respectively, died than boys among mothers with below-primary and primary education, while one less girl died compared with boys among secondary-educated mothers.

Cox-proportional hazard models

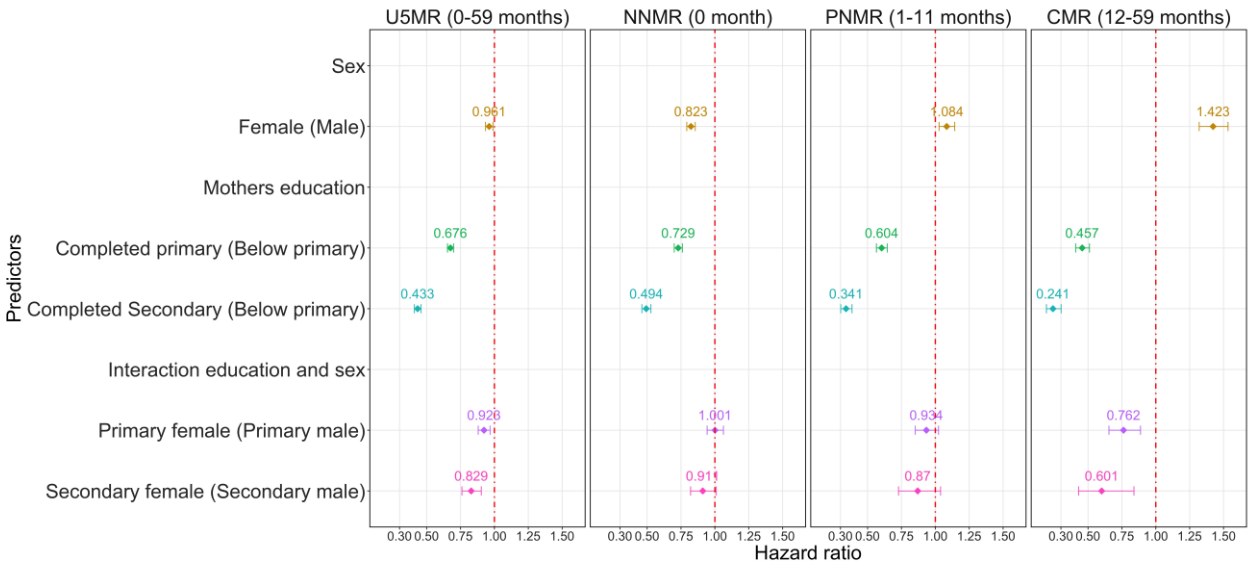
Regression results in controlling the interaction of the sex of the child and the mother's educational attainment

Figure 2 demonstrates the hazard ratios of death estimated employing the MECPH model for the under-five age group and disaggregated by age for 0 months, 1-11 months, and 12-59 months by sex and level of maternal education. To compare the relationship between maternal education and the mortality of male and female children, we modelled pooled data (NFHS-1 to NFHS-5) controlling for the sex of the child, the mother's educational attainment, and the interaction between these two variables and the year of the survey.

The results show that although the risk of under-five death is slightly lower for girls (HR=0.961, CI=0.934-0.989) than for boys, it is insignificant. The results show that the sex differences in the risk of death vary according to the age of the child. During the neonatal period, females had a survival advantage; the risk of death was 18% lower for girls (HR=0.823, CI=0.793-0.855) than for boys. After the neonatal period, females experienced higher mortality in the 1-11 months and 12-59 months of age groups. In the 1-11 months age group, the risk of death for females was 8% (HR=1.084, CI=1.028-1.143) higher than for males. In the 12-59 months of age group, this rose to 40% higher mortality (HR= 1.423, CI=1.32-1.533) for females than for their male counterparts. The findings suggest that females have more survival disadvantages in the 12-59 age group.

Maternal educational attainment is significantly associated with improvements in the child's survival status. Compared to the children born to mothers with below-primary education, the risk of U5M was reduced by over one-third (HR=0.676, CI=0.654-0.698) and by more than one-half (HR= 0.433, CI=0.409-0.459), respectively, for those born to mothers who completed primary and secondary education. We also analyzed the effect of a mother's educational attainment on their child mortality in the 0 months, 1-11 months and 12-59 months of age groups. The model results suggest that higher educational attainment significantly increases a child's survival. Interestingly, a mother's education affects her child's mortality to varying degrees depending on the child's age. During the neonatal period, the risk of death among the children was 28% lower (HR= 0.729, CI=0.70-0.76) and 51% lower (HR=0.494, CI=0.461-0.528) respectively, for mothers who had completed primary and secondary education, compared to mothers reported as being of below-primary education status.

Further, the impact of maternal education on mortality in 1-11 months appears to be stronger, with a reduction of 40% risk of death (HR=0.604, CI=0.565-0.645) and 66% risk of death (HR=0.341, CI=0.302-0.385), respectively, for children whose mothers completed primary and secondary education, compared to those whose mothers with below-primary education. Furthermore, a mother’s education emerged as a stronger predictor of child mortality in 12-59 months of age than of mortality at 1-11 months of age. Compared to children born to mothers with less than primary education, the risk of death was 55% lower (HR= 0.457, CI=0.409-0.511) and 73% lower (HR=0.241, CI=0.193-0.301), respectively, for those whose mothers completed primary and secondary education. The results indicate that the mother’s education played an important role in improving the survival status among children under five years and that the impact of educational attainment increased for older children.



Note: year of survey controlled

Figure 2. Hazard ratio of dying among under-five children at different ages for boys and girls by maternal education in India.

Further, using the interaction term, we examined whether the impact of the mother's education shields against the risk of deaths equally for boys and girls in the under-five age group. The results show that for mothers who completed primary education, the risk of death for female children is 8%—significantly lower than for males (HR= 0.923, CI=0.88-0.968). Furthermore, for mothers with secondary education, the risk of death among girls is reduced by 18% (HR=0.829, CI=0.76-0.903) compared to boys. This indicates that maternal education saves more girls from dying in the under-five age group. There is even greater protection against the risk of death for girls whose mothers completed secondary education.

In the above results, we found that mothers' educational attainment appears to be a stronger shield against death risk for girls than for boys under the age of five. In the further analysis, we extracted the differential impact of mothers' education on both males and females' mortality in the ages 0 month, 1-11 months, and 12-59 months. During the first months of child age, the risk of death was similar for both boys and girls whose mothers had completed primary education. The differential effect of education by sex appeared among those whose mothers had completed secondary education, showing a 9% lower risk of death (HR= 0.911, CI=0.821-1.011) for girls than for boys. Further, the model employed for 1-11 months of child age shows significant differences in the impact of maternal education on the survival status of both boys and girls. The Hazard ratio is 7% lower (HR= 0.934, CI=0.852-1.024) and 13% (HR=0.87, CI=0.728-1.039) for girls born to mothers who had completed primary and secondary education, respectively. Similarly, throughout the 12-59-month age group, the risk of death for girls was 24% lower (HR=0.762, CI=0.654-0.887) and 40% lower (HR=0.601, CI=0.43-0.839), respectively, then for boys whose mothers had completed primary and secondary education.

Regression results after controlling for socioeconomic factors

Figure 3 compares the hazard ratio for deaths of boys and girls and by the education of their mothers after controlling for socioeconomic (mothers' education, religion, caste, wealth), regional (rural–urban, India's regions) and maternal health factors (maternal age at birth, birth order, birth interval) at individual and community (average education and wealth) levels. In line with the rest of the paper, we estimated the risk of death in the under-five age group (0–59 months) disaggregated into ages 0–1 month, 1-11 months, and 12-59 months. After controlling for socioeconomic, regional, and maternal health factors, the hazard ratio of death by sex remained similar to that in the previous model. Similarly, the impact of maternal education on deaths remained significant after controlling for other factors. The hazard ratio of death for the 0–59 months age group by mother's educational attainment shows that the risk of death was reduced by 17% (HR=0.83, CI=0.8-0.86) and 44% (HR=0.661, CI=0.621-0.705), respectively, for children whose mothers had completed primary and secondary education, compared to those whose mothers reported below-primary education.

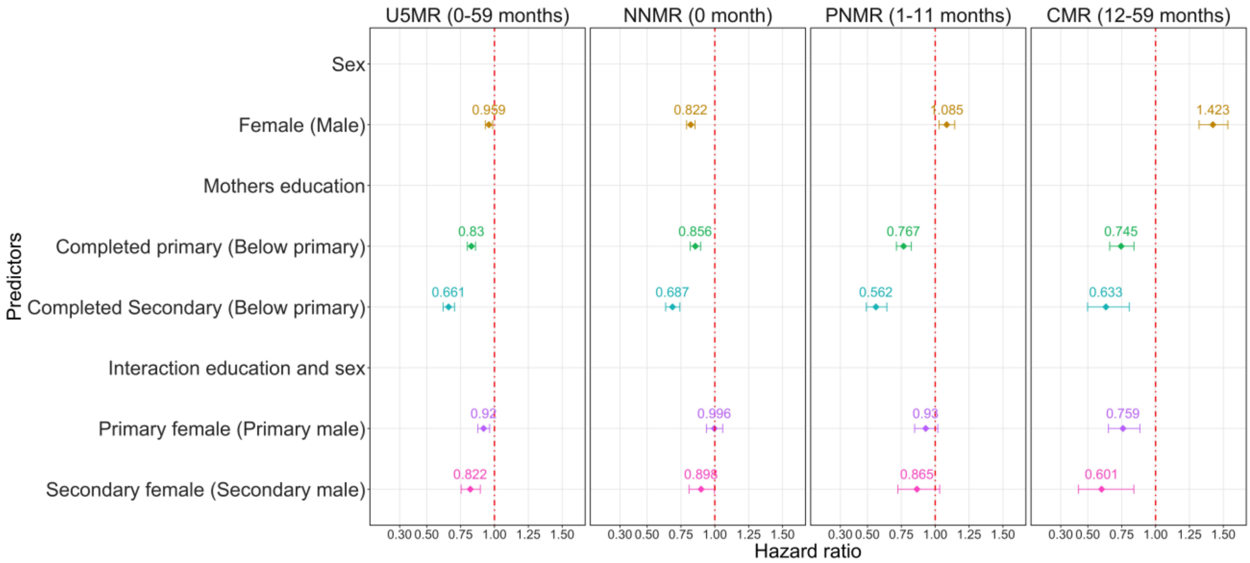


Figure 3. Hazard ratio of dying among under-five children at different ages for boys and girls by maternal education with other predictors of U5M in India controlled for.

Moreover, the impact of a mother's educational attainment differs across the under-five age-group. Maternal educational attainment significantly affects mortality in the first months of child age, and its impact on mortality increases with the subsequent age of the child. The risk of death in the neonatal period (0 month) was reduced by 14% (HR=0.856, CI=0.819-0.895) and by 31% (HR=0.687, CI=0.637-0.742), respectively, for children born to mothers who had completed primary and secondary education. The impact of maternal education on post-neonatal (1-11 months) mortality was more substantial, respectively reducing the 23% (HR=0.767, CI=0.714-0.824) and 43% (HR=0.562, CI=0.492-0.643) risk of death among children whose mothers had completed primary and secondary education, compared to children whose mothers had below-primary education. Further, the impact of mothers' education is even stronger on mortality in 12-59 months of age child, respectively reducing the 26% (HR=0.745, CI=0.661-0.841) and 37 % (HR=0.633, CI=0.498-0.806) likelihood of death among children whose mothers had completed primary and secondary education, compared to the children born to below-primary educated mothers. The model further examined the differential effect of mothers' education on boys' and girls' mortality at different ages in the under-five age group after controlling for other socioeconomic and maternal predictors of under-five mortality at the individual level and community level. The results show that the differential effect of maternal education on boys' and girls' survival status remained similar to the previous model, despite other predictors of mortality having been controlled for.

The results show that other socioeconomic predictors also significantly impact under-five mortality. The economic status of the household has a significant influence on the survival status among under-five children. Children born in more affluent households have a lower risk of death than those born in economically poor households. The social group of the mothers also has had a substantial impact on their child's survival. Children born to women in a socially disadvantaged caste group are more likely to die in childhood than those born to mothers in socially advantaged caste groups.

As expected, maternal characteristics, such as the mother's age at childbirth, birth order, and birth interval, also significantly impact a child's survival. The risk of death among children was lower for those born to mothers in the 20–29 age group compared to the children born to mothers younger than 20 at the time of childbirth. Notably, children born to mothers older than 35 have a higher risk of death compared even to those born to mothers under 20. The birth order of the child significantly determines the survival status of the children and the risk of death increases for the children who have a higher birth order. The timing of the birth also affects the risk of death; children born shortly after the previous birth have a higher risk of death than those born after a longer birth interval.

The risk of child death is also affected by the place of residence, with children living in urban areas having a higher risk of death than their counterparts residing in rural areas. India's regions also significantly influence children's survival status. The risk of death across all age groups for a child living in the southern regions of India was significantly lower than for those living in another region in India: children living in central, northern, and eastern regions have a higher risk of death than those from the southern regions. Furthermore, the model also controlled for community-level characteristics, including education and wealth status. The findings show that community-level education significantly impacts mortality across all ages. On average, for each additional year of community education, the risk of under-five deaths reduces by 3% (HR=0.97, (0.963-0.978). The impact of community-level education is strongest in improving the child's survival status during the neonatal period. Community-level wealth status does not, however, have a significant impact on the child health of those living in a similar community. The details of the model are given in Appendix Table 3. The random part indicates a considerable degree of clustering in the study sample. The ICC value shows a significant correlation among the children who died within the community. After controlling for the community-level variables, the ICC value has been reduced; this indicates the significance of using the multilevel model.

Discussion

A substantial proportion of global under-five deaths take place in India, where in contrast to global trends, there has been a persistently higher death rate for girls than for boys (UN IGME, 2023). In this study, we systematically examined the impact of maternal education on protecting girls from all-cause higher mortality risk from live birth to five years of age in India using nationally representative health surveys. Our analysis has led to new insights into the male–female gap in mortality in the context of maternal education in the under-five age group. We found that the relationship between the education and mortality gap was not constant across the ages in the under-five age group.

First, we showed that under-five mortality trends indicate that more girls died than boys between 1992–1993 and 2005–2006. During 2005–2006, the mortality rate for girls was 14% higher than for boys, in contrast to Western European countries characterized by lower gender discrimination, where the mortality rates for males were 21% higher than those for females due to biological factors (UNICEF, 2021). The excessive number of female deaths caused a female deficit in the population of India (Agnihotri, 1995; Sen, 1992, 1990). Sen (1992, 1990) brought the world's attention to the problem of India's "missing women." He estimated there were about 37 million missing women in India in 1991, mainly due to widespread excess female deaths during childhood and the practice of sex-selective abortions. In recent years, the mortality level has improved for female children under the age of five. In the 2019–2021 survey, the U5MR for boys was 8% higher than for girls. Even though the survival status of children in the under-five age group has improved, females still have a lower survival advantage compared to Western European countries where gender-based discrimination is negligible, and U5MR was reported to be 20% higher for boys than girls in 2021 (UNICEF, 2021).

Second, we compared the mortality levels of boys and girls by maternal educational attainment in the under-five age group The results show that girls child born to lower-educated mothers have a significantly higher U5MR than boys, whereas the girls born to higher-educated mothers have lower mortality than boys up until the NHFS 2005–2006 survey. The 1992–1993 survey showed that about 28 more girls (per 1000) died whose mothers had below-primary education than those whose mothers had completed secondary education. This higher rate of deaths for girls among below-primary-educated mothers, implies that about 0.27 million per year more girls than boys died in India in the five years preceding the 1992–1993 survey.

Third, we employed a MECPH model, which confirmed that maternal education attainment significantly reduces the risk of under-five mortality, even after controlling for the other important socioeconomic and other predictors of mortality. A child born to a secondary-educated mother has a 34% lower risk of mortality before their fifth birthday compared with a child born to a mother with below-primary education. Similar findings were observed in other studies, namely that increased maternal education is associated with lower under-five mortality beyond the effect of other economic and other determinants (Andriano and Monden, 2019; Balaj et al., 2021; Caldwell, 1979; Hobcraft, 1993; Lutz and Kebede, 2018; Meitei et al., 2022; Pamuk et al., 2011a; Wu, 2022). Moreover, the association between the mother's education and the child's mortality varies according to the child's age. Mothers' education has a stronger effect on reducing child mortality between 1-11 months and 12-59 months of age. This was supported by findings reported for maternal education at different ages based on low-income and middle-income countries (Balaj et al., 2021).

The interaction analysis by sex and maternal education from the MECPH model also confirms that the survival advantage of girls improves with increasing maternal education. Girls have an 8% lower risk of death than boys if their mother's completed primary education. In addition, among children born to secondary-educated mothers, the risk of death for girls is 18% lower than that for boys and close to what is observed in Western European countries (UNICEF, 2021). This indicates that mothers' education helps to achieve the biological survival advantage for girls in India.

Further, we have disaggregated the differential effect of the mother's education by age. During the neonatal period, boys are expected to have higher mortality than girls. A recent study by Aghai et al. (2020) confirmed this relation also for India. This is because, in the neonatal period, biological rather than socioeconomic factors play a major role in determining the child's survival status (Akinyemi et al., 2015). Excess male mortality is a biological norm (Waldron, 1998) and is present in most developed and underdeveloped countries (Hammoud, 1977; Preston, 2013). It has been shown that male infants die at a higher rate than female infants owing to higher risks of prematurity, intrauterine growth restrictions, and respiratory morbidities, respiratory, and gastrointestinal infections caused by high testosterone (Hammoud, 1977; Preston, 2013). Our analysis shows, however, that the girl's advantage in the neonatal period is higher among secondary-educated mothers.

Furthermore, our findings show that mortality rates increased among girls with rising ages; during the post-neonatal (1-11 months) period, more girls died than boys until 2015–2016. After the post-neonatal period, mortality rates escalated for females at 12-59 months of age, whereas boys' mortality remained almost similar to the post-neonatal mortality. The mortality rate in the 11-59 months of child age is much higher among females and remained higher even in recent surveys. The higher mortality among girls with rising their age is reported in others South Asian countries due to gender-based discriminations (Aghai et al., 2020; Subedi et al., 2022). Nevertheless, it is widely recognized that the mortality rate of males during the neonatal period, post-neonatal, and child (12-59 months of age) is higher than that of females (Melamed et al., 2009; Speakman, 2013; Steen et al., 2014; Stevenson et al., 2000). The risk of death for girls is more than 40% higher than for boys in the 11-59 months of age in India.

A transformation from lower mortality for girls during the neonatal period to higher mortality during the post-neonatal periods and child age-group is considered as discrimination against girls' access to the right to life (Bardhan, 1974; Gupta, 1987; Kishor, 1993; Miller, 1981). Excess female mortality in early childhood results from underinvesting in life-sustaining resources like food and medical care for females at the household level

(Corsi et al., 2009; Moradhvaj and Saikia, 2019; Singh, 2013). With increasing the age of child, when breastfeeding ceases and a child needs extra care from their parents for nutrition and for treatment of frequent infections (Black 1982). Due to the preference for sons over daughters, and the overall lower status of women in society, this has resulted in gender-based discrimination against girls in receiving healthcare (e.g., immunization, medical treatment) and nutrition (e.g., breastfeeding, food) and, in turn, to excess female mortality (Caldwell and McDonald, 1982; Dixit et al., 2020; Gupta, 1987; Miller, 1981; Pande, 2003; Singh, 2013).

Maternal education significantly protects girls from a higher risk of death in post-neonatal (1-11 months) and 12-59 months of age-group. Notably, the impact of a mother's education on reducing the risk of death for girls is stronger in the 12-59 months age group, when girls experienced a higher risk of death. Girls born to primary-educated mothers have a 24% lower risk of death than boys born to similarly educated mothers. Further, girls are even more protected with an almost 40% lower risk of death than boys, when their mothers have completed secondary education. This indicates that girls born to higher-educated mothers are not exposed to gender-based discrimination; therefore, the girls have lower mortality as the biological norm.

The education of mothers appears to be a protective cage for girls, shielding them from the high mortality rates in India. Mothers with higher education tend to have fewer children, enabling them to invest more resources in their children (McCrary and Royer, 2011; Osili and Long, 2008). In addition, education reduces gender-based discrimination, and the preferences for a son over a daughter, leading to equal treatment for boys and girls (Nguyen and Le, 2022). As a result, educated women are less dependent on their sons as a source of social status and old-age security, and this, too, may be a reason to treat daughters and sons equally. More educated women are more likely to be empowered through higher labor-force participation and less likely to be economically dependent, which helps break the persistent gender role assumptions in the household economy (Cameron et al., 2001; Duflo, 2012; Pagés and Stampini, 2009; Zhang et al., 2002).

Another important finding from this study is that in addition to the mother's individual level of education, community-level education also protects against the risk of death in the under-five age-group. The children of women living in a higher-educated community obtain additional survival benefits compared to those whose mothers live in a lower-educated community. Community-level characteristics can add numerous impacts, including an imitative effect where less-educated women would benefit from the generally higher level learning of educated women and live up to the health behavior of the broader community (Kravdal, 2004; Pamuk et al., 2011b). A review of contextual factors on child mortality suggested that community-level characteristics have a positive effect on child health and nutritional status (Boyle et al., 2006; Fotso and Kuate-Defo, 2005; Lutz and Kebede, 2018; Montgomery and Hewett, 2005), as well as on access to healthcare and health infrastructure (Andes, 1989; Matteson et al., 1998; Pickett and Pearl, 2001). As shown in our comprehensive analysis, however, a mother's level of education has the highest impact even when we control for such community-level characteristics.

This study analyzes the 0.66 million births during the five years preceding the NFHS surveys between 1992–1992 and 2019–2021. It thus enhances the understanding of the relationship between under-five mortality and mothers' education specifically by gender. As such, these are key findings on the basis of which policymakers can take the necessary steps to address the gender differences in child mortality in India. The MECPH model provides a robust estimate to analyze the interaction of mother's education and child sex mortality taking into account the censoring and clustering in the hierarchical data. In India, under-five mortality is higher for females particularly in the 1-11 months and 12-59 months age group of the child. Maternal education protects girls from higher mortality risk and leads them to achieve higher survival advantages for their daughters in India. The sex ratio of the mortality among secondary-educated mothers is close to the natural sex ratio in the absence of gender discrimination. Maternal educational attainment has not only improved the survival status of the under-fives but has also saved girls from the higher risk of death due to gender discrimination. To improve the sex ratio and reduce the excess female deaths, India should focus on providing women with at least secondary education, as outlined in Sustainable Development Goals (United Nations, 2016).

This study also has some limitations; the data collected on birth history is based on the retrospective information reported by mothers; the reporting of the information about child death may be sensitive. Women who are low-educated, poorer, and older are more likely to fail to report the date of birth, child's age, or age at death. We have restricted our analysis to births during the five years preceding the surveys to minimize recall biases. The U5M is also affected by other factors, including the proximity to a healthcare facility, transportation, and social environment' however, these variables were not used in the analysis. Another limitation of this study is that birth records only include information about live births. There is evidence of sex-selective abortions in India, which was not considered in the analysis.

Acknowledgments

The authors would like to thank Anne Goujon, Director of the Population and Just Societies Program, for her comments and suggestions for improving this study.

References

Aghai, Z.H., Goudar, S.S., Patel, A., Saleem, S., Dhaded, S.M., Kavi, A., Lalakia, P., Naqvi, F., Hibberd, P.L., McClure, E.M., Nolen, T.L., Iyer, P., Goldenberg, R.L., Derman, R.J., 2020. Gender variations in neonatal and early infant mortality in India and Pakistan: a secondary analysis from the Global Network Maternal Newborn Health Registry. Reprod. Health 17, 178. https://doi.org/10.1186/s12978-020-01028-0

Agnihotri, S.B., 1995. Missing females: a disaggregated analysis. Econ. Polit. Wkly. 2074–2084.

Akinyemi, J.O., Bamgboye, E.A., Ayeni, O., 2015. Trends in neonatal mortality in Nigeria and effects of bio-demographic and maternal characteristics. BMC Pediatr. 15, 1–12.

Alkema, L., Chao, F., You, D., Pedersen, J., Sawyer, C.C., 2014. National, regional, and global sex ratios of infant, child, and under-5 mortality and identification of countries with outlying ratios: a systematic assessment. Lancet Glob. Health 2, e521–e530. https://doi.org/10.1016/S2214-109X(14)70280-3

Alotaibi, R.M., Rezk, H.R., Guure, C., 2020. Bayesian frailty modeling of correlated survival data with application to under-five mortality. BMC Public Health 20, 1–24.

Amin, S., 1990. THE EFFECT OF WOMEN'S STATUS ON SEX DIFFERENTIALS IN INFANT AND CHILD MORTALITY IN SOUTH ASIA. Genus 46, 55–69.

Andes, N., 1989. Socioeconomic, Medical Care, and Public Health Contexts Affecting Infant Mortality: A Study of Community-Level Differentials in Peru. J. Health Soc. Behav. 30, 386–397. https://doi.org/10.2307/2136987

Andriano, L., Monden, C., 2019. The Causal Effect of Maternal Education on Child Mortality: Evidence From a Quasi-Experiment in Malawi and Uganda. Demography 56. https://doi.org/10.1007/s13524-019-00812-3

Arnold, F., Choe, M.K., Roy, T.K., 1998. Son preference, the family-building process and child mortality in India. Popul. Stud. 52, 301–315.

Arnold, F., Kishor, S., Roy, T.K., 2002. Sex-selective abortions in India. Popul. Dev. Rev. 28, 759–785.

Arokiasamy, P., 2007. Sex Ratio at Birth and Excess Female Child Mortality in India:Trends, Differentials and Regional Patterns, in: Watering the Neighbours' Garden: The Growing Demographic Deficit in Asia. pp. 49–72.

Arokiasamy, P., Goli, S., 2012. Explaining the skewed child sex ratio in rural India: Revisiting the landholding-patriarchy hypothesis. Econ. Polit. Wkly. 85–94.

Austin, P.C., 2017. A Tutorial on Multilevel Survival Analysis: Methods, Models and Applications. Int. Stat. Rev. 85, 185–203. https://doi.org/10.1111/insr.12214

Badaoui, E.E., Rebière, T., 2013. Éducation, informalité et efficience: un modèle d'appariement pour une économie en développement. Rev. Déconomie Polit. 423–441.

Balaj, M., York, H.W., Sripada, K., Besnier, E., Vonen, H.D., Aravkin, A., Friedman, J., Griswold, M., Jensen, M.R., Mohammad, T., Mullany, E.C., Solhaug, S., Sorensen, R., Stonkute, D., Tallaksen, A., Whisnant, J., Zheng, P., Gakidou, E., Eikemo, T.A., 2021. Parental education and inequalities in child mortality: a global systematic review and meta-analysis. The Lancet 398, 608–620. https://doi.org/10.1016/S0140-6736(21)00534-1

Baqui, A.H., Darmstadt, G.L., Williams, E., Kumar, V., Kiran, T., Panwar, D., Srivastava, V., Ahuja, R., Black, R., Santosham, M., 2006. Rates, timing and causes of neonatal deaths in rural India: implications for neonatal health programmes. Bull. World Health Organ. 84, 706–713.

Bardhan, P.K., 1974. On life and death questions. Econ. Polit. Wkly. 1293–1304.

Bhat, P.M., Zavier, A.F., 2007. Factors influencing the use of prenatal diagnostic techniques and the sex ratio at birth in India. Econ. Polit. Wkly. 2292–2303.

Bhuiya, A., Streatfield, K., 1991. Mothers' Education and Survival of Female Children in a Rural Area of Bangladesh. Popul. Stud. 45, 253–264.

Bourne, K.L., Walker, G.M., 1991. The Differential Effect of Mothers' Education on Mortality of Boys and Girls in India. Popul. Stud. 45, 203–219.

Boyle, M.H., Racine, Y., Georgiades, K., Snelling, D., Hong, S., Omariba, W., Hurley, P., Rao-Melacini, P., 2006. The influence of economic development level, household wealth and maternal education on child health in the developing world. Soc. Sci. Med. 63, 2242–2254.

Caldwell, J., McDonald, P., 1982. Influence of maternal education on infant and child mortality: Levels and causes. Health Policy Educ. 2, 251–267. https://doi.org/10.1016/0165-2281(82)90012-1

Caldwell, J.C., 1979. Education as a Factor in Mortality Decline An Examination of Nigerian Data. Popul. Stud. 33, 395–413. https://doi.org/10.2307/2173888
Caldwell, J.C., Reddy, P.H., Caldwell, P., 1989. The Causes of Demographic Change: Experimental Research in South India. University of Wisconsin Press, Madison, Wis.
Cameron, L.A., Malcolm Dowling, J., Worswick, C., 2001. Education and labor market participation of women in Asia: Evidence from five countries. Econ. Dev. Cult. Change 49, 459–477.
Chen, L.C., Huq, E., D'Souza, S., 1981. Sex Bias in the Family Allocation of Food and Health Care in Rural Bangladesh. Popul. Dev. Rev. 7, 55–70. https://doi.org/10.2307/1972764
Choudhury, P.K., 2015. Explaining the Role of Parental Education in the Regional Variations in Infant Mortality in India. Asia Pac. Policy Stud. 2, 544–572. https://doi.org/10.1002/app5.97
Chowdhury, A.R., 2010. Money and marriage: The practice of dowry and brideprice in rural India. Brown Univ. URL Httppaa2010 Princet. Edupapers100225.
Coale, A.J., Banister, J., 1994. Five decades of missing females in China. Demography 31, 459–479.
Corsi, D.J., Bassani, D.G., Kumar, R., Awasthi, S., Jotkar, R., Kaur, N., Jha, P., 2009. Gender inequity and age-appropriate immunization coverage in India from 1992 to 2006. BMC Int. Health Hum. Rights 9, 1–12.
Croll, E., 2000. Endangered Daughters: Discrimination and Development in Asia. Psychology Press.
Das Gupta, M., Mari Bhat, P., 1997. Fertility decline and increased manifestation of sex bias in India. Popul. Stud. 51, 307–315.
Desai, S., Alva, S., 1998. Maternal education and child health: is there a strong causal relationship? Demography 35, 71–81.
Diamond-Smith, N., Saikia, N., Bishai, D., Canudas-Romo, V., 2020. What has contributed to improvements in the child sex ratio in select districts of India? A decomposition of the sex ratio at birth and child mortality. J. Biosoc. Sci. 52, 27–36. https://doi.org/10.1017/S0021932019000221
Dixit, P., Cleland, J., James, K., 2020. Sex differences in child health and healthcare: a reappraisal for India. Popul. Stud. 74, 379–398.
Drevenstedt, G.L., Crimmins, E.M., Vasunilashorn, S., Finch, C.E., 2008. The rise and fall of excess male infant mortality. Proc. Natl. Acad. Sci. 105, 5016–5021. https://doi.org/10.1073/pnas.0800221105
D'Souza, S., Chen, L.C., 1980. Sex differentials in mortality in rural Bangladesh. Popul. Dev. Rev. 257–270.
Duflo, E., 2012. Women empowerment and economic development. J. Econ. Lit. 50, 1051–1079.
Elsmén, E., Pupp, I.H., Hellström-Westas, L., 2004. Preterm male infants need more initial respiratory and circulatory support than female infants. Acta Paediatr. 93, 529–533.
Fotso, J.-C., Kuate-Defo, B., 2005. Socioeconomic inequalities in early childhood malnutrition and morbidity: modification of the household-level effects by the community SES. Health Place 11, 205–225.
Gakidou, E., Cowling, K., Lozano, R., Murray, C.J., 2010. Increased educational attainment and its effect on child mortality in 175 countries between 1970 and 2009: a systematic analysis. The Lancet 376, 959–974. https://doi.org/10.1016/S0140-6736(10)61257-3
Grépin, K.A., Bharadwaj, P., 2015. Maternal education and child mortality in Zimbabwe. J. Health Econ. 44, 97–117. https://doi.org/10.1016/j.jhealeco.2015.08.003
Guilmoto, C.Z., Saikia, N., Tamrakar, V., Bora, J.K., 2018. Excess under-5 female mortality across India: a spatial analysis using 2011 census data. Lancet Glob. Health 6, e650–e658. https://doi.org/10.1016/S2214-109X(18)30184-0
Gupta, M.D., 1997. Socio-Economic Status and Clustering of Child Deaths in Rural Punjab. Popul. Stud. 51, 191–202.
Gupta, M.D., 1987. Selective Discrimination against Female Children in Rural Punjab, India. Popul. Dev. Rev. 13, 77–100. https://doi.org/10.2307/1972121
Hammoud, E.I., 1977. Sex differentials in mortality. An enquiry with reference to the Arab countries and others. World Health Stat. Rep. Rapp. Stat. Sanit. Mond. 30, 174–206.
Hatt, L.E., Waters, H.R., 2006. Determinants of child morbidity in Latin America: a pooled analysis of interactions between parental education and economic status. Soc. Sci. Med. 1982 62, 375–386. https://doi.org/10.1016/j.socscimed.2005.06.007
Hobcraft, J., 1993. Women's education, child welfare and child survival: a review of the evidence. Health Transit. Rev. 3, 159–175.
Hosseinpoor, A., Doorslaer, E., Speybroeck, N., Naghavi, M., Mohammad, K., Majdzadeh, R., Delavar, B., Jamshidi, H., Vega, J., 2006. Decomposing socioeconomic inequality in infant mortality in Iran. Int. J. Epidemiol. 35, 1211–9. https://doi.org/10.1093/ije/dyl164

IIPS, 1995. National Family Health Survey (MCH and Family Planning, India 1992-93. International Institute for Population Sciences, Bombay.
IIPS and ICF, 2021. National Family Health Survey (NFHS-5), 2019-21. International Institute for Population Sciences, Mumbai.
IIPS and ICF, 2017. National Family Health Survey (NFHS-4), 2015-16: India. International Institute for Population Sciences, Mumbai.
IIPS and Macro International, 2007. National Family Health Survey (NFHS-3), India, 2005-06. International Institute for Population Sciences, Mumbai.
IIPS and ORC Macro, 2000. National Family Health Survey (NFHS-II), 1998-99: India. International Institute for Population Sciences Mumbai, Mumbai.
Jejeebhoy, S., 1992. High fertility, outcomes for children and gender disparities: the case of rural Maharashtra State. Presented at the Proceedings of the Seminar on Micrl-Level Consequences of High Fertility.
Karam, A., 2014. Education as the pathway towards gender equality. UN Chron. 50, 31–36.
Kashyap, R., 2019. Is prenatal sex selection associated with lower female child mortality? Popul. Stud. 73, 57–78.
Kashyap, R., Behrman, J., 2020. Gender Discrimination and Excess Female Under-5 Mortality in India: A New Perspective Using Mixed-Sex Twins. Demography 57, 2143–2167. https://doi.org/10.1007/s13524-020-00909-0
Keats, A., 2018. Women's schooling, fertility, and child health outcomes: Evidence from Uganda's free primary education program. J. Dev. Econ. 135, 142–159. https://doi.org/10.1016/j.jdeveco.2018.07.002
Khoury, M.J., Marks, J.S., McCarthy, B.J., Zaro, S.M., 1985. Factors affecting the sex differential in neonatal mortality: the role of respiratory distress syndrome. Am. J. Obstet. Gynecol. 151, 777–782.
Kishor, S., 1993. "May God Give Sons to All": Gender and Child Mortality in India. Am. Sociol. Rev. 58, 247–265. https://doi.org/10.2307/2095969
Klein, S.L., 2000. Hormones and mating system affect sex and species differences in immune function among vertebrates. Behav. Processes 51, 149–166.
Kravdal, Ø., 2004. Child mortality in India: The community-level effect of education. Popul. Stud. 58, 177–192. https://doi.org/10.1080/0032472042000213721
Kumari, A., Goli, S., 2022. Skewed child sex ratios in India: a revisit to geographical patterns and socio-economic correlates. J. Popul. Res. 39, 45–72.
Lutz, W., Kebede, E., 2018. Education and Health: Redrawing the Preston Curve. Popul. Dev. Rev. 44, 343–361. https://doi.org/10.1111/padr.12141
Matteson, D.W., Burr, J.A., Marshall, J.R., 1998. Infant mortality: A multi-level analysis of individual and community risk factors. Soc. Sci. Med. 47, 1841–1854. https://doi.org/10.1016/S0277-9536(98)00229-9
McCrary, J., Royer, H., 2011. The Effect of Female Education on Fertility and Infant Health: Evidence from School Entry Policies Using Exact Date of Birth. Am. Econ. Rev. 101, 158–95. https://doi.org/10.1257/aer.101.1.158
Meitei, W.B., Singh, A., Ladusingh, L., 2022. The effects of community clustering on under-five mortality in India: a parametric shared frailty modelling approach. Genus 78, 18. https://doi.org/10.1186/s41118-022-00165-7
Melamed, N., Yogev, Y., Glezerman, M., 2009. Effect of fetal sex on pregnancy outcome in twin pregnancies. Obstet. Gynecol. 114, 1085–1092.
Miller, D.A., 1981. The "sandwich" generation: adult children of the aging. Soc. Work 26, 419–423.
Monden, C.W., Smits, J., 2013. Maternal education is associated with reduced female disadvantages in under-five mortality in sub-Saharan Africa and southern Asia. Int. J. Epidemiol. 42, 211–218. https://doi.org/10.1093/ije/dys201
Montgomery, M.R., Hewett, P.C., 2005. Urban poverty and health in developing countries: Household and neighborhood Effects. Demography 42, 397–425. https://doi.org/10.1353/dem.2005.0020
Moradhvaj, Saikia, N., 2019. Gender disparities in health-care expenditure (HCE) and financing strategies for in-patient care in India. SSM - Popul. Health 100372. https://doi.org/10.1016/j.ssmph.2019.100372
Moradhvaj, Samir, K., 2023. Differential impact of maternal education on under-five mortality in rural and urban India. Health Place 80, 102987.
Mosley, W.H., Chen, L.C., 1984. An Analytical Framework for the Study of Child Survival in Developing Countries. Popul. Dev. Rev. 10, 25–45. https://doi.org/10.2307/2807954
Muhuri, P.K., Preston, S.H., 1991. Effects of Family Composition on Mortality Differentials by Sex Among Children in Matlab, Bangladesh. Popul. Dev. Rev. 17, 415–434. https://doi.org/10.2307/1971948

Nguyen, M., Le, K., 2022. Maternal education and son preference. Int. J. Educ. Dev. 89, 102552.
ORGI, 2011. Data 2011 Census of India. Office of the Registrar General of India and Census Commissioner India.
Osili, U.O., Long, B.T., 2008. Does female schooling reduce fertility? Evidence from Nigeria. J. Dev. Econ. 87, 57–75.
Pagés, C., Stampini, M., 2009. No education, no good jobs? Evidence on the relationship between education and labor market segmentation. J. Comp. Econ. 37, 387–401.
Pamuk, E.R., Fuchs, R., Lutz, W., 2011a. Comparing relative effects of education and economic resources on infant mortality in developing countries. Popul. Dev. Rev. 37, 637–664. https://doi.org/10.1111/j.1728-4457.2011.00451.x
Pamuk, E.R., Fuchs, R., Lutz, W., 2011b. Comparing relative effects of education and economic resources on infant mortality in developing countries. Popul. Dev. Rev. 37, 637–664. https://doi.org/10.1111/j.1728-4457.2011.00451.x
Pande, R.P., 2003. Selective gender differences in childhood nutrition and immunization in rural India: the role of siblings. Demography 40, 395–418.
Parsons, J., Edmeades, J., Kes, A., Petroni, S., Sexton, M., Wodon, Q., 2015. Economic Impacts of Child Marriage: A Review of the Literature. Rev. Faith Int. Aff. 13, 12–22. https://doi.org/10.1080/15570274.2015.1075757
Peppen, R., 2016. Gender equality and education in the Sustainable Development Goals.
Pickett, K.E., Pearl, M., 2001. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. J. Epidemiol. Community Health 55, 111–122. https://doi.org/10.1136/jech.55.2.111
Premi, M.K., 2001. The missing girl child. Econ. Polit. Wkly. 1875–1880.
Preston, S.H., 2013. Mortality patterns in national populations: with special reference to recorded causes of death. Elsevier.
Rashmi, R., Malik, B.K., Mohanty, S.K., Mishra, U.S., Subramanian, S., 2022. Predictors of the gender gap in household educational spending among school and college-going children in India. Humanit. Soc. Sci. Commun. 9, 1–11.
Rosenzweig, M.R., Schultz, T.P., 1989. Schooling, Information and Nonmarket Productivity: Contraceptive Use and Its Effectiveness. Int. Econ. Rev. 30, 457–477. https://doi.org/10.2307/2526657
Saikia, N., Moradhvaj, Bora, J.K., 2016. Gender difference in health-care expenditure: evidence from India human development survey. PloS One 11, e0158332.
Saikia, N., Singh, A., Jasilionis, D., Ram, F., 2013. Explaining the rural-urban gap in infant mortality in India. Demogr. Res. 29, 473–506. https://doi.org/10.4054/DemRes.2013.29.18
Sen, A., 1992. Missing women. BMJ 304, 587.
Sen, A., 1990. More Than 100 Million Women Are Missing.
Sen, A., Sengupta, S., 1983. Malnutrition of Rural Children and the Sex Bias. Econ. Polit. Wkly. 18, 855–864.
Singh, P.K., 2013. Trends in child immunization across geographical regions in India: focus on urban-rural and gender differentials. PloS One 8, e73102.
Speakman, J.R., 2013. Sex-and age-related mortality profiles during famine: testing the 'body fat'hypothesis. J. Biosoc. Sci. 45, 823–840.
Steen, E.E., Källén, K., Maršál, K., Norman, M., Hellström-Westas, L., 2014. Impact of sex on perinatal mortality and morbidity in twins. J. Perinat. Med. 42, 225–231.
Stevenson, D.K., Verter, J., Fanaroff, A.A., Oh, W., Ehrenkranz, R.A., Shankaran, S., Donovan, E.F., Wright, L.L., Lemons, J.A., Tyson, J.E., 2000. Sex differences in outcomes of very low birthweight infants: the newborn male disadvantage. Arch. Dis. Child.-Fetal Neonatal Ed. 83, F182–F185.
Subedi, S., Katz, J., Erchick, D.J., Verhulst, A., Khatry, S.K., Mullany, L.C., Tielsch, J.M., LeClerq, S.C., Christian, P., West, K.P., 2022. Does higher early neonatal mortality in boys reverse over the neonatal period? A pooled analysis from three trials of Nepal. BMJ Open 12, e056112.
Sudha, S., Rajan, S.I., 1999. Female demographic disadvantage in India 1981–1991: Sex selective abortions and female infanticide. Dev. Change 30, 585–618.
Thomas, K., 1990. Gender and Subject in Higher Education. Taylor and Francis Publishers, 1900 Frost Road, Suite 101, Bristol, PA 19007-1598; phone: 800-821-8312; fax: 215-785-5515 ($29.
UN IGME, 2023. Levels & Trends in Child Mortality: Report 2022. Estimates developed by the United Nations Inter-agency Group for Child Mortality Estimation, United Nations Children's Fund., New York, 2023.
UNICEF, W., World Bank Group and United Nations, 2021. Levels and trends in child mortality 2020: estimates developed by the UN Inter-agency group for child mortality estimation.

United Nations, 2016. Sustainable development goals (SDGs). U. N. Sustain. Dev. URL http://www.un.org/sustainabledevelopment/sustainable-development-goals/ (accessed 7.12.16).
United Nations, 2015. The Millennium Development Goals Report 2015. United Nations, New York, USA.
United Nations, 2011. Sex Differentials in Childhood Mortality (No. (United Nations publication, ST/ESA/SER.A/314)). United Nations, Department of Economic and Social Affairs, Population Division.
Visaria, P., 1971. The Sex Ratio of the Population of India, Census of India 1961, Monograph No. 10. New Delhi Off. Regist. Gen. India.
Vlassoff, M., Vlassoff, C., 1980. Old age security and the utility of children in rural India. Popul. Stud. 34, 487–499.
Waldron, I., 1998. Sex differences in infant and early childhood mortality: major causes of death and possible biological causes. na.
Wang, H., Frasco, E., Takesue, R., Tang, K., 2021. Maternal education level and maternal healthcare utilization in the Democratic Republic of the Congo: an analysis of the multiple indicator cluster survey 2017/18. BMC Health Serv. Res. 21, 850. https://doi.org/10.1186/s12913-021-06854-x
World Economic Forum, 2022. Global Gender Gap Report 2022. The World Economic Forum's Centre for the New Economy and Society, Geneva Switzerland.
Wu, H., 2022. The Effect of Maternal Education on Child Mortality in Bangladesh. Popul. Dev. Rev. 48, 475–503. https://doi.org/10.1111/padr.12467
Yadav, A.K., Sahni, B., Kumar, D., Bala, K., Kalotra, A., 2021. Effect of women's and partners' education on maternal health-care services utilization in five empowered action group States of India: An analysis of 13,443 women of reproductive age. Int. J. Appl. Basic Med. Res. 11, 231.
Yorita, K.L., Holman, R.C., Sejvar, J.J., Steiner, C.A., Schonberger, L.B., 2008. Infectious disease hospitalizations among infants in the United States. Pediatrics 121, 244–252.
Zhang, L., Huang, J., Rozelle, S., 2002. Employment, emerging labor markets, and the role of education in rural China. China Econ. Rev. 13, 313–328.

Table 1 Hazard ratio from multilevel Cox-proportional hazard model to the compared risk of deaths for male-female by maternal education, India

Predictors	Categories	U5MR (0-59 months) (HR [CI 95])	NNMR (0 months) (HR [CI 95])	PNNM (1-11 months) (HR [CI 95])	CMR (12-59 months) (HR [CI 95])
Gender	Female (Male®)	0.961***(0.934-0.989)	1.423***(1.32-1.533)	1.084***(1.028-1.143)	0.823***(0.793-0.855)
Mothers' education	Completed primary (Below-primary®)	0.67***6(0.654-0.698)	0.457***(0.409-0.511)	0.604***(0.565-0.645)	0.729***(0.7-0.76)
	Completed Secondary	0.433***(0.409-0.459)	0.241***(0.193-0.301)	0.341***(0.302-0.385)	0.494***(0.461-0.528)
Interaction education and sex	Primary female (Primary male®)	0.923***(0.88-0.968)	0.762***(0.654-0.887)	0.934(0.852-1.024)	1.001(0.943-1.063)
	Secondary female (Secondary male)	0.829***(0.76-0.903)	0.601***(0.43-0.839)	0.87(0.728-1.039)	0.911*(0.821-1.011)
Survey years	1998-99 (1992-93®)	1.006(0.956-1.059)	1.102*(0.989-1.228)	0.962(0.883-1.048)	0.997(0.933-1.067)
	2005-06	0.786***(0.747-0.827)	0.66***(0.581-0.75)	0.707***(0.645-0.774)	0.845***(0.791-0.903)
	2015-16	0.678***(0.651-0.706)	0.465***(0.423-0.512)	0.569***(0.53-0.611)	0.772***(0.732-0.813)
	2019-21	0.557***(0.534-0.581)	0.346***(0.312-0.385)	0.482***(0.448-0.519)	0.634***(0.6-0.669)
Constant	cons	0.024***(0.023-0.025)	0(0-0)	0.005***(0.005-0.005)	0.016***(0.016-0.017)
Random part	Cluster(variance)	0.272(0.25-0.295)	0.388(0.299-0.504)	0.448(0.389-0.515)	0.393(0.36-0.429)
	ICC	0.137***(0.127-0.147)	0.409***(0.345-0.472)	0.247***(0.221-0.273)	0.157***(0.145-0.169)

Data sources: Authors calculated pooled data from NFHS-I-V (1992-92 to 2019-21); note: 95% Confidence interval in parentheses; ***significant at 1%, **significant at 5%, *significant at 10%; HR = Hazard ratio

Table 2 Hazard ratio from multilevel Cox-proportional hazard model to the compared male–female risk of death by maternal education after controlling for other predictors, India

Predictors	Categories	U5MR (0-59 months) (HR [CI 95])	NNMR (0 months) (HR [CI 95])	PNNM (1-11 months) (HR [CI 95])	CMR (12-59 months) (HR [CI 95])
Gender	Female (Male®)	0.959***(0.932-0.987)	0.822***(0.792-0.854)	1.085***(1.028-1.144)	1.423***(1.321-1.534)
Mothers education	Completed primary (Below- primary®)	0.83***(0.8-0.86)	0.856***(0.819-0.895)	0.767***(0.714-0.824)	0.745***(0.661-0.841)
	Completed Secondary	0.661***(0.621-0.705)	0.687***(0.637-0.742)	0.562***(0.492-0.643)	0.633***(0.498-0.806)
Interaction education and sex	Primary female (Primary male®)	0.92***(0.877-0.964)	0.996(0.938-1.058)	0.93(0.848-1.019)	0.759***(0.652-0.884)
	Secondary female (Secondary male)	0.822***(0.754-0.895)	0.898**(0.81-0.997)	0.865(0.724-1.033)	0.601***(0.431-0.84)
Wealth index	Poor (Poorest®)	0.956***(0.927-0.986)	0.994(0.955-1.035)	0.94**(0.886-0.998)	0.81***(0.744-0.882)
	Middle	0.853***(0.822-0.886)	0.893***(0.851-0.938)	0.843***(0.784-0.907)	0.669***(0.601-0.746)
	Rich	0.746***(0.712-0.782)	0.805***(0.758-0.855)	0.718***(0.656-0.786)	0.503***(0.436-0.58)
	Richest	0.588***(0.552-0.626)	0.649***(0.599-0.703)	0.546***(0.483-0.617)	0.367***(0.299-0.45)
Caste	Non-SCs/STs (SCs/STs®)	1.065***(1.038-1.093)	1.039**(1.005-1.074)	1.084***(1.032-1.139)	1.192***(1.108-1.282)
	Missing	0.98(0.915-1.05)	0.964(0.884-1.051)	1.048(0.921-1.193)	0.932(0.751-1.157)
Religion	Muslim (Hindu®)	0.916***(0.884-0.95)	0.922***(0.881-0.965)	0.896***(0.837-0.96)	0.937(0.847-1.037)
	Others	0.867***(0.825-0.91)	0.747***(0.699-0.798)	1.058(0.97-1.154)	1.035(0.905-1.182)
Mothers age at birth	20-34 (Below 20®)	0.833***(0.808-0.858)	0.831***(0.801-0.863)	0.799***(0.753-0.848)	0.906**(0.826-0.992)
	35+	1.073**(1.01-1.14)	1.079*(0.996-1.168)	1.02(0.911-1.142)	1.186**(1.007-1.396)
Birth order	2-4 (First birth®)	6.025***(5.42-6.698)	6.903***(6.131-7.772)	4.967***(3.87-6.375)	1.139(0.426-3.045)
	5 and above	7.652***(6.843-8.556)	8.645***(7.607-9.826)	6.608***(5.106-8.553)	1.363(0.508-3.66)
Birth interval	Shor (<24) (First birth®)	0.206***(0.185-0.229)	0.154***(0.137-0.174)	0.319***(0.248-0.41)	1.617(0.605-4.325)
	Medium (24-48)	0.112***(0.101-0.125)	0.08***(0.071-0.091)	0.175***(0.136-0.225)	0.967(0.362-2.586)
	Large (49>)	0.112***(0.1-0.125)	0.089***(0.078-0.1)	0.157***(0.121-0.203)	0.844(0.314-2.264)
Community level predictors	Mean community education	0.97***(0.963-0.978)	0.975***(0.965-0.984)	0.967***(0.953-0.981)	0.943***(0.921-0.966)

	Mean community wealth score	0.992(0.968-1.017)	0.97*(0.94-1.001)	1.051**(1.004-1.101)	0.941*(0.879-1.007)
Place of residence	Urban (Rural®)	1.068***(1.027-1.111)	1.038(0.987-1.091)	1.097**(1.02-1.181)	1.239***(1.107-1.387)
Region	North (South)	1.277***(1.213-1.343)	1.267***(1.188-1.351)	1.3***(1.182-1.431)	1.379***(1.187-1.601)
	Central	1.673***(1.596-1.754)	1.708***(1.609-1.813)	1.64***(1.499-1.794)	1.672***(1.455-1.922)
	East	1.264***(1.201-1.331)	1.358***(1.274-1.448)	1.162***(1.053-1.281)	1.039(0.893-1.209)
	West	1.056*(0.993-1.123)	1.102**(1.02-1.189)	0.915(0.811-1.031)	1.194**(1-1.425)
	Northeast	1.148***(1.082-1.218)	1.034(0.958-1.116)	1.329***(1.192-1.482)	1.301***(1.099-1.54)
Survey years	1998-99 (1992-93®)	0.949**(0.903-0.997)	0.954(0.892-1.019)	0.903**(0.829-0.984)	0.993(0.892-1.105)
	2005-06	0.758***(0.72-0.798)	0.832***(0.778-0.89)	0.672***(0.612-0.738)	0.595***(0.523-0.678)
	2015-16	0.605***(0.579-0.633)	0.684***(0.646-0.725)	0.529***(0.489-0.572)	0.381***(0.342-0.426)
	2019-21	0.52***(0.496-0.546)	0.584***(0.548-0.621)	0.473***(0.433-0.515)	0.302***(0.266-0.342)
Constant	cons	0.027***(0.025-0.03)	0.022***(0.02-0.025)	0.004***(0.003-0.005)	0.000***(0-0)
	/ln_p	-1.181***(-1.192-1.17)	-1.391***(-1.405-1.377)	-0.957***(-0.978-0.936)	-0.07***(-0.101-0.038)
Random part	Cluster(variance)	0.199***(0.18-0.221)	0.32(0.288-0.355)	0.385***(0.329-0.452)	0.238(0.16-0.355)
ICC	ICC	0.105***(0.095-0.114)	0.132***(0.12-0.144)	0.22***(0.193-0.248)	0.298***(0.214-0.382)

Data sources: Authors calculated pooled data from NFHS-I-V (1992-92 to 2019-21), Note: 95% Confidence interval in parentheses; ***significant at 1%, **significant at 5%, *significant at 10%; HR = Hazard ratio

Appendix

Table A1: Total number of births in the preceding five years of the survey and children's survival status at different ages under five years by socioeconomic characteristics.

Predictors	Categories	Survive		Died			Number
			0-59 months	0 month	1-11 months	12-59 months	Births
Sex	Male	94.88	5.12	3.63	0.98	0.51	342,233
	Female	95.23	4.77	3.05	1.05	0.67	317,341
Mothers education	Below-primary	93.2	6.8	4.32	1.48	1	283,241
	Completed primary	96.06	3.94	2.88	0.75	0.31	278,230
	Completed Secondary	97.54	2.45	1.88	0.42	0.15	97,885
Interaction education and sex	Below-primary: male	93.09	6.92	4.67	1.42	0.83	145,672
	Below-primary: female	93.33	6.67	3.95	1.54	1.18	137,569
	Completed primary-male	95.84	4.16	3.14	0.72	0.3	144,896
	Completed primary-female	96.29	3.71	2.61	0.77	0.33	133,334
	Secondary: male	97.28	2.72	2.12	0.44	0.16	51,562
	Secondary: female	97.83	2.17	1.62	0.41	0.14	46,323
Wealth index	Poorest	93.44	6.56	4.29	1.31	0.96	163,405
	Poor	94.3	5.71	3.85	1.18	0.68	147,571
	Middle	95.24	4.76	3.23	1.01	0.52	131,224
	Rich	96.08	3.92	2.76	0.81	0.35	119,252
	Richest	97.35	2.65	1.94	0.52	0.19	98,122
Caste	SCs/STs	95.19	4.81	3.33	0.96	0.52	385,321
	Non-SCs/STs	94.7	5.3	3.47	1.12	0.71	247,732
Religion	Hindu	94.81	5.19	3.57	1.02	0.6	480,860
	Muslim	95.25	4.75	3.23	0.97	0.55	99,346
	Others	96.26	3.73	2.19	1.01	0.53	79,368
Mothers age at birth	Below 20	93.36	6.64	4.7	1.27	0.67	114,483
	20-34	95.51	4.49	3.02	0.93	0.54	517,992
	35+	93.29	6.71	4.13	1.56	1.02	27,099
Child birth order	First birth	95.23	4.76	3.59	0.81	0.36	234,088
	2-4	95.46	4.54	2.95	0.99	0.6	361,811
	5 and above	92.02	7.98	4.76	1.92	1.3	63,675
Birth interval	First birth	95.11	4.89	3.71	0.82	0.36	235,926
	Shor (<24)	92.45	7.55	4.8	1.71	1.04	113,900
	Medium (24-48)	95.8	4.21	2.59	0.97	0.65	217,001
	Large (49>)	96.32	3.67	2.46	0.77	0.44	92,747
Place of residence	Rural	94.69	5.31	3.58	1.08	0.65	501,039
	Urban	96.18	3.83	2.64	0.8	0.39	158,535
Region	South	96.64	3.35	2.33	0.69	0.33	78,895
	North	95.58	4.43	2.91	1	0.52	127,700
	Central	93.36	6.65	4.53	1.3	0.82	174,399
	East	94.64	5.36	3.81	0.99	0.56	126,875
	West	96.3	3.69	2.58	0.67	0.44	56,254
	Northeast	95.92	4.07	2.48	1.02	0.57	95,451
Survey years	1992-93 (89,777 [13-49 age])[a]	91.82	8.18	4.84	2.03	1.31	60,625
	1998-99 (89,199 [15-49 age])[a]	92.5	7.5	4.48	1.72	1.3	56,734
	2005-06 (124385 [15-49 age])[a]	94.42	5.57	3.74	1.12	0.71	51,555
	2015-16 (699686[15-49 age])[a]	95.42	4.58	3.27	0.85	0.46	259,627

	2019-21 (724115 [15-49 age])[ɑ]	96.25	3.75	2.69	0.73	0.33	231,033
	Total	95.05	4.94	3.35	1.01	0.58	659,574

Note: ɑ represents the number of ever-married women interviewed in the survey

Figure A.1 shows the trends in the U5MR (Figure A.1a), NNMR (Figure A.1b), PPNMR (Figure A.1c), and CMR (Figure A.1d) for male and female children during 1992–1993 to 2019–2021 period. Figure A.1a depicts that between 1992 and 1993 and 2005 and 2006, the U5MR measured higher for females than for males. This is followed by a faster decline in U5MR for girls than boys, leading to a lower female mortality level in recent surveys (2015–2016 and 2019–2021). The U5MR, which was measured at 107 (CI: 102-111) for boys (per 1000 live births) and 112 (CI: 108-117) for girls (per 1000 live births) during 1992–1993, decreased to 43 (CI: 42-45) and 40 (CI: 38–42) in 2020–2021 for boys and girls, respectively. The trends in the neonatal mortality rate (Figure A.1b) show that the probability of death for males measured higher than for females across all surveys. It is noteworthy that during the post-neonatal period (Figure A.1c), even though the mortality rates decreased for both girls and boys, the female mortality rates remained consistently higher than male mortality rates between 1992–1993 and 2015–2016. However, the most recent 2019–2021 survey indicated a smaller sex difference with a slightly lower mortality rate for girls (with substantially overlapping confidence intervals). The mortality rate for girls in the child age group (Figure A.1d) has consistently been higher across surveys, with recent trends showing improvements in female mortality rates. While 40% more girls died than boys between the ages of 12-59 months in 1992–1993, this difference decreased to 7% in 2019–2021.

Figure A.1: Trends of U5MR, NNMR, PNNMR, and CMR by sex between 1992-93 and 2019-21, India