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Differential impact of maternal education on under-five mortality in rural and urban India

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ABSTRACT

Under-five mortality rate (U5MR) differs by rural-urban place of residence and mother's education; however, the rural-urban gap in U5MR by mother's educational attainment is unclear in the existing literature. Using five rounds of the national family health surveys (NFHS I–V) conducted between 1992–93 and 2019–21 in India, this study estimated the main and interaction effects of rural-urban and maternal education on U5MR. The mixed effect Cox proportional hazard (MECPH) model was used to predict the risk of under-five mortality (U5M). The finding shows that unadjusted U5MR remained 50 per cent higher in rural areas than in urban areas across the surveys. Whereas, after controlling for demographic, socioeconomic, and maternal health care predictors of U5M, the MECPH regression results indicated that urban children had a higher risk of death than their rural counterparts in NFHS I-III. However, there are no significant rural-urban differences in the last two surveys (NFHS IV -V). In addition, increasing maternal education levels were associated with lower U5M in all surveys. Though, in recent years, primary education has had no significant effect. The U5M risk was additionally lower for urban children than rural children whose mothers had secondary and higher education by NFHS-III; however, this additional urban advantage was no longer significant in recent surveys. The higher impact of secondary education on U5MR in urban areas in the past may be attributed to poor socio-economic, healthcare conditions in rural areas. Overall, maternal education, particularly secondary education, remained a protective factor for U5M in both rural and urban areas, even after controlling for predictors. Therefore, there is a need to increase the focus on secondary education for girls for a further decline in U5M.

1. Introduction

Reducing the under-five mortality rate (U5MR) is one of the global health targets. Under the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs), ending preventable deaths among the under-five children occupies a central goal (García-Moreno and Amin, 2016). Despite the significant reduction of global under-five deaths from 12.5 million in 1990 to 5 million in 2020, it is still a grave concern in many developing countries. India has achieved an impressive decline in under-five deaths from 3.4 million to 824,000 annually between 1990 and 2020, corresponding to the U5MR of 126 (deaths per 1000 live births) to 33, respectively. However, with Nigeria, India accounted for almost a third of under-five deaths globally in 2019 (UNICEF, 2021). The rapid decline in U5MR is mainly due to improvements in the mother's education, accompanying a rise in the standard of living and access to healthcare. However, how mothers' education affects U5MR in rural and urban areas remains unexplored in the existing literature. In this study, we examine the association between maternal education and U5MR within the rural and urban contexts of India, as well as how it has changed over the past three decades.

The U5MR varies between rural and urban areas (Dettrick et al., 2014; Kumar et al., 2021; Van Malderen et al., 2019), generally with a rural disadvantage (Bocquier et al., 2011; Cai and Chongsuvivatwong, 2006; Gould, 1998; Heaton and Forste, 2003; Knöbel et al., 1994; van de Poel et al., 2009). A study based on 35 African countries using the Demographic and Health Survey (DHS) shows, with some exceptions, that

Abbreviations: U5MR, Under-five mortality rate; NFHS, National Family Health Survey; SDGs, Sustainable Development Goals; U5M, Under-five mortality.

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most countries have higher U5MR in rural areas (Yaya et al., 2019). The rural-urban differences in infant mortality in Central and Western sub-Saharan African countries were explained by differences in factors at the household and community level (van de Poel et al., 2009; Yaya et al., 2019). Studies have highlighted the role of geographical space within a population, particularly the rural-urban place of residence, in explaining the demographic variation (Basu, 1994; Basu and Amin, 2000; Livi-Bacci, 2017). Literature shows that these differences may be attributed to the rural-urban disparities in health facilities and socio-economic, political, and environmental conditions (van de Poel et al., 2009; Yaya et al., 2019).

In India, U5MR remained higher in rural areas across states. For example, in 2019, the national level U5MR was 35 deaths per 1000 live births, with a large gap between rural (39) and urban (23) areas. Further, it varies from the lowest in Kerala within India, with 9 and 8 in rural and urban areas, respectively, to the highest in Madhya Pradesh, 57 and 37 (ORGI, 2022). Rural-urban differences in individual and structural factors may contribute to U5M differences between rural and urban India (Agrawal, 2014; Hnatkovska and Lahiri, 2013; Saikia et al., 2013). For example, rural women generally have a lower level of education (ORGI, 2011), and the mother's education is negatively associated with U5M (Balaj et al., 2021; Bicego and Boerma, 1990; Caldwell, 1979).

It is widely acknowledged that the mother's education is a crucial factor contributing to reducing child mortality (Balaj et al., 2021; Bicego and Boerma, 1990; Caldwell, 1979; Cleland et al., 1992; Keats, 2018; Wu, 2022). In a study by Gakidou et al. (2010), a 51% global decline in child mortality between 1970 and 2009 was attributed to the increasing women's education in the reproductive age group. Each additional year of mother's schooling reduced the risk of death among children under five by 10% and 16% in Malawi and Uganda, respectively (Andriano and Monden, 2019). An analysis conducted by Balaj et al. (2021) on 114 unique surveys across 58 DHS countries found that a single additional year of education for mothers resulted in a 34% reduction in U5M. Grépin and Bharadwaj (2015) found that an additional year of maternal secondary schooling in Zimbabwe contributed to about 21% lower risk of child deaths. Studies from India also show a negative association between mothers' educational attainment and child mortality (Choudhury, 2015; Kravdal, 2004a).

There is also evidence that the effect of maternal education on children's mortality varies across regions and countries (Andriano and Monden, 2019; Fuchs, 2010; Meitei et al., 2022). An analysis by Fuchs (2010) found that higher maternal educational attainment reduced infant mortality significantly in only 18 of 25 DHS countries, albeit to different degrees. A study by Andriano and Monden (2019) showed that maternal education has a differential impact on the U5M in Malawi and Uganda. The author found that additional years of maternal education have a stronger (16%) effect on reducing U5M in Uganda than in Malawi (10%). A study by Meitei et al. (2022) found the differential effect of the mothers education on child mortality in North and South region of India.

Various pathways through which maternal education contributes to improving child survival (Alemayehu Azeze and Huang, 2014; Andriano and Monden, 2019; Cleland and Van Ginneken, 1988; Desai and Alva, 1998; Grépin and Bharadwaj, 2015; Keats, 2018). Education improves the health of children by enhancing income and wealth, as well as empowering women, changing attitudes, and improving their knowledge about health care. The variability in the potential mechanisms that cause the impact of maternal education on child mortality results in a differential effect of education on mortality. A differential effect of maternal education on child mortality between Uganda and Malawi was caused by differences in the mechanisms by which maternal education reduces child mortality (Andriano and Monden, 2019). Mothers' educational attainment had a significant positive impact on U5M through rising wealth and improved control of personal illness in Uganda, but not in Malawi. Whereas education reduces U5M through increased proximity to a health facility and health knowledge higher in Malavi than in Uganda. The education significantly increased the use of modern contraception, resulting in lower levels U5M in both courtiers. In the case of Bangladesh, maternal education reduces under-five mortality through increasing wealth, lower fertility, increasing age at marriage and childbearing age, enhanced health knowledge, and better health-seeking but not through female employment (Wu, 2022). To our knowledge, no investigation has been conducted to determine whether the effect of maternal education on the U5M differs between urban and rural contexts within a country.

There is ample reason to believe that the degree of association between U5M and maternal education may differ between rural and urban areas. As education affects child mortality through various pathways, which may vary between rural and urban areas due to different socio-economic, cultural, environmental, healthcare and political circumstances or conditions (Mitra and Singh, 2007; Webber, 2014; Yang, 2017; Yue and Liu, 2007, 2007, 2007; Zurack, 1977). It is documented that the socioeconomic return of education differs across the place and regions (Gao and Li, 2022; Long et al., 2022).

Education reduces child health by improving economic status (Andriano and Monden, 2019; Funk and Brown, 2009; Wu, 2022). India has a wide disparity between the rural and urban areas in terms of economic status and standard of living (Hnatkovska and Lahiri, 2013; IIPS and ICF, 2021; Pradhan et al., 2000). The economic status of the women is negatively associated with the risk of U5M (Chao et al., 2018). More generally, women in the more affluent economic household receive better antenatal care (ANC), postnatal care (PNC), nutrition, and use of institutional facilities during childbirth, which reduces the risk of child death (Ahmed et al., 2010; Kumar et al., 2019). An educated woman is more likely to have gainful employment, be empowered, and have autonomy in making healthcare choices (Badaoui and Rebière, 2013; Caldwell et al., 1983; Keats, 2018; Thomas, 1990). However, in rural areas, women have a lesser opportunity to participate in gainful employment than in urban areas in India, which may have a lesser impact on women's economic empowerment (Srivastava and Srivastava, 2010). Moreover, rural households mainly rely on agricultural income or less-paid jobs, which causes a larger share of poverty in rural areas (Hnatkovska and Lahiri, 2013; ORGI, 2011; Pradhan et al., 2000).

Increasing maternal education helps improve child health by altering behaviours and habits that positively impact both women and their children through a shift from traditional practices to modern medicine (Wong et al., 1987). The educated women increase the use of the ANCs during pregnancy and shift from traditional to modern care providers (Wong et al., 1987). Education changes reproductive behaviour and practices during pregnancy (Grossman, 1972). Education may contribute to personal illness control through the use of preventive care. A study by Basu and Stephenson's (2005) in India found that completed primary education mothers adopt various measures of personal illness control (e.g., seeking treatment for their child's cough/fever, receiving prenatal care during pregnancy, and receiving prenatal care in the first trimester). Children of educated mothers are more likely to receive vaccinations against common diseases and vitamin A supplements to prevent blindness, diarrhea, and measles (Desai and Alva, 1998; Keats, 2018). Generally, women in rural areas have a more healthy lifestyle with a favourable diet and higher physical activity, leading to lower levels of overweight and obesity (Jayamani et al., 2013).

Mothers' education can help reduce child mortality by adopting good environmental factors such as greater access to healthcare facilities and as well as sanitation and hygiene in the household. The risk of diarrhea was lower among children with more educated mothers (Hatt and Waters, 2006; Hobcraft, 1993). More educated women are more likely to utilize effective healthcare facilities to treat their children's illnesses and prevalent diseases that are fatal among under-five children (Basu and Stephenson, 2005; Bicego and Boerma, 1990; Keats, 2018). Notably, there are apparent differences in the healthcare facilities between urban and rural India, which may cause differences in the utilization of healthcare between rural and urban (Chauhan and Kumar,

2016). Urban health services continue to be allocated a larger share of the public resources, and rural parts have minimal private facilities (Balarajan et al., 2011; Chokshi et al., 2016). Rural women have poor health status and face more complications during pregnancy than their urban counterparts (Jain et al., 2017). They have more healthcare needs and face substantial access barriers (Banerjee, 2021). They are usually deprived of the safety net of insurance facilities, which directly impacts their access to healthcare services (Banerjee, 2021; National Sample Survey Office, 2018).

Moreover, a larger proportion of rural households has no access to toilet facility, safe drinking water, clean cooking fuel and connectivity to a drainage system (Banerjee, 2019; Bhagat, 2014a,b; Chaudhuri and Roy, 2017). Child mortality due to household air pollution from cooking fuel is higher in rural areas than in urban parts (Khan, 2022). The poor air quality index impacts urban children more severely than rural ones (Umemura et al., 2020).

The effects of education on child mortality may be felt through the acquisition of health knowledge (Glewwe 1999). More educated women possess better nutrition knowledge for their children in under-five age (Basu and Stephenson, 2005; Bicego and Boerma, 1990; Keats, 2018). Educated women have more knowledge of contraceptive methods and efficiently use them (Rosenzweig and Schultz, 1989). A study by Agüero and Bharadwaj (2014) in Zimbabwe found that Higher education increases the awareness of HIV transmission and HIV-preventive behaviours.

The education process for women may have opened up new opportunities for autonomy and empowerment in the household. Women's education increases their relative position in the household (Jejeebhoy, 1992; Thomas, 1990). The evidence from India suggests that education positively influences women's participation in household decision-making (Khare, 2021; Namdeo, 2017). Further, the level of women empowerment is higher in an urban setting than rural setting in India (Saravanakumar and Varakumari, 2019). It is important to note that the health benefit of education is also determined by the quality of education (returns of the education). Lower education quality is associated with lower economic empowerment (Psacharopoulos, 1994).

Many health policies and program changes have been implemented in the past three decades to improve maternal and child health. In 1992 and 1997–98, the government of India initiated Child Survival and Safe Motherhood (CSSM) and the Reproductive and Child Health (RCH) Programme, respectively, to reduce infant and maternal mortality rates. It was found that limited access to these programs in urban areas led to widening socioeconomic and regional disparities (Duggal, 2005). In 2011, India's 69% of the population lived in rural areas with limited health facilities (ORGI, 2011). To ensure accessible, affordable, and quality healthcare in rural and urban areas, India launched the National Rural Health Mission (NRHM) in 2005 and the National Urban Health Mission (NUHM) in 2013 (MoHFW, 2013, 2005). Moreover, many other initiatives by GOI to reduce U5M, particularly in rural areas through the intervention of different programs such as Janani Shishu Suraksha Karyakram (JSSK), National ambulance services, Rashtriya Bal Swasthya Karyakram (RBSK), Mother and child health wings (MCH Wings), District hospital and knowledge center (DHKC), Poshan Abhiyan, National Iron + Initiative and National Mobile Medical Units (NMMUs) etc. Urban-rural divide may have changed as a result of these policy efforts. Furthermore, rural women's education has improved significantly in India during the last few decades (ORGI, 2011, 2001, 1991). In this light, examining differences in U5MR between rural and urban areas by the mothers' education would be necessary.

In the previous studies, these two variables were analyzed separately, i.e., rural-urban and maternal education association to U5MR. However, whether the degree of association between a mother's education and under-five death is similar between rural and urban areas and how it has changed over time is unclear from the existing literature.

In India, the risk of U5M differs by the mother's education (Kravdal, 2004a), and the place of residence (rural or urban) matters too (Saikia et al., 2013). Previous studies based on the DHS data examined the rural-urban differences in infant mortality and considered the mother's education as a predictor in their analysis (Bocquier et al., 2011; Choudhury, 2015; Saikia et al., 2013, 2013v; van de Poel et al., 2009; Yaya et al., 2019). Currently, there are a limited number of studies in India are attempting to extract differences between rural and urban U5M (Choudhury, 2015; Saikia et al., 2013). However, no study examined the interaction of rural-urban and mother's educational attainment impact on under-five deaths. Thus, the main aim of this study is to find whether a mother's educational attainment interacts with the U5M differentially between rural and urban areas of India and how it has been changing during the last three decades.

2. Materials and methods

2.1. Data

This study used five rounds of the National Family Health Survey (NFHS) conducted in India between 1992–93 and 2019–21. NFHS is a nationally representative repeated cross-sectional survey that provides unit-level information on a wide range of demographic, health, and family welfare indicators, *viz.* fertility, infant and child mortality, the practice of family planning, maternal and child health, reproductive health, nutrition, anaemia, utilization and quality of health and family planning services. All surveys were conducted in collaboration with the International Institute for Population Sciences (IIPS), Mumbai, a nodal agency under the aegis of the Ministry of Health and Family Welfare (MoHFW) and ORC Macro (USA) (IIPS, 1995; IIPS and ICF, 2021, 2017; IIPS and Macro International, 2007; IIPS and ORC Macro, 2000). Each NFHS survey employs the same sampling design, which allows easier analysis of trends and comparison of the outcome variables. The survey adopts a multi-stage cluster random sampling design. Primary Sampling Units (PSUs) and Census Enumeration Blocks (CEB) were selected at the first stage for rural and urban areas, respectively, followed by a random selection of households in each PSU and CEB at the second stage (IIPS and ICF, 2017).

The NFHS used the rural-urban classification the Census of India gave based on the following two criteria. First, all municipalities, corporations, cantonment boards, or notified town area committees are known as statutory towns. Second, settlements that are not a statutory town but satisfy all three demographic and economic structural criteria (a minimum population of 5000; at least 75% of the male workers engaged in non-agricultural pursuits as a primary occupation; and a population density of at least 400 per sq. km) are also considered urban areas and named census towns (ORGI, 2001). Any settlement that does not fall within the two categories is considered a rural area.

The first round of NFHS was conducted in 1992–93 (NFHS–I), the second round in 1998–99 (NFHS-II), the third round in 2005–06 (NFHS-III), the fourth round in (NFHS-IV), the fifth and the recent round was conducted in 2019–21 (NFHS V) (IIPS, 1995; IIPS and ICF, 2021, 2017; IIPS and Macro International, 2007; IIPS and ORC Macro, 2000). The questionnaire for women collected detailed information about their birth history data, especially the date of birth and survival status of each live birth, and the age at death of each deceased live birth are used to calculate the U5MR. The women's questionnaire also provides information such as age, education, religion, caste, and reproductive behaviours, which allows for estimating the U5MR by women's background characteristics. The details of the number of households and women interviewed under each survey are provided in Table 1.

2.1.1. Analytical sample

Under this study, we have considered children born during the five years preceding the survey in each of the five NFHS rounds. Stillbirth, abortion, and miscarriages were not included in the study. In Table 1, we provide the details of the sample analyzed (number of live births during the last five years analyzed) under each survey.

Table 1
Number of live births during the five years preceding the survey from the women interviewed in each survey.

Survey name and years	Number of households interviewed	Number of women interviewed	Sample analyzed (live births preceding five years of the survey)
NFHS–I (1992–93)	88,562	89,777	60,625
NFHS-II (1998–99)	91,196	89,199	56,734
NFHS-III (2005–06)	109,041	124,385	51,555
NFHS-IV (2015–16)	628,900	699,686	259,627
NFHS–V (2019–21)	636,699	724,115	231,033

Note: All surveys interviewed women between the ages of 15 and 49, except the NFHS–I, which interviewed women between the ages of 13 and 49.

2.1.2. Outcome variables

The outcome variable in this analysis is the probability of dying between birth and the child's fifth birthday. We have assigned a value of 1 for a child who died before age 59 months and 0 if they are still alive and have not reached their fifth birthday.

2.1.3. Explanatory variables

This study considered a range of demographic, socioeconomic, maternal, and community characteristics as explanatory variables recognized as important predictors of infant and child mortality in previous studies (Gupta, 1987, p. 19, 1997; Hosseinpoor et al., 2006; Kravdal, 2004a; Saikia et al., 2013, 2013). The explanatory variables considered in our study are the place of residence (rural or urban); maternal education (below primary, primary, secondary, and above); child's sex (male or female); wealth status of the household (poorest, poorer, middle, richer, richest); caste (Scheduled castes/Scheduled tribes (SCs/STs) - socially disadvantaged, Non-SCs/STs); religion (Hindu, Muslim, Others); place of delivery (institutional, home); a combination of birth order (first birth, 2–4, 5+) and birth interval (short [less than 24 months], medium [25–48 months], and large [49 and more months]). Previous studies showed that the community's intimately shared physical and social environment also impacts child mortality (Kravdal, 2004b; Lutz and Kebede, 2018; Meitei et al., 2022). Therefore, we have controlled the community-level factors for education and economic status, calculated as the average individual years of schooling and a household wealth score, respectively.

2.2. Methods

We estimated the U5MR by mother's educational attainment for rural-urban areas using the methods explained in the guide to the DHS statistics (Croft et al. 2018). This method allows full use of the most recent data for specific periods. After that, the survival analysis was performed to examine the effects of place of residence (rural-urban) and mother's educational attainment and their interaction effect on the risk of death among under-five children. We measured the survival status of a child for the duration given in months from birth to before reaching their fifth birthday, this is time-to-death or time-to-event data. The time-to-event data has censored cases. Children who died before reaching their fifth birthday were considered as an event. The children who were still alive, did not reach their fifth birthday, and were event-free at the end of the study were considered the censored cases in the analysis (Austin, 2017). The time-to-event data considers both the event has occurred or not and the time of the event occurrence. The standard regression models are only able to account for the information regarding whether the event has occurred or not. In this way, they do not take into account the time of the occurrence of an event; thus, they do not take into account censorship. The Cox proportional hazard model is a widely used approach to data analysis in which the outcome specifies the time until an event of interest occurs (Cox and Oakes, 2018). An important feature of this model is that it accounts for the problem of censoring data.

However, the Conventional regression models (in this case, Cox proportional hazard) fail to provide unbiased estimates when the observations are dependent. The data used in this study is in a hierarchical structure. The children and their mothers are nested in a cluster; therefore, outcomes are more likely correlated with one another. This within-cluster homogeneity might be induced by unobserved cluster characteristics (e.g. community culture) that affect the outcome variable at the individual level (e.g. healthcare or environment) that shares similar characteristics for all subjects within the same cluster. As a result of the homogeneity within-cluster, the estimated parameters of the Cox proportional hazards models are biased and inconsistent, as well as underestimated the standard errors (Trussell et al., 1990). The inclusion of the random effects terms in the cox-proportional hazard model is called mixed-effects cox-proportional hazards (MECPH); it can take into account within-cluster homogeneity in the outcome variable. The MECPH model is becoming increasingly popular in recent years for the study of under-five mortality from the data that have a multilevel structure (Alotaibi et al., 2020; Mani et al., 2012; Meitei et al., 2022). The MECPH model can assess and account for cluster-level variations of U5M within the community with information on the time-to-death of the child; therefore, we used the MECPH model.

The MECPH model resembles the hierarchical generalized linear model for time-to-event outcomes (Austin et al., 2010). We used a two-level MECPH model to adjust the unobserved characteristics of individual and community levels (cluster). A model incorporating maternal education, rural-urban, and their interaction appears as follows:

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

where,

$h(t_{ji})$ represents the conditional hazard of child death at time t, j (1, …,m) denotes the cluster, while i (1, …,n_j) denotes the observations (child) within a cluster;

$h_0(t_{ji})$ is the baseline hazard (k = 0 and l = 0);

$\beta_{residence_{jik}}$ is a coefficient for the residence (*k: k = 0, rural as the base category*).

$\beta_{education_{jil}}$ is a coefficient for the education (*l: l = 0, below primary education as the base category)*, and

$\beta_{residence_{jik} \times education_{jil}}$ is a coefficient for the interaction of residence and education ($k * l$)

x_{ji} is a vector of covariates with the associated vector of fixed parameters β. The random-effects uj is M realizations from a multivariate normally distributed with zero means and with variances σ_1^2 and σ_2^2 at individual and cluster levels.

For example, when the residence is rural (k = 0), the hazard function is

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

where $\beta_{residence_{jio}}$ is equal to 0 for the base category. This means that for a given cluster,

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

Further, we calculated the degree of clustering in the data using the intraclass correlation coefficient (ICC) and the variance partition coefficient (VPC). The ICC measures the correlation between hazard ratios for the child in the same cluster, while the VPC measures the proportion of total variance at the cluster level. The details of the ICC calculation after the mixed effect Cox proportional hazard model are discussed in other studies (Rodríguez, 2010; Canette, 2016). We fitted two models for

each survey. The first model controlled only for rural-urban and mother's educational attainment and their interaction effect. The second model included the other determinants of under-five deaths at individual and community levels.

3. Results

3.1. Sample description of the study variables by rural-urban and mother's education

Table 2 shows the socioeconomic and demographic characteristics of the study sample by mother's educational attainment and place of residence in the five surveys. Improvement in educational attainment has occurred in India. The proportion of women with below primary education is higher in rural areas than in urban areas. It has declined from NFHS–I, 75% in rural and 44% in urban to 30% and 14%, respectively, until NFHS–V. Only 6% of women completed secondary and higher education in rural areas compared to 28% in urban areas during NFHS–I. It increased to 53% and 73% during NFHS–V for rural and urban areas, indicating significant rural-urban differences in women's educational attainment.

Moreover, there is a clear rural-urban difference in the economic status of households by mother's education. In general, women living in rural areas reported poorer wealth status, and women with below primary education reported poorer wealth status at higher rates than women with primary or secondary education. Additionally, mothers who give birth at a shorter birth interval and have more children predominantly reside in rural India and belong to lower educational backgrounds. Besides, women living in rural areas use fewer institutional healthcare facilities during childbirth than their urban counterparts.

3.2. Under-five mortality rates by rural-urban in different Indian states

Table 3 shows U5M by rural-urban areas estimated from Sample Registration System (SRS) life tables for 1991–95 and 2011–15 for India and its major states. It shows clear regional differences in U5MR across the states. Madhya Pradesh, Uttar Pradesh, Odisha, Rajasthan, Assam, and Bihar have higher mortality levels, whereas Kerala, Tamil Nadu, Himachal Pradesh, and Punjab have lower levels of mortality. The U5MR is higher in rural parts across the states during both periods. Moreover, the rural-urban differences in U5MR varied across the states in India. The percentage change in U5M between 1991–95 and 2011-15 by rural-urban differs across the Indian states. More decline was observed in urban areas across states except for Andhra Pradesh, Karnataka, and Himachal Pradesh, which achieved a higher decline in rural areas from 1991-95 to 2011–15. Whereas Tamil Nadu, Uttar Pradesh and Bihar show an almost similar decline in U5M in the rural and Urban areas.

3.3. Under-five mortality rates by rural-urban and maternal education

Fig. 1 shows the trends of U5MR by mother's educational attainment in rural-urban areas across the five consecutive rounds of NFHS. Trends show that mortality has declined sharply in rural and urban areas. Nevertheless, the rural-urban gap shows a slight decline from 1.6 to 1.5 times higher mortality among rural children across the surveys. U5MR declined from 120 (per 1000 live births) and 75 in NFHS–I to 46 and 31 in NFHS–V for rural and urban areas, respectively. The probability of death among under-five children differs considerably by the mother's educational attainment in rural and urban areas. The probability of death before reaching the age of five was two times higher in rural areas and three times higher in urban areas among children of mothers with below primary education compared to those with completed secondary and higher education during NFHS–I. However, the differences between below-primary and secondary and higher-educated mothers were reduced to 1.7 times for rural and 1.8 times for urban areas during NFHS–V. This indicates that the relative differences in the U5MR between the below primary and secondary education groups have been reduced during NFHS–I and NFHS–V. The U5MR trends by mother's educational attainment show that the highest decline was observed among below primary educated mothers. The faster decline among the low-educated group and the slower decline among the higher-educated group led to convergence across the educational categories.

Moreover, the decline in U5MR by mother's education differs between rural-urban areas. Below primary and primary educated women show a similar decline in rural and urban areas, whereas secondary and higher educated mothers show a higher decline in rural areas between NFHS–I and NFHS–V. Further, the relative difference in rural-urban U5M across the educational groups shows a higher difference in more educated mothers except for NFHS-II. This indicates that the child of a mother with higher education living in an urban area has more advantages than the child of a mother with the same level of education living in a rural area.

3.4. Regression results

3.4.1. Risk of U5M by maternal education and place of residence: multilevel analysis without controlling for other predictors

Fig. 2 shows the main effect and interaction effect of the mother's educational attainment and rural-urban on U5M of the multilevel Cox-PH model analyses. The model fitted for each survey from NFHS I to V by controlling for rural-urban, mothers' education, and their interaction. The results show that the hazard ratio of U5M is significantly lower among urban children between NFHS I (HR = 0.869, $p < 0.001$) and NFHS V (HR = 0.881, $p < 0.001$) as compared to their rural counterparts. Similarly, the risk of death among under-five children significantly declined with their mother's educational attainment. In subsequent surveys, however, the magnitude of the effect of education on U5M decreases. The risk of under-five death was 40% and 57% lower among children born to mothers who completed primary education (HR = 0.606, $p < 0.001$) and secondary higher education (HR = 0.471, p,0.001), respectively, as compared to the children born to mothers with below primary education during NFHS I. At the same time, results for NFHS V show that HR was 17% and 37% lower for children whose mothers finished primary (HR = 0.838, $p < 0.001$) and secondary (HR = 0.634, $p < 0.001$) education compared to below primary educated mothers.

Further, the interaction analysis of mother's educational attainment and rural-urban clearly shows that the impact of a mother's education differs between rural and urban areas. The results indicate that the risk of death is lesser among urban children than in rural children born to primary educated mothers across the surveys. However, this is insignificant in NFHS I and NFHS V. While the hazard ratio of U5M was significantly lower for urban children than their rural counterparts whose mothers accomplished secondary and higher education across the surveys except for NFHS II (HR = 0.66, $p < 0.001$ in NFHS I, HR = 0.799, $p < 0.001$ in NFHS V). This indicates that children who belong to higher educated mothers living in urban areas have more protective effects against under-five death risk compared to children born to secondary level educated mothers living in rural areas. The model also shows that cluster variation (ICC) accounted for significant variations in U5M. The details of the model are shown in Table 4.

3.5. Risk of U5M by maternal education and place of residence: multilevel analysis with controlling for other predictors

Fig. 3 shows the impact of maternal education and place of residence on U5M after controlling for other socioeconomic and maternal health factors at both individual and community levels. Findings show that the risk of dying before age five differs by gender, with hazard ratios (HR) slightly higher for females than males during NFHS–I (HR = 1.007) and

Table 2
Background characteristics study sample by mother's educational attainment and rural-urban for each survey (NFHS–I–V), India.

Background characteristics	NFHS–I (1992–93)						NFHS-II (1998–99)					
	Rural			Urban			Rural			Urban		
Child Sex	Below Primary	Primary	Secondary	Below Primary	Primary	Secondary	Below Primary	Primary	Secondary	Below Primary	Primary	Secondary
Male	51.4	51.3	50.8	52.2	51.8	50.8	51.4	51.6	53.8	50.2	52.0	54.1
Female	48.6	48.7	49.2	47.8	48.2	49.2	48.6	48.4	46.2	49.8	48.0	45.9
Household wealth status												
Poorest	30.9	7.3	1.7	3.9	0.4	0.0	34.5	8.3	2.9	7.0	1.1	0.2
Poorer	27.6	13.1	4.1	12.0	2.3	0.2	29.7	17.9	9.4	10.4	2.9	0.8
Middle	24.8	24.0	12.7	19.2	7.4	0.7	22.5	32.4	21.1	24.0	11.8	3.7
Richer	15.2	42.1	37.1	38.1	29.0	7.1	11.7	32.3	37.1	40.2	42.7	19.6
Richest	1.5	13.5	44.5	26.7	61.0	92.0	1.6	9.1	29.4	18.4	41.6	75.7
Caste group												
Non-SCs/STs	67.0	79.2	85.7	78.7	83.0	91.5	58.2	70.5	75.2	68.6	72.2	82.0
SCs/STs	33.0	20.8	14.3	21.3	17.0	8.5	40.6	28.9	24.3	30.6	27.3	17.8
Missing							1.3	0.6	0.5	0.8	0.5	0.2
Religion												
Hindu	79.2	72.4	74.0	68.7	70.3	76.8	77.0	72.9	75.3	65.0	65.8	72.7
Muslim	12.9	10.5	4.2	25.0	15.9	7.7	14.6	11.3	7.2	29.4	22.2	11.5
Others	7.9	17.1	21.9	6.3	13.8	15.6	8.5	15.8	17.5	5.7	11.9	15.8
Mother's age at birth												
<20	27.2	29.4	15.9	24.1	24.3	9.9	27.1	30.8	24.0	24.3	25.4	13.8
20–34	66.8	68.6	82.7	70.1	73.5	88.1	67.5	67.0	74.6	71.4	72.1	84.3
35≥	6.1	2.0	1.5	5.7	2.2	2.1	5.4	2.3	1.4	4.3	2.6	2.0
Birth order												
1	22.6	35.7	47.0	21.2	33.1	45.6	20.9	32.1	44.6	21.7	30.4	46.0
2–4	52.8	55.1	49.8	55.8	58.0	52.2	53.8	58.1	51.9	56.7	60.0	52.0
5+	24.7	9.2	3.2	23.0	8.9	2.2	25.4	9.8	3.4	21.6	9.6	2.1
Birth interval												
1st birth order	22.7	35.8	47.2	21.4	33.5	46.1	21.0	32.4	45.0	21.8	30.7	46.2
short <24 month	20.0	19.6	17.9	22.1	21.6	14.6	22.0	20.8	16.9	22.9	21.0	14.2
Medium 24–48 months	44.2	35.3	26.1	43.2	33.0	25.3	44.7	37.6	28.9	41.4	35.4	25.7
49> large	13.1	9.3	8.9	13.4	12.0	14.0	12.4	9.3	9.3	14.0	12.9	14.0
Place of delivery												
Institutional	7.91	28.72	49.36	26.21	49.28	65.95	8.06	20.56	32.54	23.97	39.06	50.93
Missing	71.95	53.29	33.14	53.58	30.45	14.63	47.93	39.27	30.76	32.61	18.11	9.49
Home	20.13	17.99	17.49	20.22	20.28	19.43	44.01	40.17	36.7	43.42	42.83	39.58
Region												
South	13.0	20.7	22.9	13.5	20.4	17.5	9.3	16.3	20.5	12.3	20.3	19.9
North	18.8	22.3	25.3	27.4	26.0	36.6	22.0	22.7	23.6	27.5	20.0	28.4
Central	30.2	16.7	11.9	20.1	12.8	14.0	27.8	18.4	13.6	20.6	13.2	13.0
East	19.5	14.3	11.2	16.1	10.2	9.3	21.5	15.3	13.6	13.5	11.2	9.6
West	8.1	10.7	15.5	14.2	16.7	14.0	6.1	8.9	9.7	17.2	24.5	16.9
Northeast	10.4	15.2	13.2	8.8	13.9	8.6	13.3	18.5	19.2	8.9	10.8	12.3
Cluster average years of schooling	1.5	3.8	5.2	3.2	6.1	8.8	3.4	3.6	3.6	3.8	4.1	4.4
Cluster average wealth score	2.4	3.1	3.5	3.9	4.4	4.7	2.9	2.9	2.9	3.2	3.2	3.2
Total	75.7	17.91	6.39	44.26	27.15	28.59	70.19	13.06	16.75	37.65	16.05	46.3
N	33,381	7897	2818	7227	4434	4669	29,615	5511	7065	5465	2330	6721
Background characteristics	NFHS-III (2005–06)						NFHS-IV (2015–16)					
	Rural			Urban			Rural			Urban		
Child Sex	Below Primary	Primary	Secondary	Below Primary	Primary	Secondary	Below Primary	Primary	Secondary	Below Primary	Primary	Secondary
Male	51.3	51.3	52.7	52.3	50.8	53.1	51.3	52.2	52.5	52.0	52.3	52.5
Female	48.7	48.7	47.3	47.7	49.2	46.9	48.7	47.8	47.5	48.0	47.7	47.5
Household wealth status												
Poorest	39.7	13.9	4.5	9.3	1.9	0.2	55.0	28.2	12.2	15.6	5.0	1.3
Poorer	30.9	25.8	12.9	16.7	7.2	1.6	28.5	34.5	24.2	23.8	14.4	5.0
Middle	20.7	32.1	24.5	29.7	20.4	7.0	12.0	23.4	27.5	28.8	27.5	13.9
Richer	7.5	23.1	33.2	32.9	46.9	24.9	3.7	10.7	21.9	23.5	35.1	31.5
Richest	1.2	5.1	24.9	11.4	23.6	66.3	0.8	3.2	14.2	8.4	18.0	48.4
Caste group												
Non-SCs/STs	51.6	57.2	66.9	64.4	66.7	74.1	47.9	50.0	60.3	63.0	62.3	69.5
SCs/STs	43.9	37.7	28.0	32.1	30.1	22.2	47.6	45.4	35.2	32.3	33.0	26.6
Missing	4.5	5.1	5.2	3.6	3.2	3.8	4.5	4.6	4.5	4.8	4.7	4.0
Religion												
Hindu	69.9	69.7	72.8	61.8	62.9	69.3	72.1	73.0	77.1	59.0	60.2	69.3
Muslim	16.9	11.5	8.5	31.0	24.7	14.4	17.8	12.7	9.5	35.4	29.5	17.1
Others	13.2	18.8	18.7	7.2	12.5	16.2	10.1	14.2	13.5	5.6	10.2	13.7
Mother's age at birth												

(*continued on next page*)

Table 2 (*continued*)

Background characteristics	NFHS-III (2005–06)						NFHS-IV (2015–16)					
	Rural			Urban			Rural			Urban		
Years	23.3	30.5	20.1	20.7	28.8	13.2	12.7	19.6	19.2	12.9	17.0	11.6
20–34	70.1	67.4	77.8	74.3	69.4	84.3	79.6	78.1	79.0	81.4	80.2	85.2
35≥	6.6	2.1	2.1	5.1	1.7	2.5	7.8	2.3	1.8	5.7	2.8	3.3
Birth order												
1	20.5	34.9	44.6	21.9	35.0	47.3	22.6	34.9	49.5	24.3	35.1	49.3
2–4	54.4	55.8	51.7	57.4	57.2	50.6	59.9	59.2	48.5	61.0	59.5	49.5
5+	25.1	9.3	3.8	20.8	7.8	2.1	17.5	5.9	2.0	14.7	5.5	1.2
Birth interval												
1st birth order	20.6	35.1	45.0	22.0	35.1	47.8	22.7	35.1	49.9	24.5	35.4	49.8
short <24 month	20.8	19.7	15.8	23.1	20.2	13.2	20.7	18.7	13.9	21.4	16.8	10.7
Medium 24–48 months	44.3	34.7	28.0	39.4	30.9	24.4	41.2	33.9	25.2	37.5	32.0	22.6
49> large	14.3	10.6	11.2	15.6	13.9	14.6	15.4	12.3	11.1	16.7	15.8	16.9
Place of delivery	17.91	37.52	58.1	40.21	65.22	84.7	59.37	73.24	84.98	69.76	84.43	93.06
Institutional	82.09	62.48	41.9	59.79	34.78	15.3	40.63	26.76	15.02	30.24	15.57	6.94
Missing												
Home												
Region	73.7	64.5	50.7	45.4	36.4	22.3	82.3	75.9	67.0	63.5	57.8	44.8
South	8.2	14.9	18.5	11.9	20.5	20.1	3.8	7.9	12.7	6.9	13.4	19.4
North	17.5	17.8	22.8	18.6	12.8	16.4	15.8	17.9	20.8	22.4	20.2	20.1
Central	29.3	18.3	14.4	27.4	19.7	17.1	33.2	29.5	25.5	37.6	28.8	24.6
East	21.2	14.6	10.4	17.7	12.6	10.5	30.2	19.0	17.8	17.3	11.8	11.5
West	6.1	10.1	11.0	10.6	18.5	17.7	4.1	8.7	7.1	7.8	14.1	10.1
Northeast	17.8	24.3	22.9	13.8	15.9	18.2	12.9	16.9	16.1	8.0	11.6	14.5
Cluster average years of schooling	2.4	4.5	6.4	4.3	6.4	9.2	3.5	5.6	7.5	5.0	7.1	9.9
Cluster average wealth score	2.2	2.7	3.2	3.5	3.9	4.3	1.9	2.3	2.7	3.3	3.6	4.0
Total	59	15	26	31.42	15.45	53.13	42.67	16.65	40.68	21.89	14.37	63.74
N	18,921	4811	8339	6121	3010	10,352	84,589	33,004	80,655	13,438	8821	39,120

Background characteristics	NFHS–V (2019–21)					
	Rural			Urban		
Child Sex	Below Primary	Primary	Secondary	Below Primary	Primary	Secondary
Male	51.53	51.58	51.98	51.89	50.95	52.18
Female	48.47	48.42	48.02	48.11	49.05	47.82
Household wealth status						
Poorest	57.28	36.92	17.98	17.13	6.54	1.88
Poorer	26.53	31.68	25.76	21.92	15.29	6
Middle	11.07	19.56	24.57	26.7	26.57	15.19
Richer	4.14	9.28	20.03	23.38	33.04	30.43
Richest	0.99	2.55	11.67	10.86	18.55	46.5
Caste group						
Non-SCs/STs	43.67	46.23	57.1	56.57	56.19	67.34
SCs/STs	51.25	47.45	38.11	36.23	35.95	27.29
Missing	5.07	6.32	4.8	7.2	7.86	5.37
Religion						
Hindu	71.17	70.85	77.49	60.89	62.35	71.82
Muslim	16.73	14.56	10.04	31.65	28.83	17.16
Others	12.1	14.6	12.47	7.47	8.82	11.02
Mother's age at birth						
Years	11.43	16.28	17.6	10.76	14.12	10.03
20–34	80.84	80.87	80.65	82.87	82.46	86.16
35≥	7.73	2.85	1.75	6.37	3.42	3.8
Birth order						
1	21.56	30.98	47.81	23.51	31.09	48.37
2–4	62.19	62.69	50.59	64.28	64.52	50.54
5+	16.26	6.33	1.59	12.22	4.38	1.09
Birth interval						
1st birth order	21.69	31.18	48.2	23.87	31.27	48.97
short <24 month	21.42	18.57	14.15	20.69	16.87	10.56
Medium 24–48 months	39.73	34.94	25.43	35.47	31.85	22.07
49> large	17.16	15.32	12.23	19.96	20.01	18.41
Place of delivery						
Institutional	73.46	83.12	91.66	82.43	91.23	96.41
Home	26.54	16.88	8.34	17.57	8.77	3.59
Region						
South	5.01	8.73	14.1	8.17	15.71	24.17
North	14.64	17.01	18.93	26.38	23.38	22.42
Central	29.16	25.97	26.73	27.15	19.91	19.39
East	29.47	19.07	17.45	17.76	11.59	10.42
West	6.25	10.91	7.68	11.4	18.91	12.42

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Table 2 (*continued*)

Background characteristics	NFHS–V (2019–21)					
	Rural			Urban		
Northeast	15.47	18.3	15.11	9.13	10.51	11.18
Cluster average years of schooling	2.900381	4.140373	5.400174	4.662497	6.022152	8.150501
Cluster average wealth score	1.956975	2.253145	2.537551	3.412859	3.68148	3.981321
Total	30.76	15.44	53.8	14.98	11.96	73.06
N	56,450	28,384	99,426	6983	5574	34,216

Data sources: Authors calculation from NFHS–I–V.

Table 3
Under-five mortality rate (1000 live births) in India and states/union territories by type of residences during 1991–95 and 2011–15.

States/Union Territories	1991–95		2011–15		% change between 1991–95 and 2011-15	
State	Rural	Urban	Rural	Urban	Rural	Urban
India	120.21	70.03	56.6	30.87	52.92	55.92
Jammu & Kashmir			47.46	33.53	–	–
Himachal Pradesh	79.75	47.93	45.89	30.63	42.46	36.09
Punjab	81.53	51.19	36.25	22.27	55.54	56.50
Uttarakhand			33.78	27.86	–	–
Haryana	103.95	80.46	53.94	38.96	48.11	51.58
Delhi			34.45	22.71	–	–
Rajasthan	135.54	89.53	68.88	41.53	49.18	53.61
Uttar Pradesh	147.35	106.42	79.16	57.83	46.28	45.66
Bihar	123.65	90.04	50.5	36.22	59.16	59.77
Assam	126.04	81.62	73.92	26.79	41.35	67.18
Jharkhand			50.95	28.14	–	–
Odisha	144.78	91.17	64.78	31.07	55.26	65.92
Chhattisgarh			55.98	38.27	–	–
Madhya Pradesh	164.3	91.39	81.43	42	50.44	54.04
Gujarat	106.99	72.11	63.94	33.28	40.24	53.85
Maharashtra	85.68	47.28	27.96	15.52	67.37	67.17
Andhra Pradesh	88.35	56.63	43.5	28.76	50.76	49.21
Karnataka	99.28	55.41	40.06	27.83	59.65	49.77
Kerala	19.11	19.17	13.64	10.95	28.62	42.88
Tamil Nadu	67.76	50.64	26.09	19.32	61.50	61.85
West Bengal	95.23	58.69	37.01	22.37	61.14	61.88

Data sources: RGI (2017)

NFHS-II (HR = 1.053). There has been a shift in mortality risk from higher to lower among females since NFHS III, with NFHS IV (HR = 0.883, p < 0.001) and NFHS V (HR = 0.847, p < 0.001) showing significantly lower mortality risk for females than males.

In contrast to the previous model, the hazard ratio for urban children increased when other predictors of child mortality were taken into account in NFHS I (HR = 1.221, p < 0.001), NFHS II (HR = 1.158, p < 0.01) and NFHS III (HR = 1.179, p < 0.01). However, rural-urban differences do not appear significant in the recent NFHS IV-V surveys indicating that controlling for the predictors of under-five mortality erases the urban advantage.

We found that mothers' educational attainment significantly reduces the risk of under-five deaths even after controlling for other predictors across the surveys. Children of a mother with primary education and secondary and higher education have 23% and 29% lower death risk than those with below-primary education during NFHS I. Furthermore, children of mothers with primary and secondary education are 6% and 23% less likely to die than those with below primary education in NFHS–V. Recent surveys indicate that primary education does not lead to a significant decrease in U5M.

Further, the estimates from the NFHS I shows that a mother's secondary level educational attainment interacts differently, with an urban advantage, with a smaller U5M risk (HR = 0.665, $p < 0.001$) than among children whose mothers completed secondary level educational living in urban areas. However, recent survey estimates do not show significant differences. The findings indicate that children of secondary level educational mothers living in urban areas have greater protection against U5M than children of secondary level educational mothers living in rural areas.

We found (Fig. 3) that a household's economic status significantly impacts U5MR. Children born to women of affluent households were less likely to die than those born to an economically poor household across the surveys. A mother's social affiliation also has a significant impact on the U5M. Children born to women belonging to the SCs/STs caste group had higher hazard ratios than those born in non-SCs/STs households. The place of delivery significantly affects the child's survival status. The children born to mothers who belonged to the Muslim or other religious groups were less likely to die before the age of five than those belonging to the Hindu religious group. The association between social affiliation and the risk of under-five death is confirmed in all survey years. The probability of death was lower among children whose mothers used institutional health facilities at birth than among children born at home. Preceding birth interval and birth order are also associated with child mortality. Children who belong to the 2–4 birth order and short birth intervals were at a higher risk of death than the firstborn children. The

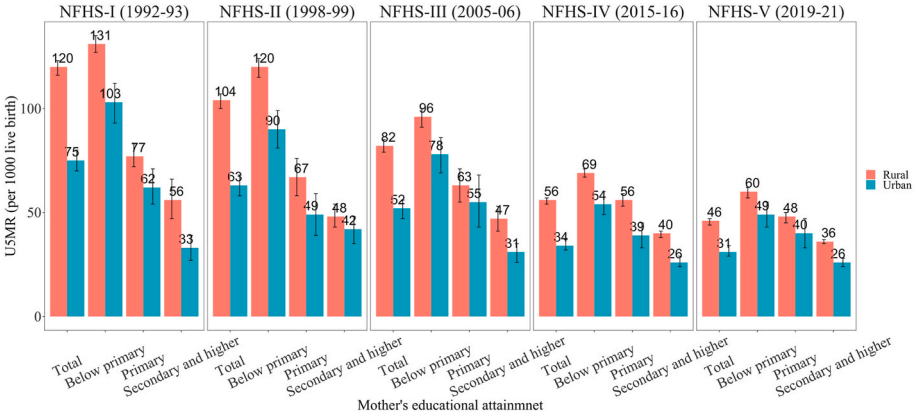

Fig. 1. Trends of U5MR by rural-urban and mothers' educational attainment, India, NFHS–I to NFHS-IV.

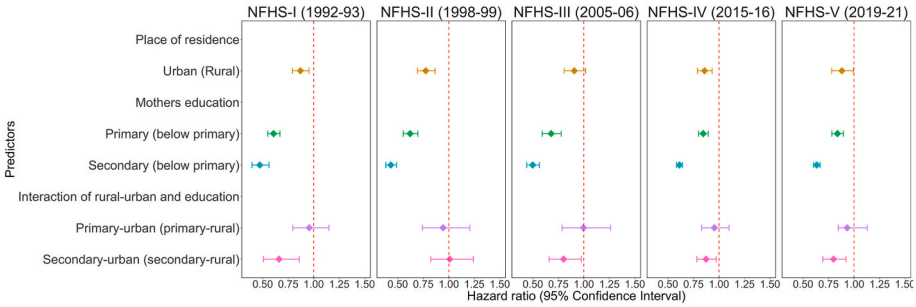

Fig. 2. Hazard ratio of U5M by maternal education and rural-urban without controlling for U5M predictors, NFHS–I, NFHS-II, NFHS-III, NFHS-IV, and NFHS V, India. Sources: Authors own calculation from NFHS-1-V

Table 4
Results of multilevel Cox proportional hazard model: risk of child mortality by mothers' educational attainment and rural-urban, NFHS–I–V, India.

Predictors	Categories	NFHS–I (1992–93)	NFHS-II (1998–99)	NFHS-III (2005–06)	NFHS-IV (2015–16)	NFHS–V (2019–21)
		(HR [CI 95])	(HR [CI 95])	(HR [CI 95])	(HR [CI 95])	(HR [CI 95])
Place of residence	Urban (Rural)	0.869(0.791–0.954) ***	0.774(0.692–0.865) ***	0.906(0.807–1.018) *	0.858(0.788–0.933) ***	0.881(0.781–0.995) **
Education level	Primary (below primary)	0.606(0.549–0.669) ***	0.62(0.553–0.696) ***	0.679(0.592–0.778) ***	0.845(0.799–0.895) ***	0.838(0.783–0.896) ***
	Secondary (Above)	0.471(0.394–0.562) ***	0.431(0.382–0.487) ***	0.498(0.44–0.564) ***	0.612(0.584–0.642) ***	0.634(0.602–0.667) ***
Interaction of rural-urban and education level	Primary-Urban	0.956(0.795–1.149)	0.944(0.739–1.206)	0.996(0.787–1.262)	0.955(0.83–1.099)	0.932(.0769–1.128)
	Secondary and above-Urban	0.66(0.507–0.858) ***	1.009(0.822–1.24)	0.801(0.658–0.975) **	0.873 (0.783–0.973)**	0.799(0.693–0.921) ***
Constant		0.025(0.023–0.026) ***	0.024(0.023–0.026) ***	0.02(0.019–0.022) ***	0.015(0.015–0.016) ***	0.012(0.011–0.013) ***
Random part	Cluster	0.164(0.129–0.208)	0.154(0.118–0.202)	0.172(0.122–0.242)	0.373(0.334–0.415)	0.422(0.373–0.477)
VPC = ICC(%)		9.4	9.1	9.2	17.4	17.8

Data sources: Authors calculation from NFHS–I–V, Note: 95% Confidence interval in parentheses; ***significant at 1%, **significant at 5%, *significant at 10%; HR = Hazard ratio; VPC - variance partition coefficient, ICC - intra-community correlation coefficient.

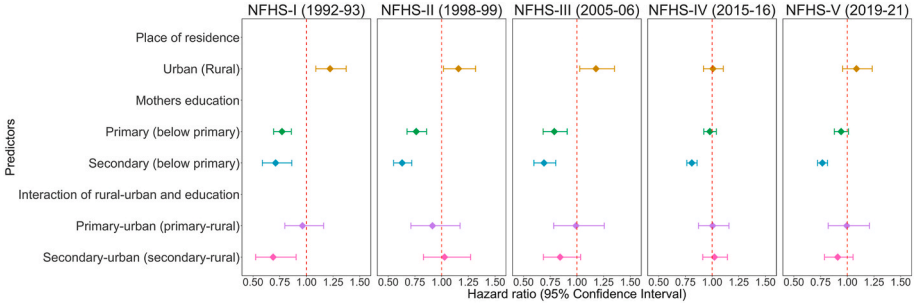

Fig. 3. Hazard ratio of U5M by maternal education and rural-urban after controlling U5M predictors, NFHS–I, NFHS-II, NFHS-III, NFHS IV and NFHS-IV, India. Sources: Authors own calculation from NFHS-1-V

incidence of death with birth order of the children; the risk of death was greater among high birth order and those who were also born with a shorter birth interval.

Our results also showed that community-level education has a significant impact on the survival status of children. Those born to a mother in a higher educated community have a lower risk of U5M. The community-level education impact is confirmed in all survey years except for NFHS-II. However, the community-level economic status does not impact the U5M except for the NFHS-II, which shows that the children of women living in economically better communities have a lower risk of the U5M. The regional division of India shows a significant impact on the U5M. The likelihood of death is significantly higher among children born to women living in the North, Central, East, and Northeast region than those living in the South region of India. Results are similar across the surveys.

Moreover, the risk of death is much higher among children born in India's northern and central regions. The ICC showed that community-level characteristics are also prominent along with individual-level characteristics in explaining the under-five mortality in India. The details of the model are shown in Table 5.

4. Discussion

This study shows that the overall U5MR has declined in India over the last three decades, from 1992-93 to 2019–21. However, the rural-urban gap remained higher across the surveys, with a slight decline from 1.6 to 1.5 times higher mortality in rural India. Similar findings were observed from the MECPH model adjusted only for the place of residence and the mother's educational attainment. The decrease in rural disadvantage after the 2005-06 survey may be attributed to the

Table 5
Results of multilevel Cox proportional hazard model: risk of child mortality by rural–urban and mother's educational attainment after controlling for other predictors, NFHS–I–V, India.

Predictors	Categories	NFHS–I (1992–93)	NFHS-II (1998–99)	NFHS-III (2005–06)	NFHS-IV (2015–16)	NFHS–V (2019–21)
		(HR [CI 95])	(HR [CI 95])	(HR [CI 95])	(HR [CI 95])	(HR [CI 95])
Child Sex	Female (Male)	1.007 (0.951–1.065)	1.053(0.991–1.119)*	0.977(0.907–1.052)	0.883(0.851–0.916)***	0.847(0.812–0.884)***
Place of residence	**Urban (Rural)**	1.221 (1.087–1.372)***	1.158(1.018–1.318)**	1.179(1.028–1.352)**	1.008(0.919–1.105)	1.086(0.956–1.233)
Education level	**Primary (below primary)**	0.771 (0.693–0.858)***	0.762(0.675–0.859)***	0.788(0.684–0.909)***	0.979(0.922–1.04)	0.942(0.879–1.011)
	Secondary (Above)	0.711 (0.586–0.863)***	0.63(0.55–0.72)***	0.692(0.597–0.802)***	0.81(0.763–0.859)***	0.767(0.721–0.815)***
Interaction of rural-urban and education level	**Primary (Urban)**	0.962 (0.798–1.161)	0.914(0.712–1.173)	0.992(0.783–1.257)	1.005(0.872–1.158)	0.995(0.821–1.207)
	Secondary and above-Urban	0.688 (0.524–0.903)***	1.027(0.829–1.272)	0.843(0.686–1.035)	1.022(0.913–1.143)	0.91(0.786–1.054)
Wealth status	Poorer (Poorest)	1.025 (0.945–1.112)	0.859(0.788–0.936)***	1.034(0.926–1.154)	0.961(0.912–1.013)	0.968(0.91–1.029)
	Middle	0.896 (0.819–0.981)**	0.785(0.712–0.866)***	0.875(0.769–0.997)**	0.884(0.826–0.945)***	0.853(0.789–0.922)***
	Richer	0.737 (0.659–0.825)***	0.658(0.582–0.744)***	0.777(0.661–0.912)***	0.783(0.719–0.852)***	0.808(0.735–0.888)***
	Richest	0.628 (0.528–0.747)***	0.505(0.421–0.606)***	0.679(0.546–0.844)***	0.589(0.527–0.658)***	0.607(0.536–0.687)***
Caste	SCs/STs (No-SCs/STs)	1.056 (0.987–1.131)	1.062(0.989–1.14)*	1.083(0.992–1.182)*	1.045(1.001–1.092)**	1.092(1.039–1.148)***
Religion	Muslim (Hindu)	0.86(0.784–0.944)***	0.871(0.789–0.962)***	0.845(0.75–0.951)***	0.949(0.895–1.007)*	0.88(0.819–0.947)***
	Others	0.714 (0.624–0.816)***	0.968(0.846–1.107)	0.959(0.828–1.11)	0.848(0.779–0.924)***	0.883(0.802–0.973)**
Mother's age at birth	20-34 (Below 20)	0.853(0.792–0.92)***	0.822(0.759–0.891)***	0.792(0.719–0.873)***	0.831(0.788–0.875)***	0.854(0.803–0.909)***
	35 and above	1.08(0.926–1.26)	1.106(0.938–1.305)	0.843(0.681–1.042)	1.194(1.082–1.317)***	1.047(0.925–1.186)
Birth order and birth interval	2-4 and short interval (First birth)	1.291 (1.186–1.407)***	1.326(1.21–1.454)***	1.215(1.088–1.357)***	1.137(1.077–1.2)***	1.102(1.035–1.172)***
	5+ and short interval	1.51(1.337–1.706)***	1.571(1.377–1.792)***	1.718(1.46–2.022)***	1.849(1.688–2.026)***	1.545(1.368–1.746)***
	2-4 and medium interval	0.653 (0.598–0.714)***	0.687(0.625–0.756)***	0.656(0.585–0.735)***	0.66(0.625–0.696)***	0.696(0.654–0.74)***
	5+ and medium interval	0.783 (0.695–0.883)***	0.856(0.752–0.973)**	0.827(0.703–0.973)**	0.791(0.72–0.869)***	0.936(0.832–1.052)
	2-4 and large interval	0.59(0.513–0.678)***	0.631(0.542–0.734)***	0.639(0.542–0.752)***	0.756(0.705–0.812)***	0.751(0.695–0.812)***
	5+ and large interval	0.51(0.416–0.626)***	0.597(0.476–0.749)***	0.555(0.417–0.738)***	0.843(0.736–0.965)**	0.894(0.748–1.069)
Place of delivery	Home delivery (Institutional delivery)	1.011 (0.917–1.116)	0.881(0.788–0.984)**	0.854(0.776–0.94)***	1.145(1.096–1.196)***	1.241(1.17–1.317)***
Community level predictor	Cluster average years of schooling	0.976(0.953–1)**	1.024(0.992–1.058)	0.955(0.932–0.979)***	0.967(0.957–0.977)***	0.98(0.967–0.993)***
	Cluster average wealth score	0.912(0.81–1.027)	0.825(0.752–0.905)***	0.955(0.833–1.095)	1.012(0.954–1.072)	0.998(0.993–1.004)
Region	North (South)	1.196(1.06–1.349)***	1.511(1.328–1.72)***	1.342(1.134–1.588)***	1.339(1.217–1.474)***	1.257(1.139–1.387)***
	Central	1.392 (1.248–1.553)***	1.573(1.389–1.781)***	1.698(1.456–1.98)***	1.801(1.647–1.969)***	1.738(1.587–1.904)***
	East	1.286 (1.146–1.444)***	1.161(1.016–1.326)**	1.307(1.11–1.538)***	1.26(1.145–1.388)***	1.321(1.196–1.459)***
	West	1.005 (0.876–1.153)	1.078(0.919–1.265)	1.12(0.929–1.351)	1.057(0.939–1.19)	1.096(0.976–1.23)
	Northeast	1.103(0.958–1.27)	1.15(0.987–1.339)*	1.283(1.076–1.529)***	1.205(1.081–1.343)***	0.989(0.878–1.116)
Constant		0.025(0.02–0.03)***	0.018(0.014–0.023)***	0.026(0.02–0.035)***	0.019(0.016–0.022)***	0.016(0.014–0.018)***
		−1.1 (-1.127–1.073)***	−1.103 (-1.132–1.073)***	−1.171 (-1.207–1.135)***	−1.211 (-1.228–1.193)***	−1.218 (-1.239–1.197)***
Random part	Cluster	0.088(0.06–0.129)	0.092(0.061–0.137)	0.104(0.062–0.175)	0.287(0.251–0.329)	0.331(0.285–0.385)
VPC = ICC(%)		5.3	5.5	5.8	14.0	15.8

Data sources: Authors calculation from NFHS–I–V, Note: 95% Confidence interval in parentheses; ***significant at 1%, **significant at 5%, *significant at 10%; HR = Hazard ratio; VPC - variance partition coefficient, ICC - intra-community correlation coefficient.

implementation of the NRHM by the Government of India in 2005 in order to improve the maternal and child healthcare status in rural India (Nagarajan et al., 2015).

Previous studies show that many other household socioeconomic factors explain the rural-urban gap in U5M (Gebresilassie et al., 2021; Saikia et al., 2013). After controlling for these factors at individual and community levels, our analysis found that the risk of death among under-five children was higher in urban areas in the first three surveys

(NHFS–I to III), which is the opposite of what we found when we did not consider these factors. It appears that rural children's survival disadvantages in the first three surveys resulted in poor socioeconomic conditions, maternal health conditions, and child health conditions (Balarajan et al., 2011; Bhagat, 2014a,b; Chaudhuri and Roy, 2017; Chokshi et al., 2016; ORGI, 2011; Pradhan et al., 2000). Considering these factors, urban children in India have poorer child health outcomes than those in rural areas. Similar results were found in some African countries where urban children experienced higher mortality than their rural counterparts when wealth and sociodemographic factors were controlled (van de Poel et al., 2009). Pamuk et al. (2011) found that the excess likelihood of infant mortality in rural areas was eliminated after adjusting for education and economic resources.

Some studies from India concurred that children living in urban areas have poor health outcomes (Huey et al., 2019; Pörtner and Su, 2018). Pörtner and Su (2018) found that when household wealth and health environment conditions are constant, there are no rural-urban differences in child mortality. However, children who live in slums have worse health outcomes than their rural counterparts. In India, urban dwellers are characterized by greater socio-economic inequality (Vakulabharanam and Motiram, 2018). Access to maternal and child healthcare services varies significantly between women of affluence and those in poverty in urban areas (Montgomery, 2009). In 2018, about 38% of India's urban population lived in slum areas, characterized by inadequate water and sanitation facility, deplorable housing conditions and livelihood opportunity, and limited health, education, and other social service facilities (Kimani-Murage et al., 2014; Padhi et al., 2021). People living in slum areas are less healthy and suffer from a higher poverty level than those in non-slum urban regions (Basta, 1977; Ezeh et al., 2017; Mullick and Goodman, 2005). The slum condition is more associated with a higher level of stunting among slum children (Huey et al., 2019). Therefore, slum children in urban areas have a higher level of mortality than in rural India, which may contribute to poor child health outcomes in urban areas (Pörtner and Su, 2018).

Moreover, the unplanned rapid urban population growth and the increasing slum population are more exposed to environmental hazards, such as pollution, high population density, and increased risk of communicable and infectious diseases (Adiga et al., 2018). Furthermore, according to the WHO global air pollution database, among the 15 most polluted cities globally, 14 belonged to India and were responsible for 1.1 million deaths in India in 2015 (Health Effects Institute, 2020). Recent studies in India show that exposure to air pollution has a negative health impact and increases mortality among children below five years (Mahapatra et al., 2020; Siddique et al., 2011; Singh et al., 2019).

Further, the results from the MECPH model did not find significant rural-urban differentials in U5M in the recent surveys. This indicates that the survival status among urban children has improved. In recent years, urban disadvantage in U5M may disappear after improving the basic amenities in urban slums like education, health, sanitation, electricity, and water facilities (Padhi et al., 2021). Moreover, the government of India in 2013 introduced the NUHM as part of the National Health Mission, keeping the urban poor in view to improve their health condition, which has succeeded in improving infrastructure and better staffing in slum areas (Kumar, 2021). In some high mortality states such as Odisha, Uttrakhand, Chhatisgarh and Assam, the community volunteer known as an Urban Accredited Social Health Activist (Urban ASHA) and Mitanni work under the framework of NUHM played a crucial facilitating maternal and child health services for slum women (Sahoo et al., 2022).

A further finding from the regression shows that increasing mothers' educational attainment significantly reduces the risk of death of their under-five children. The birth that occurred to primary and secondary and above educated mothers have lower levels of U5M than mothers with below primary education. These findings are consistent with past studies in India (Basu and Stephenson, 2005; Bourne and Walker, 1991, 1991, 1991; Kravdal, 2004b; Mandal and Chouhan, 2021; Meitei et al., 2022; Vikram and Vanneman, 2020). The similar finding observed in other low- and middle-income countries (Andriano and Monden, 2019; Balaj et al., 2021; Grépin and Bharadwaj, 2015; Lutz and Kebede, 2018; Pamuk et al., 2011; Wu, 2022). Although primary education has had no significant impact in recent years, secondary and above education of mothers still significantly impacts reducing U5M. It may indicate that primary education may not be efficient in protecting against the current causes of U5M in India. According to WHO (2020), the major causes of U5M have changed from acute lower respiratory infections and diarrheal disease in 2000 to prematurity, birth asphyxia, and birth trauma in 2017 (WHO, 2020).

Further, our findings show that maternal education affected U5M differently in rural and urban areas in the past. Interaction analysis indicates that children born to a secondary and above-educated mother living in urban areas have a lower risk of death than children born to similarly educated mothers living in rural areas. Despite the similar level of education, the lower returns of maternal education on U5M in rural areas may result in poor socioeconomic and health care condition in rural India (Balarajan et al., 2011; Banerjee, 2019; Bhagat, 2014a,b; Chaudhuri and Roy, 2017; Chokshi et al., 2016; Hnatkovska and Lahiri, 2013; IIPS, 1995; Pradhan et al., 2000).

The differential effect of education on U5M may be due to larger differences in the quality and opportunities for education between rural and urban areas, which may result to an unequal return of education for rural and urban areas (Baum-Snow et al., 2018; Combes and Gobillon, 2015; Desai and Vanneman, 2018; Gould, 2007). It is widely known that rural areas have minimal education facilities; most education institutions are located in urban areas, which leads to more options for urban residents (Desai and Vanneman, 2018; National Sample Survey Office, 2018). In 1991, only 30% of women were literate in rural areas as compared to 64% in urban areas (Agrawal, 2014; ORGI, 1991). This figure increased to 57.9% and 79% in 2011 for rural and urban, respectively (ORGI, 2011).

Several pieces of evidence reveal considerable rural-urban education differences in the distribution and quality of education facilities and human capital investment (Opoku-Asare and Siaw, 2015). Education quality differs significantly between rural and urban areas (Desai and Vanneman, 2018; National Sample Survey Office, 2018). Thus, children in urban environments show a higher return to education in terms of cognitive and academic ability, which may be translated into individual health behaviour (Baum-Snow et al., 2018; Combes and Gobillon, 2015; Gould, 2007). A study from India shows that the effect of maternal education on U5M is stronger in the South region than in the northern part of India, this may result from the significant female educational differences between these two regions (Meitei et al., 2022). The female education status is better in India's southern region than in the Northern (ORGI, 2011). There are evidence that the quality of education impacts health in later life, including health behaviour, smoking, obesity, and maternal and child mortality (Frisvold and Golberstein, 2011; Karlsen et al., 2011).

Further, the employment opportunities for educated women in rural-urban areas differ largely (PLFS, 2019). Women's employment is an important component in determining their empowerment. The educated women in areas face constraints in well paid economic activities because of limited opportunities (Lavy and Zablotsky, 2015). Women in rural areas are largely involved in the less paid jobs in agriculture, other manual labour and household activity (PLFS, 2019). Less involvement in paid work leads to less empowerment to make decisions about their child's health (Hossain et al., 2012; Mitra and Singh, 2007). It is documented that the mothers' employment status affects their child's survival status, and the risk of U5M is higher among the children of unemployed women (Akinyemi et al., 2018). The relationship between employment status and child mortality is not consistent; some studies show that a working mother's child has a higher risk of death than not working mothers in developing countries (Ayele et al., 2015; Ghimire et al., 2019; Kishor and Parasuraman, 1998; Naz et al., 2021).

The rural-urban differences in the availability of healthcare services also may have resulted in the lower return of maternal education on children's health in rural areas. Rural areas have less healthcare infrastructure than urban areas in India; women have to travel to urban areas to access healthcare facilities (Balarajan et al., 2011; Chokshi et al., 2016). The distance from the hospitals negatively affects the health facility utilization for rural households (Awoyemi et al., 2011). A study by Chauhan and Kumar (2016) found that the rural women with the same education and economic status as urban women are less likely to use the ANCs, PNCs, and institutional delivery facilities at the time of childbirth.

Additionally, more educated women are clustered in the more developed and the non-slum regions of cities, which may have an additional impact on their children's health, while people living in slums are generally less educated. (Tsujita, 2009). Our findings also show that women living in more educated communities have an additional advantage of a lower risk of death among under-five children.

In recent years, the differential effect of maternal education on U5M between rural and urban has disappeared. This indicates that maternal education similarly positively affects the child's survival status. The evidence shows that NRHM succeeds in increasing the maternal and child healthcare indicators such as uptake institutional of delivery, ANCs and PNCs, nutrition, and immunization through providing affordable, equitable, and quality of healthcare services to the rural population, particularly for the economically poor groups (Vellakkal et al., 2017). The evidence also suggested that the decrease in the rural-urban disparity in U5M has been attributed to improvements in household wealth status, maternal education, transportation connectivity, and health infrastructure in rural areas (Kumar et al., 2020; Sahu et al., 2015). Another important intervention to improve the economic status of the rural household is the implementation of the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA, 2005) has implemented. The MGNREGA provides poor rural households with legal guarantees of at least 100 days of employment at minimum wages each year. In rural areas, the evidence indicates a positive impact on women's empowerment and their participation in household decision-making (Bhat and Mariyappan, 2016; Mattos and Dasgupta, 2017; Rajalakshmi and Selvam, 2017). It was also found that participation in the MGNREGA was associated with an improvement of infant nutritional status in Rajasthan, India (Nair et al., 2013). The MGNREGA significantly improved the income of rural households (Patwardhan and Tasciotti, 2022; Varman and Kumar, 2020). The economic status is negatively associated with the risk of U5M (Chao et al., 2018). Women in more affluent households receive more ANCs, and PNCs, have better nutrition and use institutional facilities during childbirth more often, which reduces the risk of child death (Ahmed et al., 2010; Kumar et al., 2019).

Results of the random part from the MECPH indicate that community-level factors affect U5M in India. The ICC revealed a correlation in child death within the community, and VPC suggests that a significant proportion of total variance lies at the community level. The finding suggests that for analyzing the predictors of the U5M, the community-level factors should take into account to get a robust estimate. Previous studies highlighted the importance of the community level factors on U5M in India Several studies have documented the effects of community characteristics on child mortality in India (Bora, 2020; Kravdal, 2004b; Kumar et al., 2012; Lutz and Kebede, 2018). However, very few studies accounted for censoring or considered the time-to-death information in the mortality analysis (Meitei et al., 2022).

5. Conclusions

This study extended the literature on the association between maternal education and U5M by comparing rural and urban settings within the country using the five rounds of the NFHS between 1992–93 and 2019–21. Evidence of the differential effect of education on U5M is crucial for understanding the mortality transition and the future population dynamics in developing countries. Employing the MECPH facilitate the robust estimate for analyzing predictors of U5M accounting for the clustering due to unobserved cluster characteristics and censoring data in the time-to-event data. Understanding the association between mothers' education and U5M for the last three decades will be a policy insight to improve the child's health status through social policies. The trends analysis able to show that how the association of these variables has changed over the last three decades. The finding indicates that maternal education significantly positively affects U5M in India; however, the degree of effect has changed over time. In recent years, there have been no significant differences in U5M of the below primary and primary education mothers' children. Mothers' secondary and above education has a stronger positive impact on U5M. The findings show that maternal education was not equally beneficial to U5M in rural and urban areas in the past but that in recent years, maternal education has had similar effects on U5M in India. For the further decline in U5M in rural and urban areas, with the continuation of the existing policy, there is a need to increase the educational opportunities in rural and urban areas, mainly focusing on secondary education for girls.

5.1. Strengths and limitations of the study

The study's strength is that it used five nationally representative data representing India's findings at different time points. The larger sample size, high response rate, and rigorous statistical methods provide much more reliable estimates. Moreover, using multilevel hierarchical input in the model, our study examines these numerous factors and the interaction between mothers' educational level and place.

This study's limitation is the lack of information on known important determinants of U5M factors such as the proximity to a health care facility, transportation, and social customs, therefore, not used in the analysis. Further, there might be some under-reporting of child deaths. The sample was collected based on retrospective self-reports from mothers. There might be the possibility that mothers may find it difficult to reveal mortality information. Uneducated women, poorer women, and older women may have been among those who would most likely fail to report deaths and the child's age. However, we have restricted our analysis to the births during the last five years to minimize the recall biases.

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