Beyond the Biological Prime: Deciphering the Link Between Child Survival and Maternal Age in India

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Abstract

This paper investigates the impact of maternal age at birth on child mortality in India, the world's most populous country burdened with significant neonatal and infant mortality. Utilizing data from the latest National Family Health Surveys, covering around 1 million children, our analysis incorporates models with household and biological-mother fixed-effects to address unobserved heterogeneity. Outcomes include neonatal mortality (<28 days), infant mortality (<12 months), and under-5 mortality. Findings reveal a U-shaped relationship between maternal age and child mortality, with the highest risk for mothers below 17 and above 40 years old. Robustness checks confirm the enduring significance of maternal age even after adjusting for socioeconomic factors and time-variant unobservables. Moreover, models with biological-mother fixed-effects suggest higher risks compared to models that only control for observables, indicating that regressions without controls for time-invariant heterogeneity may underestimate the risks of maternal age at birth.

Key Words: Maternal age, Child mortality, India
JEL Codes: I12, J13, O15

1. Introduction

Despite significant improvements over time, child mortality rates in India remain high, especially in relation to other middle-income countries in East and Southeast Asia (Figure 1). In terms of absolute number of child deaths, India ranks second to only Nigeria, with 709,366 Indian children dying under the age of 5 years (WHO, 2022). A significant body of literature, primarily from developed countries, has established a correlation between both young and advanced maternal age at birth and an increased risk of adverse birth outcomes, including early-life mortality. However, there is limited understanding regarding the causal effect of maternal age at birth on early-life mortality in high-burden countries like India.

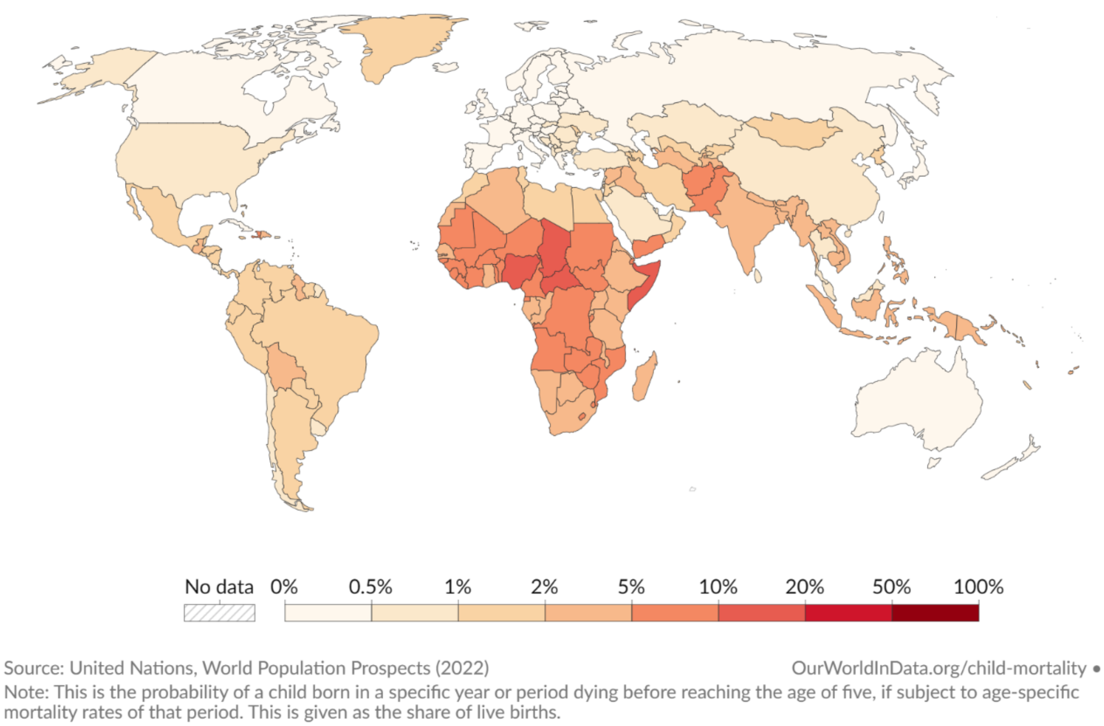

Figure 1: Share of children who die before reaching the age of five years, by country, 2021.

Unraveling the causal effect of maternal age at birth is not straightforward. Teen mothers may have lower levels of education and limited access to resources, whereas mothers who give birth at advanced ages may face a complex interplay of factors, including advanced education and working commitments, or potentially other socio-economic challenges in the marriage market related to religion or caste. From a biological perspective, with older age, research suggests that oocyte (immature egg cell) quality may decline, and there may be a higher risk of chronic conditions that could lead to riskier births (Attali and Yogev, 2021; Moghadem et al., 2022). However, as more women seek education and focus on their careers, it is possible that they may be able to mitigate some of the additional biological risk of mortality for their newborn children through better nurturing, such as seeking pre- and post-natal health care and better child feeding and nutritional practices. Overall, these effects make it difficult to isolate the effects of maternal age at birth from confounding variables.

We examine the effect of maternal age at birth on neonatal, infant, and under-five child mortality using two large, nationally-representative household surveys from India – the National Family and Health Surveys (NFHS) of 2015-16 and 2019-2021.[1] These surveys include information on nearly one million births spanning the 15-year period 2005-20. We estimate the relationship using OLS models that include as controls several individual and family background variables to account for selection into early or advanced motherhood. We also estimate models with household and maternal fixed effects to control for unobserved household and individual heterogeneity that might affect selection into motherhood at different ages.

Our analysis reveals a U-shaped pattern, indicating higher risks for very young mothers (under 12) and the oldest mothers (40 years and older) compared to mothers aged 21-23. Although the risk differences between the youngest and oldest mothers are not statistically significant, the utilization of maternal and household fixed effects produces larger estimates, suggesting that OLS estimates underestimate risks for mothers below 18 or above 30. This underscores the necessity of incorporating maternal fixed effects to better comprehend the genuine biological risk associated with late childbearing, accounting for the competing effects of biological and socioeconomic factors.

[1] In India, the DHS surveys are referred to as the National Family Health Surveys (NFHS).

In the context of birth outcomes in low- and middle-income countries (LMICs), our study pioneers the identification of a robust U-shaped relationship between maternal age and birth outcomes, meticulously addressing selection bias with an extensive sample of nearly 1 million births. While previous research predominantly concentrated on developed nations and teenage births with restricted samples (Aizer et al., 2022), our study extends these insights to the unique challenges faced in LMICs. Although research in Finland and Norway (Aizer et al., 2022; Fredriksson et al., 2022) provides valuable contributions, it does not fully capture the specific hurdles encountered in LMICs, where child mortality and underdevelopment are critical issues, and healthcare services are not as comprehensive for both teenage and advanced-age mothers. Additionally, our study contributes by addressing selection biases through multiple approaches, examining births across women in the same households and those from the same biological mothers.

2. Data

We analyze two waves of the National Family and Health Survey (NFHS) from India: 2015-16 and 2019-21.[2] This survey is a national representative sample of women aged 15–49, their children, and their spouses/partners aged 15–49. We collected data on complete fertility histories, including child deaths, for ever-married women aged 49 years and younger. This information allows us to track child mortality from birth. Our study focuses on neonatal mortality (within the first 28 days of birth), infant mortality (within the first year of life), and child mortality under 5 years of age. To ensure accurate results, we exclude children born in the 28 days, first twelve months, and first 5 years before the survey date, depending upon whether we are analyzing neonatal, infant, and child mortality, respectively. To address concerns about recall accuracy, our analysis considers only births occurring in the 10 years preceding the survey date, although, as a robustness check, we also conducted similar analysis using data within 5 and

[2] We focused on NFHS-4 (2015-16) and NFHS-5 (2019-21) due to their larger sample sizes and more recent data, which provide significantly more representative insights at the district level. This allows us to better assess current trends in child mortality and recent policy changes in India. NFHS-4 and NFHS-5 covered 600,000 and 630,000 households, respectively, in contrast to the much smaller sample sizes of NFHS-2 and NFHS-3, which included only 91,000 and 109,000 households. The older data from NFHS-2 and NFHS-3 does not offer the same level of representation needed to analyze recent developments. Additionally, NFHS-4 and NFHS-5 used Computer-Assisted Personal Interviewing (CAPI) for data collection, which enhances accuracy and efficiency, unlike the paper-based methods used in earlier surveys. These advancements provide a more granular and comprehensive dataset, crucial for examining the causal effects of maternal age at birth on early-life mortality.

20 years preceding the survey date (results available upon request). Mother's age at birth is measured in years and refers to mother's age at the time of birth of a child. We also include a large number of covariates, including religion, caste, urban/rural residence, education, wealth and a child's gender, to control for socioeconomic effects on the risk of child mortality.

Table 1 shows descriptive statistics for the pooled sample from the two rounds of the survey. The dataset includes a large number of observations for neonatal (1,052,264), infant (1,017,990), and under-5 (846,912) mortalities, offering us the opportunity to estimate the relationship between child mortality and mother's age at birth with great precision.

The proportions of live births dying within specific time frames are relatively large: 2.8% within 28 days, 4.4% within 12 months, and 5.7% within 60 months (translating into neonatal, infant and under-5 mortality rates of 28, 44 and 57 per 1,000 live births). The average age at which mothers gave birth (any birth, not necessarily their first birth) is roughly 25 years, although there is wide variation in the age at which births occur. Only about 4% of births occurred at maternal ages less than 18, with 18% occurring at ages 18-20 and 26% occurring at maternal ages 21-23. Beyond age 29, births are more infrequent, with roughly 15% of all births in the sample occurring at ages 30-38 years and only about 1½% at ages 39 and above.

Table 1: Descriptive Statistics

Variable	*Mean*	*Std. dev.*
Proportion of live births dying within the first:		
28 days of birth	0.028	0.166
12 months of birth	0.044	0.204
60 months of birth	0.057	0.233
Mother's age at birth of child (in years)	24.584	5.105
Proportion of mothers giving birth at age (years):		
Less than 12	0.000	0.007
12 to 14	0.002	0.047
15 to 17	0.039	0.193
18 to 20	0.180	0.384
21 to 23	0.259	0.438
24 to 26	0.216	0.411
27 to 29	0.141	0.348
30 to 32	0.082	0.274
33 to 35	0.045	0.207

36 to 38	0.023	0.151
39 to 41	0.010	0.100
42 to 44	0.003	0.052
45 to 49	0.001	0.023
Mother's schooling		
None	0.324	0.468
Some primary	0.107	0.309
Primary complete	0.042	0.201
Some secondary	0.396	0.489
Secondary complete	0.042	0.201
Post-secondary	0.089	0.285
Household's religion		
Hindu	0.724	0.447
Muslim	0.152	0.359
Christian	0.083	0.276
Other	0.041	0.199
Household's caste		
Scheduled caste	0.203	0.402
Scheduled tribe	0.214	0.410
Other Backward Caste	0.401	0.490
Other	0.182	0.385
Whether household headed by female	0.134	0.341
Household's place of residence		
Urban	0.223	0.416
Rural	0.777	0.416
Household's composite wealth quintile		
Poorest	0.279	0.448
Second	0.237	0.425
Third	0.194	0.396
Four	0.162	0.368
Richest	0.129	0.335
Proportion of births that are female	0.479	0.500
Number of observations for:		
neonatal mortality	1,052,264	
infant mortality	1,017,990	
under-5 mortality	846,912	

Notes: Authors calculations using pooled NFHS Data from 2004-05 and 2019-21 rounds.

Education levels are low in the sample, with nearly a third of births taking place among mothers with no formal schooling. The majority, 72%, of births are to Hindu mothers, and an even larger proportion (82%) to mothers from "scheduled castes" (SCs), "scheduled tribes" (STs), and other backward castes (OBCs). Slightly more than three-quarters of the births took place in rural areas, with the remaining in urban and semi-urban areas. The distribution of births across wealth quintiles indicates a higher proportion (52%) of births in the poorest and second quintiles, reflecting higher fertility rates among mothers from poor backgrounds. The gender distribution of births shows that only 48% are female, reflecting the continuing problem of "missing girls and women" in India (Sen 1992; Saika et al., 2021).

Figure 2 plots infant mortality rates (IMR) against mother's age at birth (in two-year intervals). (In Appendix Figures A1 and A2, we present similar graphs for neonatal and under-5 mortality.) We find a strong U-shaped curve, with IMRs that are highest for the youngest mothers but that decline with age up to the mid-20s. After this point, the mortality risk for infants increases such that it is approximately as high for births occurring when the mother is aged 39-40 years as it is when she is 17-18 years of age.

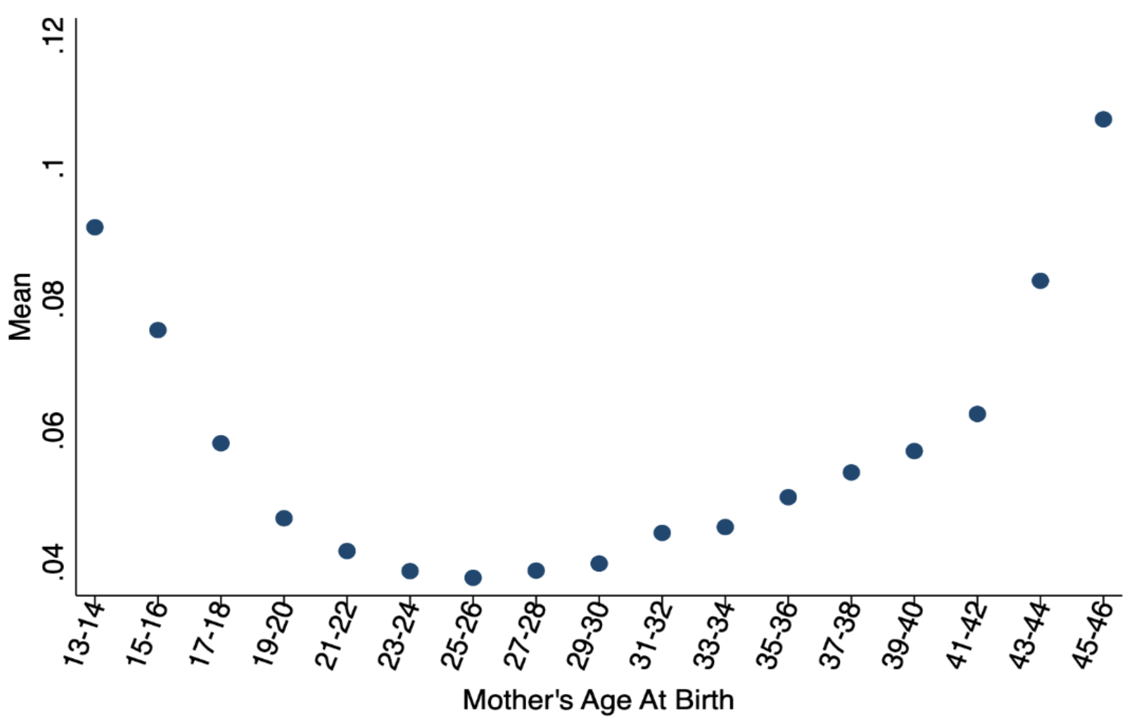

Figure 2: Share of ever-born children dying before the age of one year, by mother's age at birth, pooled data from NFHS 2015-16 and 2019-21 for all births in the 10 years preceding survey.

3. Methods

In our study, we use OLS models of mortality determination with controls for maternal and household characteristics as well as models incorporating household fixed effects and biological mother fixed effects. These adjustments help account for unobserved attributes that remain constant over time and could potentially skew (bias) the relationship between mother's age and birth outcomes. Moreover, we control for mother's age in flexible ways to obtain a more robust link between child mortality and mother's age at birth.

To describe the relationship between death outcome D_i for child i of mother j residing in household k, we use four variants of an OLS regression of the likelihood of neonatal, infant, and child mortality as a function of mother's age at birth and several control variables:

$$\text{(1a)} \quad D_{ijk} = f(A_{ijk}) + g(t_{ijk}) + \mu_{ijk}$$

$$\text{(1b)} \quad D_{ijk} = f(A_{ijk}) + g(t_{ijk}) + \boldsymbol{\beta}\, \boldsymbol{H}_k + \gamma\, S_j + \delta\, F_{ijk} + \mu_{ijk}$$

$$\text{(1c)} \quad D_{ijk} = f(A_{ijk}) + g(t_{ijk}) + \gamma\, S_j + \delta\, F_{ijk} + \varphi_k + \mu_{ijk}$$

$$\text{(1d)} \quad D_{ijk} = f(A_{ijk}) + g(t_{ijk}) + \delta\, F_{ijk} + \zeta_j + \mu_{ijk}$$

where D is a dichotomous variable assuming a value of one for a birth outcome ending in death within a period of 28 days, one year, or five years, respectively (depending upon whether neonatal, infant or child mortality is being "explained") and zero otherwise; A is the mother's age at the time of the i^{th} child's birth, and t denotes the year of the reference child's birth.[3] Household characteristics (e.g., religion, caste, urban/rural residence status, whether it is headed by a female, and the wealth quintile to which it belongs[4]) are represented by the vector $\boldsymbol{H}$, while S

[3] In practice, we define t as a child's birth year minus 2004, so that the variable t ranges from a value of one for the earliest birth in our sample to a value of 17 for the most recent birth.

[4] The wealth index used in the NFHS – and more generally in the Demographic and Health Surveys worldwide – is a composite measure of a household's living standard based on household ownership of certain assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities. Generated with principal components analysis, the wealth index places individual households on a continuous scale of relative wealth. The survey only reports the wealth quintile that each household falls in.

stands for the mother's completed schooling. F is a dummy variable indicating whether the i^{th} child is female. φ_k denotes household fixed effects, while ζ_j denotes mother fixed effects.

Equation 1(a) only includes the mother's age at birth and time trends as control variables. The inclusion of time trends is important to capture general improvements in medical technology and public health infrastructure for safe deliveries that would have reduced mortality for all children in the sample --irrespective of their mothers' socioeconomic status – during the span of 16 years covered by our data.

Equation 1(b) adds household-, mother-, and child-specific variables as controls, while equation 1(c) adds household fixed effects that allow for comparison of children from biological sisters, foster families, or other women who are related within a family. Equation 1(d) is our preferred model that includes control for unobserved maternal heterogeneity that could influence the mother's choice of early or late childbearing. Obviously, household-specific variables are dropped with control for household fixed effects in 1(c), and both household- and mother-specific variables are dropped with control for mother fixed effects. We also controlled for birth order effects in our preferred model (mother fixed effects) and the results remain robust.[5]

In addition, we estimated equations 1(a) and 1(b) with the maximum-likelihood logit method but found no appreciable differences in the significance or sign of the estimated coefficients. Since fixed-effects logit estimation is computationally challenging for a sample as large as the one we use (with a million observations), we restrict ourselves to OLS estimates for all four specifications.

The function $f(A_{ijk})$ is expressed in terms of a set of dummy variables for different three-year age intervals, starting with mothers who were 11 years and younger at the time of birth and ending with mothers who were 45 years and older. This method offers more flexibility than almost any other parametric functional form we could have chosen to represent mother's age at birth.

[5] The results are available upon request.

4. Results

4.1. Main Results

Table 2 reports the OLS – including fixed-effects – regression results for the likelihood of a live birth ending in death during the first year after birth. Appendix Tables A1 and A2 display the corresponding estimates for live births ending in 28 days and five years after birth, respectively. Because the results for neonatal mortality and under-five mortality are broadly similar to those obtained for infant mortality, we focus our discussion here on the infant mortality results (viz., infant death within one year of birth) shown in Table 2.

Table 2: Determinants of the likelihood of a live birth ending in death within 12 months

	OLS		*OLS with controls*		*Household fixed effects*		*Mother fixed effects*	
Independent Variable	*Coeff.*	*T-Ratio*	*Coeff.*	*T-Ratio*	*Coeff.*	*T-Ratio*	*Coeff.*	*T-Ratio*
Mother's age (in years)								
Less than 12	0.116	2.350	0.119	2.360	0.153	3.940	0.143	3.500
12 to 14	0.048	8.140	0.046	7.340	0.081	12.460	0.074	10.140
15 to 17	0.026	19.820	0.024	17.670	0.042	22.000	0.034	13.020
18 to 20	0.008	13.070	0.007	11.400	0.013	13.320	0.009	6.450
21 to 23								
24 to 26	-0.003	-5.090	-0.003	-4.370	-0.006	-6.490	-0.001	-0.640
27 to 29	-0.002	-3.170	-0.002	-3.030	-0.008	-5.800	0.003	1.230
30 to 32	0.002	2.700	0.002	1.850	-0.005	-2.650	0.011	3.270
33 to 35	0.005	4.780	0.003	2.700	-0.005	-1.880	0.017	3.750
36 to 38	0.012	8.200	0.008	5.420	0.002	0.760	0.032	5.330
39 to 41	0.016	6.930	0.009	3.950	0.011	2.410	0.047	6.090
42 to 44	0.041	7.900	0.031	5.950	0.042	5.810	0.086	8.440
45 to 49	0.064	4.710	0.056	4.060	0.071	4.980	0.107	6.380
Number of observations	1017990		973510		781795		749096	
Mean of dependent variable	0.044		0.044		0.050		0.051	

Notes: "Coeff." represents key coefficients/parameters of interest, and T-Ratio indicates the statistical significance of coefficients, with values above 1.96 considered significant at the 5% level. All models control for time trends up to the 4th polynomial. In addition, the "OLS with controls" model includes mother's schooling, household's religion, household's caste, whether the household is headed by a female, mother's urban/rural residence, and reference child's gender. The household fixed effect model controls for mother's schooling and child gender. The mother fixed effect model controls for child gender.

Figure 3 plots the estimated coefficients on the 11 age categories (dummy variables) for our preferred specification – namely, mother fixed effects and contrast it with OLS models with controls (shown in Table 2). We have not shown estimates for those less than 12 in Figure 3 (in contrast to Table 2 where we do) as there are few observations here and the confidence intervals are very large for all models (results available upon request). For ease of interpretation, we have multiplied the estimated coefficients by 1,000, so the y-axis reflects the higher infant mortality rate of a specific age group of mothers relative to the excluded age category of 21-23 years.

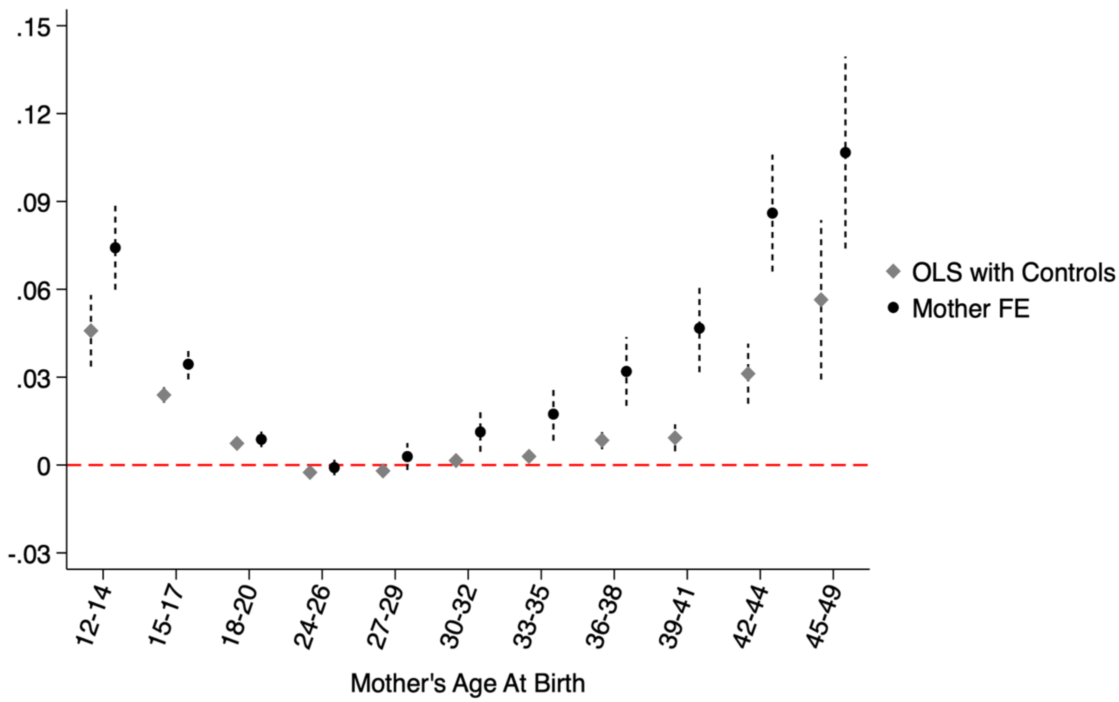

Figure 3: Estimated change in the infant mortality rate (IMR) with 95% confidence intervals for different mothers' ages at birth (relative to the IMR of mothers aged 21-23 years), mother's fixed effects, and OLS with controls models.

There are few observations that can be made from Table 2 and Figure 3. First, all four model specifications in Table 2 – OLS, OLS with controls, household fixed effects, and mother fixed effects – indicate a U-shaped pattern between the risk of infant mortality and a mother's age at birth of a child, with the risk being higher for very young mothers – those aged under 15 – and the oldest mothers – those aged 40 years and older – relative to mothers aged 21-23. Second, the point estimates suggest that the magnitude of the infant mortality risk also have a symmetry in them that risk for older mothers mirrors that for youngest mothers. Indeed, Figure 3 shows that the mortality risk for children born to mothers aged 12-14 years and 15-17 years are also not significantly different from the risk faced by children born to mothers aged 42-44 years and 39-41 years, respectively. It is only when we compare mothers aged 18-20 against mothers aged 36-38 years that we begin to see significantly different mortality risks, with the infant mortality risk being significantly greater for the latter age group. The third observation is that among both the young mothers (those under 18) and older mothers (above 30), the household and mother fixed effects specifications yield infant mortality risk estimates that are larger in magnitude than the corresponding OLS estimates. This suggests that OLS estimates that do not control for unobserved household or maternal heterogeneity underestimate the risk of infant mortality from childbearing below the age of 18 or above the age of 30. The exception is the very extreme tail (e.g., age 45-49), where, although the point estimates for models measuring mother-child effects are much higher than OLS models, the confidence intervals are large enough that they overlap. This may be because, as discussed in Table 1, only 1% of our sample consists of mothers aged 45-49.

4.2. Discussion

Mechanisms: We hypothesize that there are two competing effects of maternal age on the risk of mortality for a child: (i) a biological effect whereby older mothers are more likely to have both lower oocyte (or immature egg cell) quality and chronic health conditions (e.g., elevated blood pressure), both of which could result in delivery complications and higher risk of mortality for the newborn; and (ii) a socioeconomic or self-selection effect whereby older mothers elect to delay child-birth because they are confident that, with their better education and socioeconomic status and more experience at childbearing, they will be able to mitigate their child's mortality risk through such health-improving interventions as timely pre- and post-natal care and better child feeding and nutritional practices. The two effects are likely to work against one another. Simple OLS estimates confound these two effects, whereas maternal fixed effects' estimates control for the selection/socioeconomic effect and better highlight the 'pure' biological effect. If this is the case, our results suggest that the true (biological) risk of childbearing is similar among mothers aged 18-29 years but is higher for both young (under 18) and older mothers (over 29) than suggested by naïve OLS estimates of infant mortality.

Heterogeneity: Despite a substantial sample size of almost a million observations, the tails of the sample, specifically the extremely young or advanced-age mothers, are relatively small (refer to Table 1). Consequently, our capacity to explore heterogeneity of the child mortality–mother's age relationship over time and across different dimensions of socioeconomic or demographic status is limited. Nevertheless, we conducted various tests to explore heterogeneity as follows:

Time Trends: To investigate whether the effects of mother's age on child mortality are influenced by improvements in medical technology, public health and hygiene, and infrastructure of institutional deliveries that promote safe deliveries and health of newborns and infants, we examined the implied time trends in infant mortality for each year in the sample. The results, presented in Appendix Figure A5, suggest a positive and increasing trend in 'pure' technology and infrastructure effects since 2014.[6] Subsequently, we re-estimated our preferred models (mother fixed effects), dividing the sample into those born before and after 2014. No significant differences were observed by age categories before and after 2014. (Results are available upon request.)

Child Gender: To consider the notion that male newborns intrinsically are less likely to survive, we studied if the maternal age effects varied by child gender (Cullen et al 2015; Hossin 2012). Our findings indicate that female infants generally have lower mortality risks than male infants for mothers *of all ages*, but we observed no statistically significant gender differences in the mortality risk–maternal age relationship (results are available upon request). Our results thus suggest that the biological female survival advantage at very young ages – observed in most populations around the world – appears to dominate any social disadvantage against female infants and girl children that has been commonly observed in India (Sen 1992; Saika et al., 2021).

[6] It is not clear what could account for this increase. Clearly, it cannot be attributed to the Covid pandemic alone, as the increase in infant mortality predates the pandemic by several years. Perhaps, our results indicate that the latter half of the decade of the 2010s was a period of stagnant investments in safe delivery infrastructure in India. It was also a period of sharply rising air pollution in the country, which is known to contribute to upper respiratory infections among pregnant women and newborns. Upper respiratory infections are a leading cause of infant and child mortality in India. It should be noted, however, that our results do not imply that actual infant mortality was rising during the decade of the 2010s in India; indeed, it declined significantly over this period. What our results suggest is that, had household incomes and maternal schooling not increased as much as they did, infant mortality might have increased. In turn, this implies that improvements in household income and female education hide the disappointing impact of public health infrastructure investments and medical technology on the infant death rate.

Parental Socioeconomic Status (SES): To explore the hypothesis that educated mothers and their financially stable families may make greater mortality-reducing investments, we estimated our preferred mother fixed-effects model separately for less- and more-educated mothers as well as for mothers from lower and higher wealth quintiles. However, we did not find any significant and meaningful differences across the disaggregated groups. Results are available upon request.

These heterogeneity explorations suggest some potential factors that may be influencing the child mortality–maternal age patterns. However, due to the small sample size at the extreme tails of the maternal age distribution, we are unable to discern this heterogeneity.

Limitations: Although fixed-effects models control for unobserved, time-invariant characteristics of mothers and households, they do not account for time-varying unobserved factors, such as changes in health status, access to healthcare, or income, which could also influence early-life mortality. If these factors are correlated with maternal age, they could bias the estimates. That said, we control for birth order effects to assess the importance of child-specific time-varying factors, and our results remain robust.

5. Conclusion

How do child outcomes vary based on the age of mothers at birth in LMICs? To address this question, we capitalize on the variation in age at birth among biological siblings from the same mother and across children born to mothers in the same extended family (household), utilizing data from nearly a million births in India. Our examination of mother's age at birth in relation to child mortality reveals a U-shaped pattern, signifying higher risks of mortality for both very young and older mothers compared to those aged 21-23. Specifications with household and mother fixed effects underscore the underestimation of risks by OLS models, emphasizing the importance of accounting for unobserved heterogeneity. The findings highlight the significant impact of maternal age on infant mortality, with biological factors being underestimated due to confounding effects that may not be adequately controlled by standard OLS models. Similar patterns emerge for neonatal mortality and under-5 mortality rates.

Why do risks associated with births from very young or advanced-age mothers persistently remain high in India? Is it influenced by the nation's status as a low- to middle-income country with a substantial burden of infant mortality (nurture), or does it originate from genetic factors specific to South Asians (nature or epigenetics)? Some evidence from high-income countries suggests that women of South Asian background experience higher rates of stillbirth at term compared to other women, perhaps attributable to the earlier maturation of the placenta among these women (Davies et al., 2017; Ravelli et al., 2011; Balchin et al., 2007; Audette et al., 2018; Maiti et al., 2017). Analogous studies on heart attack and cardiovascular risks reveal that South Asians face higher risks than whites at the same BMI level (Gujral et al., 2013), resulting in different obesity thresholds for South Asians and whites (Narayan and Karaya, 2020). This suggests that future research needs to investigate the disparities in birth risks associated with maternal age, delving into the nuanced interplay of socioeconomic, environmental (e.g., disease burdens), and race and epigenetic (e.g., ethnicity and race) factors.

Declaration of generative AI and AI-assisted technologies in the writing process
During the preparation of this work the author(s) used Chat GPT 3.5 in. limited manner as an editorial assistant to fix any typing errors and improve readability. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of conflict of interest: None to declare by any of the authors.

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Online Appendix

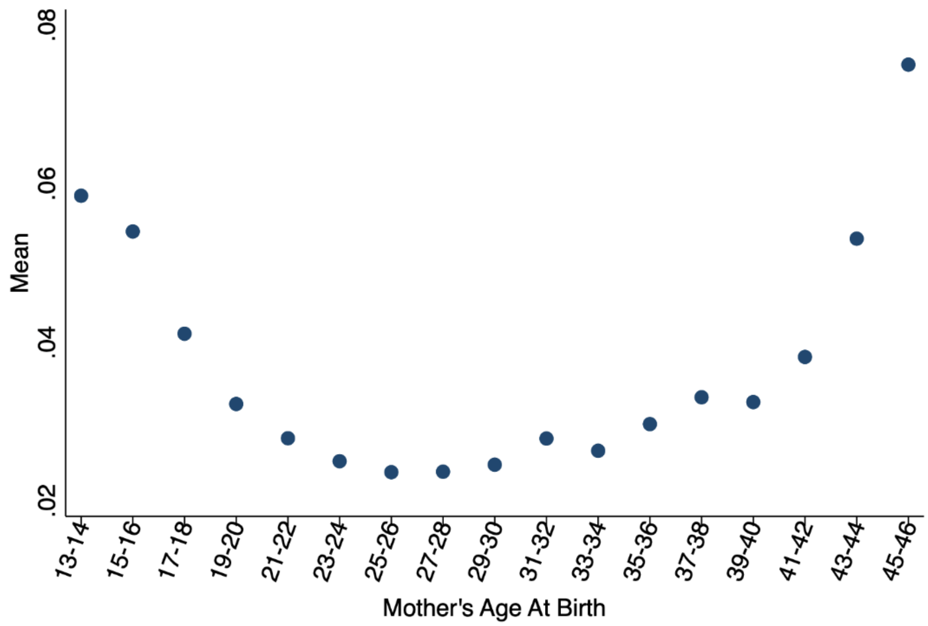

Figure A1: Share of ever-born children dying before 28 days of birth, by mother's age at birth, pooled data from NFHS 2015-16 and 2019-21 for all births in the 10 years preceding survey.

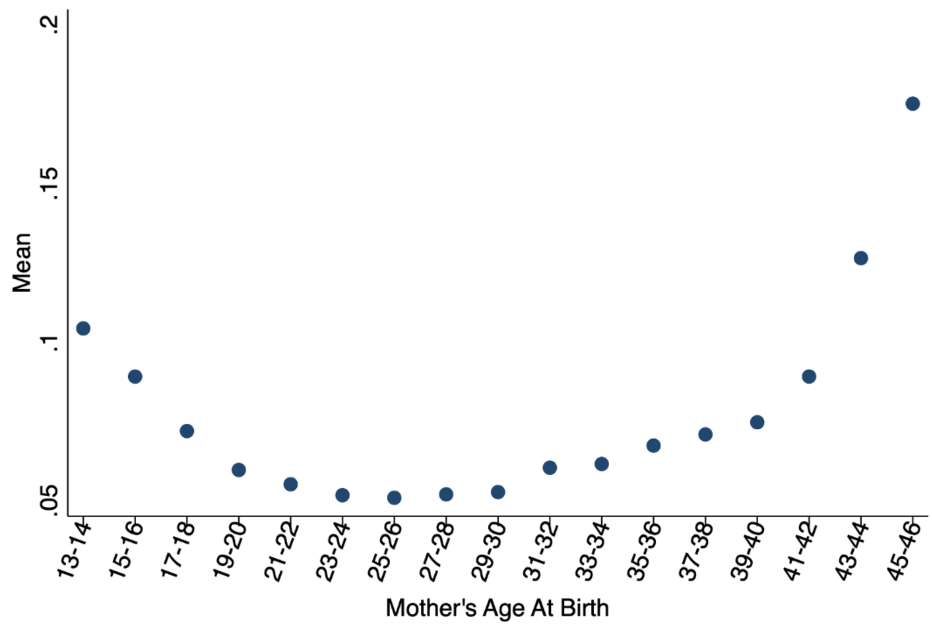

Figure A2: Share of ever-born children dying before 60 months of birth, by mother's age at birth, pooled data from NFHS 2015-16 and 2019-21 for all births in the 10 years preceding survey.

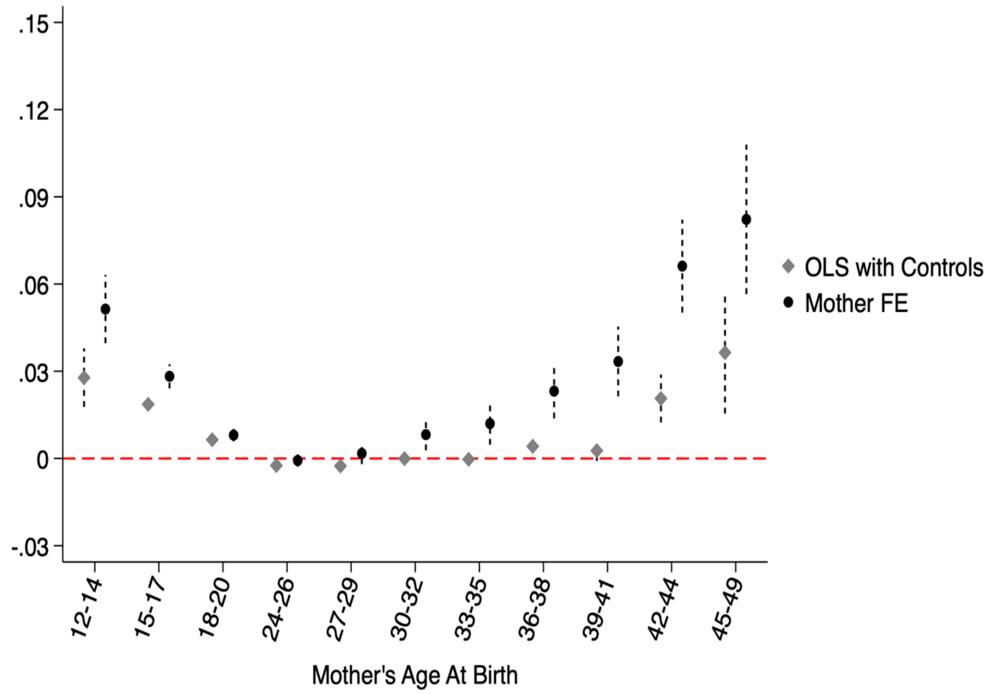

Figure A3: Estimated change in the neonatal mortality rate (NMR) with 95% confidence intervals for different mothers' ages at birth (relative to the NMR of mothers aged 21-23 years), mother's fixed effects and OLS with controls models.

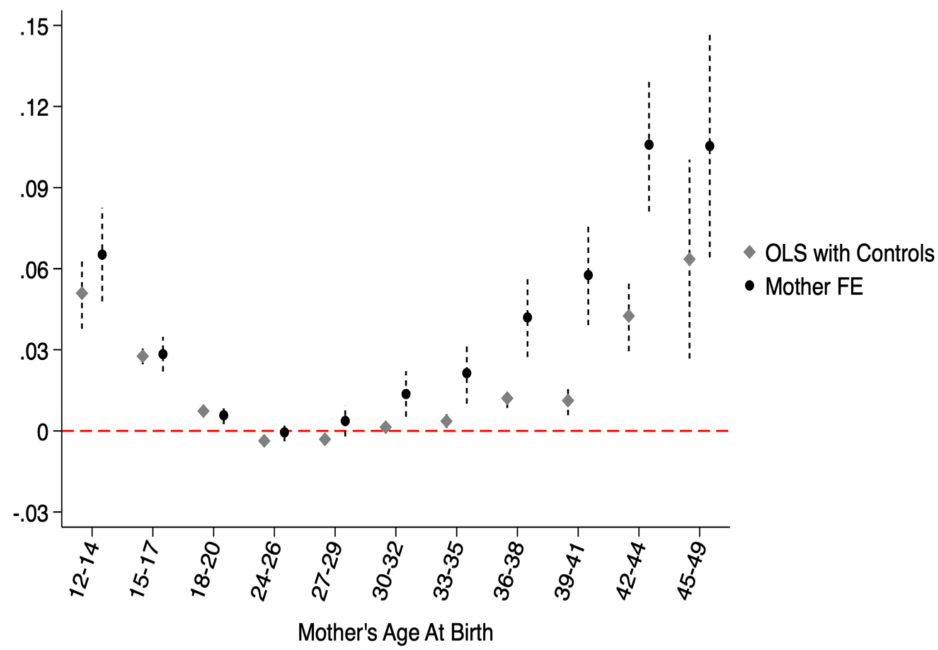

Figure A4: Estimated change in the under-5 mortality rate (U5-MR) with 95% confidence intervals for different mothers' ages at birth (relative to the U5-MR of mothers aged 21-23 years), mother's fixed effects and OLS with controls models.

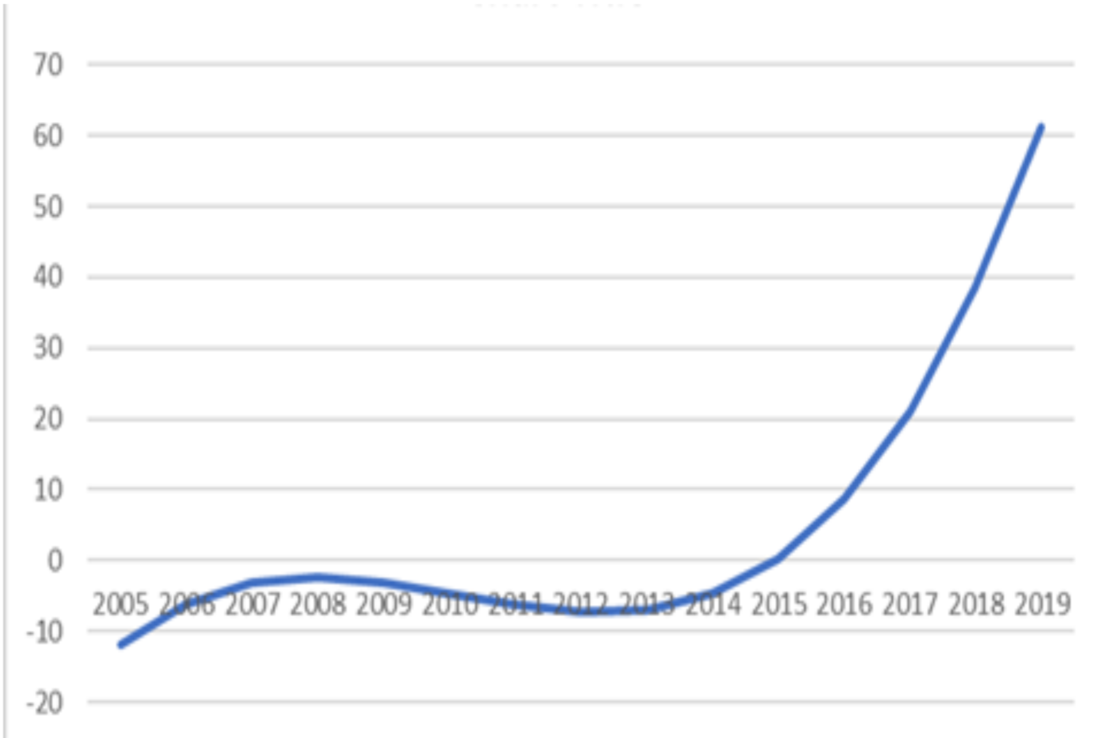

Figure A5: Estimated change in infant mortality rate over time, net of household and maternal influences, 2005-19 (mother fixed effects specification).

Table A1: Determinants of the likelihood of a live birth ending in death within 28 days								
	OLS		*OLS with controls*		*Household fixed effects*		*Mother fixed effects*	
Independent Variable	*Coeff.*	*T-Ratio*	*Coeff.*	*T-Ratio*	*Coeff.*	*T-Ratio*	*Coeff.*	*T-Ratio*
Mother's age (in years)								
Less than 12	0.030	-0.890	0.032	-0.920	0.091	-2.740	0.081	-2.350
12 to 14	0.029	-5.950	0.028	-5.390	0.057	-10.620	0.051	-8.570
15 to 17	0.019	-17.570	0.019	-16.210	0.034	-21.990	0.028	-13.300
18 to 20	0.007	-13.410	0.006	-12.090	0.012	-14.550	0.008	-7.390
21 to 23								
24 to 26	-0.003	-6.370	-0.002	-5.230	-0.005	-6.380	-0.001	-0.640
27 to 29	-0.003	-6.230	-0.003	-4.970	-0.007	-6.250	0.002	-0.930
30 to 32	0.000	-0.630	0.000	-0.080	-0.005	-3.150	0.008	-2.980
33 to 35	0.000	-0.260	0.000	-0.340	-0.005	-2.770	0.012	-3.230
36 to 38	0.005	-4.290	0.004	-3.420	-0.001	-0.230	0.023	-4.830
39 to 41	0.005	-2.750	0.003	-1.490	0.004	-1.080	0.033	-5.440
42 to 44	0.026	-6.110	0.021	-4.900	0.030	-5.270	0.066	-8.110
45 to 49	0.039	-3.730	0.036	-3.400	0.047	-4.250	0.082	-6.270
Number of observations	1052264		1006103		813870		778009	
Mean of dependent variable	0.028		0.029		0.032		0.033	

Note: "Coeff." represents key coefficients/parameters of interest, and T-Ratio indicates the statistical significance of coefficients, with values above 1.96 considered significant at the 5% level. All models control for time trends up to the 4^{th} polynomial. In addition, the "OLS with controls" model includes mother's schooling, household's religion, household's caste, whether the household is headed by a female, mother's urban/rural residence, and reference child's gender. The household fixed effect model controls for mother's schooling and child gender. The mother fixed effect model controls for child gender.

Table A2: Determinants of the likelihood of a live birth ending in death within 5 years								
	OLS		*OLS with controls*		*Household fixed effects*		*Mother fixed effects*	
Independent Variable	*Coeff.*	*T-Ratio*	*Coeff.*	*T-Ratio*	*Coeff.*	*T-Ratio*	*Coeff.*	*T-Ratio*
Mother's age (in years)								
Less than 12	0.111	2.250	0.114	2.240	0.152	3.540	0.140	3.090
12 to 14	0.054	8.470	0.051	7.570	0.076	9.640	0.065	7.380
15 to 17	0.031	20.790	0.028	18.000	0.038	15.970	0.028	8.660
18 to 20	0.009	11.570	0.007	9.620	0.011	8.870	0.006	3.420
21 to 23								
24 to 26	-0.004	-5.910	-0.004	-5.270	-0.006	-5.350	-0.001	-0.330
27 to 29	-0.003	-3.780	-0.003	-3.870	-0.008	-4.780	0.004	1.250
30 to 32	0.003	2.620	0.001	1.380	-0.004	-1.780	0.014	3.170
33 to 35	0.007	5.310	0.004	2.730	-0.002	-0.730	0.021	3.700
36 to 38	0.017	9.680	0.012	6.510	0.010	2.360	0.042	5.620
39 to 41	0.020	7.440	0.011	4.050	0.018	3.300	0.058	6.090
42 to 44	0.054	8.300	0.043	6.390	0.060	6.760	0.106	8.400
45 to 49	0.074	4.020	0.064	3.390	0.066	3.650	0.105	5.010
Number of observations	846912		810535		611097		584772	
Mean of dependent variable	0.057		0.058		0.065		0.066	

Note: "Coeff." represents key coefficients/parameters of interest, and T-Ratio indicates the statistical significance of coefficients, with values above 1.96 considered significant at the 5% level. All models control for time trends up to the 4th polynomial. In addition, the "OLS with controls" model includes mother's schooling, household's religion, household's caste, whether the household is headed by a female, mother's urban/rural residence, and reference child's gender. The household fixed effect model controls for mother's schooling and child gender. The mother fixed effect model controls for child gender.