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The association of maternal age with infant mortality, child anthropometric failure, diarrhoea and anaemia for first births: evidence from 55 low- and middle-income countries

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ABSTRACT

Objective: To examine the association between maternal age at first birth and infant mortality, stunting, underweight, wasting, diarrhoea and anaemia in children in low- and middle-income countries.

Design: Cross-sectional analysis of nationally representative household samples. A modified Poisson regression model is used to estimate unadjusted and adjusted RR ratios.

Setting: Low- and middle-income countries.

Population: First births to women aged 12–35 where this birth occurred 12–60 months prior to interview. The sample for analysing infant mortality is comprised of 176 583 children in 55 low- and middle-income countries across 118 Demographic and Health Surveys conducted between 1990 and 2008.

Main outcome measures: Infant mortality in children under 12 months and stunting, underweight, wasting, diarrhoea and anaemia in children under 5 years.

Results: The investigation reveals two salient findings. First, in the sample of women who had their first birth between the ages of 12 and 35, the risk of poor child health outcome is lowest for women who have their first birth between the ages of 27 and 29. Second, the results indicate that both biological and social mechanisms play a role in explaining why children of young mothers have poorer outcomes.

Conclusions: The first-born children of adolescent mothers are the most vulnerable to infant mortality and poor child health outcomes. Additionally, first time mothers up to the age of 27 have a higher risk of having a child who has stunting, diarrhoea and moderate or severe anaemia. Maternal and child health programs should take account of this increased risk even for mothers in their early 20s. Increasing the age at first birth in developing countries may have large benefits in terms of child health.

ARTICLE SUMMARY

Article focus

- The prevalence of nutritional deficiencies underscores the need to understand the basic determinants of poor child health outcomes.
- Young age of the mother at their first birth is one such determinant due to biological and social mechanisms.
- Comparison across low- to middle-income countries enables generalisation of cross-sectional associations between the age of the mother and child health outcomes.

Key messages

- Child health outcomes remain poor in many low- to middle-income countries.
- The age of the mother at their first birth is a key correlate of child health outcomes.
- Teen mothers have children with the worst health outcomes and children of mothers who have their first birth in their early 20s are also at risk of poor health outcomes compared to first time mothers in their late 20s.

Strengths and limitations of this study

- One of the strengths of this study is the breadth of countries included in the sample.
- In applying secondary source data, the study is subject to omitted variable and recall bias.

INTRODUCTION

Progress towards reaching Millennium Development Goal 4 focuses on measurable reduction in under-5 mortality. In low- to middle-income countries, this also means “revitalising efforts against… diarrhoea, while bolstering nutrition…”.[1] The risk of under-5 mortality and the prevalence of diarrhoeal disease and nutritional deficiencies that manifest themselves in outcomes such as stunting, wasting, underweight and anaemia in young children, underscore the need to understand the basic determinants of these poor child health outcomes. In India alone, 6.0% (95% CI 5.7% to 6.3%) of children die before their 5th birthday. In the same

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population, for children under 5, 42.2% are underweight, 47.8% are stunted, 19.7% are wasted and 69.1% are anaemic.[2] A cross-country study highlights that these prevalence percentages are the norm throughout low- to middle-income countries.[3] A report on adolescent girls in low- to middle-income countries by the Center for Global Development[4] highlights the risk to child health associated with young motherhood. When considering child health, the report draws on intergenerational influences on child health outcomes rather than a cross-sectional observation of children alone. The effect of the age of the mother at first birth on child health outcomes has been explored in several studies in low- to middle-income countries.[5–14] In the case of India, Raj *et al*[13] showed that children born to mothers who were married below the age of 18 were at a higher risk of stunting and underweight compared to children of women who had married at age 18 or older. In another study, using the World Fertility Survey, Trussell and Hammerslough[14] also found that the mother's age at first birth was a significant risk factor for infant mortality in Sri Lanka. In low- to middle-income countries, 26.5% of women have their first birth before the age of 18, and 83.1% before age 24.[15] Much debate, particularly with regard to US population samples, concerns the social versus physiological influence of young motherhood on child health outcomes.[16–22] Young age can be a proxy for "short stature, low body weight in relation to height, and greater likelihood of inadequate weight gain during pregnancy along with difficulty of delivery".[23] These physiological factors point to vulnerability to poor child health outcomes. Women in low- to middle-income countries who have children at a young age are also more likely to be, and remain, poor and uneducated.[4] These social factors also disadvantage young mothers in terms of their child's health outcomes. Analysis that generalises across and within countries, rather than focusing on a sample from a single country, provides standardised analyses and results to assess age as a proxy for physiological immaturity and social disadvantage and its effect on child health outcomes. Earlier work by Hobcraft[12] in 1992 examined the effect of age at first birth on child survival in a number of countries using Demographic and Health Surveys (DHS) available at that time. Given the prevalence of poor child health outcomes in low- to middle-income countries, and not just high infant mortality, studies that extend the monitoring of child health beyond infant mortality provide valuable information regarding health disparities and progress in achieving Millennium Development Goal 4 and its sub-goals relating to child health.

The purpose of the current study is to assess the association between maternal age at first birth and child health outcomes: infant mortality, stunting, underweight, wasting, diarrhoea and anaemia. By controlling for socioeconomic factors, the physiological effect of young motherhood on child health can be separated out from the social disadvantage that young mothers are also likely to face. The findings could critically inform family planning policies and programs aimed at delaying first birth beyond the teenage years.

METHODS

Data source

Information from 118 DHS conducted in 55 countries between 1990 and 2008 provided the data for the analysis in this study.[24] The DHS are nationally representative household sample surveys that measure population, health, socioeconomic and anthropometric indicators, emphasising maternal and child health.[25] The DHS are an important data source for studying population health across developing countries due to their extensive coverage, comparability and data quality.[26–28] To ensure standardisation and comparability across diverse sites and times, in conducting the DHS, Macro ICF employs intense interviewer training, standardised measurement tools and techniques, an identical core questionnaire and instrument pretesting.[29] Each participating country's report details pretesting and quality assurance measures by survey.[15] The DHS is modular in structure, and in addition to the core questionnaire, a set of country-relevant sections and country-specific variables are included. The DHS provides data with standardised variables across surveys.[30]

Sampling plan

The DHS involves stratified cluster randomised samples of households.[31] The sampling frame was stratified by urban and rural status and additionally by country-specific geographic or administrative regions. Within each stratified area, random clusters of households were drawn from a list of all enumeration areas taken from a population census. In the second stage of sampling, all private households within the cluster were listed (institutions excluded) and an average of 25 houses within a cluster were selected by equal probability systematic sampling to be surveyed. Detailed sampling plans are available from survey final reports.[15]

Within each sampled household, a household questionnaire was administered and women eligible for a more detailed women's survey were identified. In most surveys all women between the ages of 15 and 49 were interviewed. In a limited number of surveys, the target group is women aged 10–49 or 15–45, or ever-married women. The child anthropometry module was conducted in a selection of the Standard DHS.[32] The DHS provides weights for calculating nationally representative statistics.

Study population and sample size

Our sample consists of children born to women who had their first birth 12–60 months before the survey. The lower bound of 12 months is applied so that each child has equal exposure to 1 year of life and we can accurately calculate infant mortality (deaths within the first year of life). Detailed child health measures are only taken for

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children up to 60 months of age which establishes our upper bound (the upper bound is 60 months rather than 59 months to conform to the WHO age categories). Only the first birth for each woman is included in our sample; for multiple first births we only use data from the first recorded birth, although we control for this being a part of multiple births. The initial sample is 288 752 children across 72 countries from 181 surveys. Infant mortality status is not available for 5313 of these children, mother's age at their first birth is missing in 1564 and 103 563 observations are missing covariates since not all surveys collect data on our covariates of interest, yielding the final sample of 176 583 children across 55 countries and 118 surveys for our mortality study. The age of the mother is restricted to 12−35 as only 13 of the mothers had their children below the age of 12 and 1716 had their first birth at 36 or older. Details of the samples for the child health outcomes are given in online supplementary appendix table A1. These samples are smaller because the child anthropometric module was not conducted in a number of surveys. The data comprise 119 018 children with stunting, 120 246 with wasting, 122 680 with underweight, 135 121 with diarrhoea and 31 520 with anaemia.

Outcome measures

In this study, we focus on six outcomes: infant mortality, child stunting, underweight, wasting, diarrhoea and moderate to severe anaemia (which is abbreviated to moderate anaemia throughout the paper). All health measures are for children born 12−60 months before the interview. Infant mortality is a measure of whether or not the child survived to age 1 year. The birth history in the DHS individual recode files records the survival status of a woman's (the respondent's) child. A child's death and age at death are reported by the mother. For the measure of infant mortality, we count infants who died within the first year of life (<12 months). We also measure anthropometric failure. First, we calculate a z score given by the child's height minus the median height for that child's age and sex in a reference population. Then we divide the result by the standard deviation of the same age and sex in the WHO reference population of healthy children in developing countries.[33] Stunting is defined as a height z score of less than −2. Similarly, underweight is defined as a z score less than −2 for weight relative to children of the same sex and age in the reference population. Wasting is defined as a z score less than −2 for weight-for-height relative to children of the same sex and age in the reference population. Biologically impossible values are defined by the WHO for height (stunting) as z scores <−6 or >6, for weight (underweight) as <−6 or >5 and for weight-for-height (wasting) as <−5 or >5. Observations with biologically impossible values are dropped from our samples.

The outcome of child diarrhoea was based on the mother's recall of whether their child had had diarrhoea within the 2 weeks prior to interview. Anaemia was measured by a fingerstick blood test from the child at the time of interview. The first two drops of blood were discarded and the third drop was taken as a sample. The blood drop was analysed using the HemoCue system. Adjustments for altitude were taken into account, and children with a haemoglobin concentration <10 g/dl were considered as having at least moderate anaemia.

Exposure and covariates

In this study we classify the covariates into four different categories: child characteristics, maternal characteristics, paternal characteristics and, finally, household and social factors. The child characteristics are child sex, singleton or multiple births and the age of the child in months. The covariate for the age of the child is not included in the infant mortality model (which depends only on survival to age 1 year) but is included in all other models. Child age in months is categorised into four groups: 12−23, 24−35, 36−47 and 48−60.

The maternal factors that we include in this study are mother's age, her height and her educational attainment. Our exposure of interest is the mother's age at her first birth. The age of the mother at the first birth is a variable reported in the DHS recode manual[30] and is calculated from the CMC (century month code) of the date of the first birth and the CMC of the date of the birth of the mother. Age is categorised into 3-year intervals: ages 12−14, 15−17, 18−20, 21−23, 24−26, 27−29, 30−32 and 33−35. Online supplementary appendix table A2 shows the effect of the age of the mother at first birth, and age squared, regressed on the child health outcomes. This non-linear, continuous age variable model shows that the poor child health outcomes are minimised at age 29 for the infant mortality outcome. However, a quadratic age variable may not capture all potential heterogeneity in the effect of maternal age on child health outcomes. Furthermore, we use maternal age grouped into 3-year intervals, as opposed to single year age groups, due to the small number of infant deaths occurring for single age groups. Grouping 3 years together provides a sufficient group size to minimise random fluctuations in mortality rates. Not all surveys measure women's height. In our main results, we do not control for height but, since maternal height has been shown to be a predictor of child health,[3] we do perform a sensitivity analysis where we see the effect of adding maternal height as a covariate and restrict the sample to observations where the mother's height is available. The height of the mother is in five categories: 100−144 cm, 145−149 cm, 150−154 cm, 155−159 cm and 160−200 cm. Maternal education is classified into three categories: no education or less than completed primary, completed primary, and completed secondary or higher. Paternal covariates are whether the women has a partner or not and, if so, the partner's age and educational level. Partners are typically older than the women and the partner's age is split into six categories: 12−17, 18−23, 24−29, 30−35, 36−41 and 42−59 years. Partner's education follows the same groupings as coded for the mother's education: no education or less than completed primary, completed primary, and completed secondary or higher.

Household and social factors include the wealth quintile of the household and whether the household is in a rural or an urban location. The wealth quintile is a within-country measure of the wealth of the household relative to other households in that survey based on its ownership of household assets. This measure of wealth, based on Filmer and Pritchett,[34] is a linear index of asset ownership indicators using factor analysis to derive the weights. This measure has been standardised by Measure DHS across most of the DHS and is widely used as a measure of relative wealth within a country. Given we have country fixed effects and year of birth time dummies in the regression analyses, this wealth index is an indicator of how each household's wealth deviates from its own country's mean wealth. We also include indicators for piped water to the house and a flush toilet in the household. In addition to these household measures, we include a cluster level measure: the percentage of living children aged 12–60 months who have received measles vaccination in the cluster. We do not have vaccination data for children who have died and the cluster level measles vaccination percentage allows us to control for neighbourhood health system inputs. The cluster level average may be subject to the ecological fallacy, and we do not claim to measure the causal effect of measles vaccination on vaccinated children. Measles vaccine is administered between 9 and 12 months of age and is likely to have only a limited direct effect on infant mortality (deaths between 0 and 12 months). Rather, we think of vaccine coverage as being a proxy for healthcare provision, although there may also be a herd-immunity effect on younger children due to lower overall prevalence.

Statistical analysis

To measure the RR of a given outcome, we apply a modified Poisson regression following the methodology of Zou.[35] We estimate the unadjusted model only controlling for country fixed effects and year of birth time dummies to account for the uneven repeated cross-section. We then estimate the adjusted model and include the covariates. While summary statistics are weighted to take into account the multistage sampling design, the regressions are not weighted.[36]

RESULTS

Summary statistics

Average age at first birth across the 118 DHS is 20.18. This ranges from an average age of 17.65 in Bangladesh in 1996, to an average of 23.02 in Jordan in 2007 (table 1). Across the 118 surveys included in this study, infant mortality is as high as 17.01% of all first-born children in Mali in 1995. In 30 of the 118 surveys, average stunting is 50% or higher and 79 of the 118 surveys have stunting prevalence of 30% or higher. Madagascar in 1997 has the highest average stunting prevalence with 65.46% of first-born children being classified as stunted according to the WHO standards. Wasting (weight-for-height) is not as prevalent as stunting: 26 of the 118 surveys record an average prevalence of 10% or more. Underweight (weight-for-age) is as high as 50.01% in Niger in 1998. With regard to underweight, 32 of the 118 surveys record a prevalence of 25% or more. An average of 36.91% of first-born children in Niger in 1998 are reported to have had diarrhoea within the 2 weeks prior to the DHS interview, but across the 118 surveys the average is 13.64%. Anaemia was not recorded in all of the surveys, but in the 38 surveys that do record anaemia, average prevalence ranges from a low of 7.99% of first-born children in Egypt in 2000, to 71.55% in Burkina Faso in 2003. The average is 32.6% across the 118 surveys (table 1).

In the infant mortality model (n=176 583 children), 23.9% of the women are between the ages of 15 and 17 at their first birth and 35.2% are between the ages of 18 and 20 (table 2). The reference group in the regression analysis is children whose mothers were 27–29 years old at their first birth. This group represents 4.3% of the population with 7648 children. Children of multiple births are rare (0.8%), most women (92.9%) have partners, 60.1% of the children are born in rural areas, 43.6% have piped water to the house (the remainder have to leave the house to collect water) and 30.9% of the children have a flush toilet at the house. Distributions of covariates are similar across the different outcome models (table 2).

In figure 1 we plot the prevalence of the child health outcome against the age of the mother at first birth. The weighted fraction of child health outcomes by age is an extension of the statistics reported in table 2 of child health outcomes by age band. We see that, in general, the prevalence of poor child health outcomes declines with the mother's age to about age 27. The decline in poor child health outcomes with maternal age is particularly obvious for stunting, anaemia and underweight, but is also evident for diarrhoea, infant mortality and wasting.

Older women are more likely to have multiple births, although the event is rare across all age groups. Young mothers are less likely to have a partner: 8.6% of 15–17-year-old mothers do not have a partner compared to 5.8% of women in the 27–29-year-old category (table 3). Young mothers have lower education than older mothers: 64.6% of mothers aged 15–17 had incomplete primary or no schooling, whereas 23.1% of women who had their first birth between the ages of 27 and 29 had only incomplete primary or no schooling (table 3). Older mothers tend to be in a higher wealth quintile: 42.9% of women who had their first birth between the ages of 27 and 29 are in the richest quintile, while 11.7% of mothers age 15–17 are in the richest quintile (table 3). Overall, 71.2% of mothers who had their first birth between the ages of 15 and 17 live in rural areas, while 35% of women who had their first birth between

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Table 1 Weighted mean child health outcomes and 95% CIs by survey

	Survey year	Sample size N	Age at first birth Mean (SD)	Infant mortality Mean	Infant mortality 95% CI	Stunting Mean	Stunting 95% CI	Wasting Mean	Wasting 95% CI	Underweight Mean	Underweight 95% CI	Diarrhoea Mean	Diarrhoea 95% CI	Anaemia Mean	Anaemia 95% CI
Armenia	2000	510	21.04 (3.61)	1.51	0.77 to 2.93	16.17	12.27 to 21.00	1.40	0.55 to 3.56	1.02	0.38 to 2.65	8.53	6.20 to 11.63	8.29	5.92 to 11.49
Armenia	2005	504	21.90 (3.15)	1.47	0.51 to 4.15	17.19	11.07 to 25.72	3.12	1.63 to 5.88	3.57	1.96 to 6.41	15.60	12.00 to 20.05	15.78	10.21 to 23.57
Azerbaijan	2006	719	22.54 (3.97)	3.11	1.73 to 5.55	25.32	20.80 to 30.45	3.93	2.31 to 6.61	7.40	4.81 to 11.21	9.79	7.00 to 13.53	17.82	13.55 to 23.07
Bangladesh	1996	1309	17.65 (3.24)	9.60	8.11 to 11.33	57.25	53.52 to 60.89	16.80	14.37 to 19.53	48.81	45.41 to 52.22	8.13	6.43 to 10.23		
Bangladesh	1999	1596	18.20 (3.49)	9.86	8.45 to 11.48	56.07	52.65 to 59.44	10.46	8.69 to 12.53	40.37	37.31 to 43.51	6.30	5.04 to 7.85		
Bangladesh	2004	1633	18.04 (3.29)	7.80	6.49 to 9.35	52.60	49.58 to 55.60	14.43	12.29 to 16.87	42.73	39.70 to 45.81	5.89	4.70 to 7.37		
Bangladesh	2007	1637	18.48 (3.35)	6.14	4.82 to 7.79	43.55	40.14 to 47.01	15.12	12.90 to 17.64	40.91	37.40 to 44.52	9.98	8.24 to 12.03		
Benin	1996	594	19.57 (3.02)	8.40	6.46 to 10.86	38.94	32.70 to 45.58	14.76	10.67 to 20.08	27.60	22.44 to 33.45	27.46	21.91 to 33.80		
Benin	2001	781	20.25 (3.55)	8.27	6.49 to 10.48	40.96	36.75 to 45.31	7.25	5.53 to 9.46	21.17	17.80 to 24.99	14.54	11.70 to 17.92	55.57	49.74 to 61.26
Benin	2006	2112	20.42 (3.57)	7.34	6.23 to 8.63	45.43	42.40 to 48.48	5.43	4.25 to 6.91	17.54	15.58 to 19.69	9.41	8.06 to 10.95	48.72	44.21 to 53.26
Bolivia	1993	813	20.82 (4.05)	3.36	2.29 to 4.90	29.95	25.21 to 35.16	4.17	2.47 to 6.96	10.60	7.75 to 14.34	31.69	27.25 to 36.50		
Bolivia	1998	1224	20.85 (4.16)	4.54	3.42 to 6.00	24.24	21.38 to 27.35	0.56	0.24 to 1.32	3.43	2.47 to 4.73	18.66	16.17 to 21.44		
Bolivia	2003	1987	20.48 (4.03)	3.65	2.75 to 4.83	26.30	23.44 to 29.38	0.81	0.48 to 1.39	2.68	1.94 to 3.69	22.07	19.78 to 24.53	22.67	18.54 to 27.40
Brazil	1996	1280	21.12 (4.53)	2.15	1.48 to 3.13	8.76	7.11 to 10.73	2.43	1.48 to 3.96	2.60	1.76 to 3.82	9.62	7.96 to 11.58		
Burkina Faso	1992	771	19.12 (2.91)	12.50	10.06 to 15.44	45.86	41.34 to 50.46	15.69	12.40 to 19.66	33.99	29.51 to 38.78	12.85	10.33 to 15.87		
Burkina Faso	1998	730	19.21 (3.00)	14.94	12.25 to 18.09	53.12	48.15 to 58.03	13.36	10.62 to 16.67	39.39	35.29 to 43.64	12.64	10.02 to 15.83		
Burkina Faso	2003	1414	19.19 (2.87)	9.07	7.48 to 10.95	48.54	44.36 to 52.74	17.97	15.29 to 21.00	33.47	29.58 to 37.60	20.82	17.94 to 24.02	71.55	65.66 to 76.78
Cameroon	1991	498	18.62 (3.16)	6.67	4.50 to 9.78	35.90	29.95 to 42.33	4.38	2.41 to 7.86	16.73	11.94 to 22.96	12.10	8.78 to 16.45		
Cameroon	1998	542	18.87 (3.18)	7.27	5.29 to 9.91	43.56	37.05 to 50.30	4.52	2.21 to 9.03	17.92	12.98 to 24.22	20.23	15.66 to 25.74		
Cameroon	2004	1146	19.13 (3.45)	6.26	4.90 to 7.97	35.95	31.39 to 40.79	6.20	4.23 to 9.00	13.57	10.26 to 17.73	16.99	13.40 to 21.29	45.37	40.19 to 50.65

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Table 1 Continued

	Survey year	Sample size N	Age at first birth Mean (SD)	Infant mortality Mean	Infant mortality 95% CI	Stunting Mean	Stunting 95% CI	Wasting Mean	Wasting 95% CI	Underweight Mean	Underweight 95% CI	Diarrhoea Mean	Diarrhoea 95% CI	Anaemia Mean	Anaemia 95% CI
Central African Rep.	1994	653	18.78 (3.44)	13.62	11.25 to 16.41	49.09	43.70 to 54.50	7.51	4.83 to 11.48	22.06	17.35 to 27.62	28.00	23.40 to 33.12		
Chad	1996	1030	18.30 (2.98)	12.37	10.37 to 14.70	50.36	46.24 to 54.47	13.68	11.22 to 16.58	33.95	30.05 to 38.08	21.38	18.25 to 24.89		
Chad	2004	733	18.18 (3.09)	14.00	10.86 to 17.85	42.26	37.35 to 47.34	11.23	8.51 to 14.68	36.86	29.66 to 44.69	22.83	18.16 to 28.29		
Colombia	1995	1405	21.60 (4.43)	1.58	1.05 to 2.38	15.73	13.68 to 18.01	0.92	0.50 to 1.68	4.54	3.42 to 6.01	12.44	10.75 to 14.35		
Colombia	2000	1358	21.32 (4.70)	1.85	1.26 to 2.70	15.38	13.06 to 18.03	0.49	0.22 to 1.09	3.19	2.21 to 4.59	12.77	10.94 to 14.85		
Colombia	2004	3998	20.70 (4.49)	1.04	0.75 to 1.44	12.36	10.92 to 13.96	0.85	0.59 to 1.24	3.15	2.50 to 3.98	14.14	12.63 to 15.79		
Comoros	1996	234	21.20 (4.42)	6.84	4.40 to 10.47	47.27	37.21 to 57.56	10.81	6.25 to 18.05	19.64	12.36 to 29.77	16.81	10.75 to 25.30		
Congo, Dem. Rep.	2007	1180	19.86 (3.50)	9.97	7.87 to 12.55	45.30	38.16 to 52.65	8.54	5.39 to 13.26	25.79	21.49 to 30.61	17.11	12.48 to 23.00	45.44	38.80 to 52.25
Congo, Rep.	2005	940	19.66 (3.63)	8.85	6.69 to 11.63	36.58	31.42 to 42.07	5.64	3.85 to 8.20	12.69	9.38 to 16.94	13.49	10.72 to 16.84	34.19	27.82 to 41.19
Cote d'Ivoire	1994	927	18.28 (3.21)	11.83	9.50 to 14.63	45.40	40.31 to 50.60	8.55	6.03 to 12.00	24.23	19.89 to 29.17	17.89	14.34 to 22.10		
Cote d'Ivoire	1998	96	18.50 (3.18)	6.75	2.85 to 15.16	36.39	23.85 to 51.09	4.53	1.49 to 12.96	17.29	10.34 to 27.47	20.92	13.39 to 31.16		
Dominican Republic	1996	1035	20.31 (4.34)	3.42	2.35 to 4.97	8.21	6.30 to 10.65	1.79	0.88 to 3.60	2.85	1.85 to 4.38	10.81	8.59 to 13.51		
Dominican Republic	2002	2611	19.99 (4.19)	2.00	1.41 to 2.84	8.13	6.56 to 10.04	1.11	0.66 to 1.86	2.35	1.66 to 3.31	13.91	12.04 to 16.02		
Dominican Republic	2007	2632	20.14 (4.29)	2.00	1.38 to 2.88	7.59	6.03 to 9.52	1.40	0.93 to 2.10	2.67	1.68 to 4.20	14.66	12.74 to 16.82		
Dominican Republic	2007	164	18.72 (3.27)	1.99	0.58 to 6.52	15.18	9.25 to 23.93	1.08	0.27 to 4.28	4.03	1.85 to 8.55	22.09	15.04 to 31.24		
Egypt, Arab Rep.	1995	2136	21.41 (3.95)	4.92	3.94 to 6.14	30.90	27.95 to 34.01	3.67	2.70 to 4.97	7.48	6.11 to 9.11	13.87	12.04 to 15.93		
Egypt, Arab Rep.	2000	2370	21.81 (3.73)	3.20	2.55 to 3.99	21.40	19.35 to 23.61	2.19	1.58 to 3.03	2.40	1.82 to 3.17	5.85	4.88 to 7.00	7.99	6.40 to 9.94
Egypt, Arab Rep.	2003	1502	21.45 (3.70)	3.94	3.01 to 5.16	16.87	14.65 to 19.36	4.17	3.03 to 5.72	7.18	5.75 to 8.93	19.40	17.10 to 21.92		
Egypt, Arab Rep.	2005	3226	21.78 (3.69)	2.53	1.99 to 3.21	19.10	17.35 to 20.97	4.15	3.29 to 5.23	3.39	2.72 to 4.21	16.20	14.67 to 17.86	20.08	17.18 to 23.32
Egypt, Arab Rep.	2008	2618	21.91 (3.72)	1.88	1.41 to 2.51	30.29	28.01 to 32.67	7.28	6.05 to 8.73	5.26	4.31 to 6.39	6.63	5.66 to 7.74		

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Table 1 Continued

	Survey year	Sample size N	Age at first birth Mean (SD)	Infant mortality		Stunting		Wasting		Underweight		Diarrhoea		Anaemia	
				Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Ethiopia	2000	1689	20.09 (3.64)	11.37	9.40 to 13.70	58.70	54.76 to 62.53	9.29	7.17 to 11.95	37.03	33.21 to 41.03	22.00	18.84 to 25.53		
Ethiopia	2005	1206	19.55 (3.63)	7.59	5.67 to 10.08	48.86	42.72 to 55.04	10.38	7.47 to 14.26	33.03	27.97 to 38.53	15.79	12.11 to 20.34	28.82	23.44 to 34.88
Gabon	2000	709	18.31 (3.21)	5.10	3.60 to 7.19	30.15	25.72 to 34.99	2.40	1.31 to 4.34	7.57	5.60 to 10.16	21.01	17.52 to 24.98		
Ghana	1993	427	20.45 (3.51)	3.04	1.75 to 5.24	42.36	35.78 to 49.22	8.70	5.69 to 13.07	20.09	15.52 to 25.58	14.10	10.22 to 19.15		
Ghana	1998	531	20.72 (3.52)	4.76	3.22 to 6.96	33.92	29.21 to 38.98	7.52	5.46 to 10.26	20.99	17.56 to 24.88	16.21	13.12 to 19.86		
Ghana	2003	492	20.92 (3.71)	5.81	4.03 to 8.31	36.27	31.08 to 41.79	6.36	4.35 to 9.21	19.35	15.61 to 23.73	15.96	12.40 to 20.29	52.42	46.87 to 57.91
Ghana	2008	499	21.19 (4.19)	4.51	3.05 to 6.63	35.08	29.58 to 41.00	6.80	4.47 to 10.21	14.88	11.24 to 19.44	20.50	16.69 to 24.92	50.44	44.47 to 56.40
Guatemala	1995	1454	19.52 (3.67)	5.38	4.15 to 6.95	50.10	45.63 to 54.57	3.90	2.75 to 5.52	16.96	14.31 to 20.00	21.36	18.19 to 24.92		
Guinea	1999	743	18.32 (3.36)	10.82	8.73 to 13.35	37.23	32.89 to 41.79	6.31	4.47 to 8.83	19.86	16.59 to 23.58	22.56	19.45 to 26.00		
Guinea	2005	666	18.77 (3.72)	7.40	5.59 to 9.74	43.81	37.73 to 50.09	10.06	6.85 to 14.54	26.52	21.40 to 32.36	17.18	13.55 to 21.53	58.57	52.14 to 64.73
Haiti	1994	514	21.19 (4.18)	9.24	6.84 to 12.39	33.89	28.47 to 39.78	5.65	3.83 to 8.26	20.68	16.67 to 25.36	24.12	19.99 to 28.80		
Haiti	2005	1000	21.19 (4.44)	5.52	4.09 to 7.41	23.71	19.13 to 29.00	9.22	6.50 to 12.92	16.45	12.85 to 20.82	17.80	13.50 to 23.12	34.56	29.27 to 40.26
Honduras	2005	2390	19.70 (3.82)	1.68	1.22 to 2.32	23.09	20.90 to 25.43	1.26	0.80 to 1.96	6.73	5.55 to 8.13	15.76	14.10 to 17.57	12.30	10.69 to 14.12
India	1992	12 919	19.93 (3.55)	8.02	7.44 to 8.64	58.80	56.94 to 60.63	18.02	16.66 to 19.47	48.55	46.72 to 50.37	5.34	4.79 to 5.95		
India	1998	12 763	20.12 (3.66)	7.11	6.58 to 7.68	52.52	50.67 to 54.36	15.99	14.77 to 17.29	41.41	39.66 to 43.18	17.38	16.22 to 18.61		
India	2005	13 112	21.13 (3.86)	6.27	5.71 to 6.87	44.60	43.17 to 46.04	16.23	15.25 to 17.26	38.76	37.35 to 40.18	7.60	6.97 to 8.30	38.38	36.96 to 39.81
Jordan	1990	1035	21.22 (3.59)	1.90	1.18 to 3.02	18.53	15.85 to 21.55	3.05	1.97 to 4.70	4.97	3.45 to 7.11	9.21	7.48 to 11.29		
Jordan	1997	1074	22.17 (3.73)	2.98	2.11 to 4.20	8.55	6.88 to 10.59	1.60	0.94 to 2.71	2.92	2.05 to 4.14	15.63	13.37 to 18.19		
Jordan	2007	898	23.02 (3.90)	1.83	0.77 to 4.30	12.20	9.05 to 16.26	5.89	3.66 to 9.35	5.23	3.55 to 7.64	16.98	13.21 to 21.55	12.29	9.25 to 16.16
Kazakhstan	1995	406	21.93 (3.62)	3.68	2.17 to 6.20	17.89	11.91 to 25.99	2.59	1.07 to 6.14	5.77	2.97 to 10.91	17.56	11.77 to 25.39		

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Table 1 Continued

	Survey year	Sample size N	Age at first birth Mean (SD)	Infant mortality Mean	Infant mortality 95% CI	Stunting Mean	Stunting 95% CI	Wasting Mean	Wasting 95% CI	Underweight Mean	Underweight 95% CI	Diarrhoea Mean	Diarrhoea 95% CI	Anaemia Mean	Anaemia 95% CI
Kazakhstan	1999	395	21.99 (3.69)	4.48	2.69 to 7.38	12.66	8.15 to 19.15	2.56	0.97 to 6.54	3.86	1.53 to 9.42	17.49	13.32 to 22.63		
Kenya	1998	867	19.92 (3.20)	3.95	2.71 to 5.71	38.01	33.54 to 42.69	5.98	3.97 to 8.90	14.11	11.53 to 17.14	18.73	14.95 to 23.21		
Kenya	2003	1114	19.95 (3.43)	5.61	4.29 to 7.30	35.33	31.70 to 39.14	5.42	3.87 to 7.54	14.99	12.43 to 17.97	16.14	13.63 to 19.00		
Kenya	2008	1059	19.91 (3.60)	4.75	3.34 to 6.71	35.46	30.78 to 40.43	5.24	3.67 to 7.41	14.39	11.36 to 18.06	13.55	10.69 to 17.02		
Kyrgyz Republic	1997	388	20.97 (3.14)	5.05	3.22 to 7.83	32.43	24.30 to 41.77	2.02	0.73 to 5.49	6.77	3.51 to 12.64	19.38	14.01 to 26.20		
Lesotho	2004	749	19.81 (3.24)	6.82	5.09 to 9.09	48.43	41.99 to 54.93	2.81	1.50 to 5.18	16.97	13.00 to 21.84	13.53	9.92 to 18.19	28.47	22.99 to 34.65
Liberia	2006	940	19.38 (3.52)	7.12	5.23 to 9.63	45.57	40.86 to 50.35	5.85	4.08 to 8.32	25.72	20.96 to 31.13	21.03	17.16 to 25.50		
Madagascar	1997	915	19.22 (3.94)	10.61	8.51 to 13.14	65.46	60.10 to 70.45	7.12	5.03 to 10.00	34.37	29.41 to 39.70	29.95	25.50 to 34.81		
Madagascar	2003	951	20.19 (4.40)	5.36	3.70 to 7.69	56.18	50.85 to 61.36	12.83	9.76 to 16.70	37.42	32.05 to 43.13	7.33	5.31 to 10.05	34.48	26.54 to 43.39
Madagascar	2008	1887	19.11 (3.82)	4.78	3.78 to 6.02	44.72	40.11 to 49.42					9.11	6.96 to 11.84	14.62	11.89 to 17.85
Malawi	1992	564	18.84 (2.98)	17.00	13.63 to 20.98	64.28	58.09 to 70.03	6.08	3.88 to 9.41	22.30	17.79 to 27.57	11.15	8.10 to 15.17		
Malawi	2000	2121	18.95 (2.61)	13.71	12.13 to 15.46	62.66	59.57 to 65.66	4.79	3.64 to 6.27	22.42	19.99 to 25.05	16.49	14.48 to 18.71		
Malawi	2004	1872	18.80 (2.53)	8.53	7.15 to 10.15	58.00	54.61 to 61.31	5.87	4.55 to 7.55	18.31	15.91 to 20.98	21.50	18.90 to 24.34	39.83	34.10 to 45.84
Mali	1995	1042	18.48 (3.32)	17.01	14.74 to 19.55	48.29	42.85 to 53.77	23.45	19.14 to 28.41	39.96	34.73 to 45.43	25.17	20.64 to 30.32		
Mali	2001	1595	18.70 (3.44)	15.56	13.36 to 18.04	45.95	42.17 to 49.77	12.23	9.96 to 14.94	33.63	30.07 to 37.38	19.06	15.93 to 22.64	63.91	56.77 to 70.49
Mali	2006	1844	18.55 (3.43)	14.17	11.74 to 17.01	42.24	38.58 to 45.99	14.98	12.97 to 17.24	31.23	28.23 to 34.40	14.47	12.11 to 17.20	62.99	57.58 to 68.08
Moldova	2005	630	22.18 (3.56)	0.93	0.40 to 2.15	8.89	6.70 to 11.70	5.19	3.59 to 7.44	3.22	1.95 to 5.26	7.01	5.28 to 9.26	9.04	6.38 to 12.66
Morocco	1992	788	22.21 (4.38)	6.22	4.55 to 8.45	23.49	20.13 to 27.23	1.94	1.10 to 3.41	4.29	2.86 to 6.39	6.20	4.48 to 8.53		
Morocco	2003	1276	22.57 (4.54)	3.96	3.00 to 5.21	19.72	17.10 to 22.64	8.67	7.00 to 10.70	8.32	6.80 to 10.15	7.30	5.72 to 9.26		
Mozambique	1997	938	18.80 (3.27)	14.62	10.35 to 20.26	56.14	48.14 to 63.83	9.74	6.09 to 15.20	28.54	20.40 to 38.36	22.39	14.69 to 32.59		

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Table 1 Continued

	Survey year	Sample size N	Age at first birth Mean (SD)	Infant mortality		Stunting		Wasting		Underweight		Diarrhoea		Anaemia	
				Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Mozambique	2003	1679	18.73 (3.26)	11.68	9.88 to 13.75	51.77	47.94 to 55.58	4.75	3.40 to 6.60	21.41	18.50 to 24.65	14.41	12.22 to 16.91		
Namibia	1992	762	20.32 (3.71)	5.10	3.75 to 6.89	38.83	34.12 to 43.76	8.02	5.73 to 11.13	21.24	17.21 to 25.91	16.28	12.91 to 20.33		
Namibia	2000	830	20.44 (3.83)	3.05	1.95 to 4.72	27.82	23.92 to 32.10	8.74	6.18 to 12.22	18.69	14.28 to 24.08	12.63	9.55 to 16.53		
Namibia	2006	1123	20.76 (4.00)	3.31	2.44 to 4.50	28.69	24.81 to 32.90	5.96	4.41 to 8.02	17.92	14.58 to 21.84	16.00	12.96 to 19.59		
Nicaragua	1997	1633	19.06 (3.64)	3.75	2.86 to 4.90	25.74	23.01 to 28.66	2.18	1.39 to 3.40	8.07	6.33 to 10.23	12.33	10.57 to 14.34		
Nicaragua	2001	1663	19.26 (3.75)	2.43	1.78 to 3.30	20.84	18.42 to 23.48	1.59	0.88 to 2.85	5.03	3.84 to 6.56	12.33	10.48 to 14.45		
Niger	1998	871	18.16 (3.15)	16.42	13.68 to 19.58	56.49	50.91 to 61.91	24.52	19.95 to 29.75	50.01	44.60 to 55.42	36.91	31.70 to 42.44		
Niger	2006	922	18.64 (3.42)	9.45	7.42 to 11.96	60.64	55.35 to 65.69	9.47	6.85 to 12.95	45.40	40.09 to 50.81	18.74	14.93 to 23.26	59.43	53.08 to 65.49
Nigeria	1990	1023	19.80 (3.88)	7.65	5.64 to 10.30	55.63	51.25 to 59.92	13.60	8.01 to 22.17	38.01	32.01 to 44.40	10.97	8.23 to 14.47		
Nigeria	2003	850	19.82 (3.89)	10.00	7.71 to 12.87	46.78	40.28 to 53.39	9.13	6.60 to 12.50	31.67	26.27 to 37.61	16.72	13.26 to 20.87		
Nigeria	2008	3952	20.29 (4.24)	8.17	7.26 to 9.19	39.08	36.76 to 41.46	12.00	10.61 to 13.53	24.74	22.65 to 26.96	10.41	9.20 to 11.77		
Pakistan	1990	874	20.81 (3.88)	9.97	7.64 to 12.90	53.38	47.78 to 58.89	11.52	7.41 to 17.49	33.03	27.96 to 38.54	7.11	4.90 to 10.21		
Paraguay	1990	696	21.07 (4.21)	3.09	2.02 to 4.69	12.87	10.24 to 16.06	0.34	0.07 to 1.55	1.83	0.98 to 3.38	4.93	3.27 to 7.35		
Peru	1991	1747	21.13 (4.22)	2.50	1.87 to 3.35	30.63	27.83 to 33.57	1.21	0.73 to 1.99	6.08	4.88 to 7.56	7.93	6.57 to 9.55		
Peru	1996	3505	20.96 (4.15)	3.05	2.45 to 3.80	22.42	20.35 to 24.65	0.79	0.51 to 1.22	3.17	2.59 to 3.88	15.06	13.51 to 16.75		
Peru	2000	3151	21.02 (4.33)	2.21	1.70 to 2.87	24.09	21.85 to 26.48	0.68	0.41 to 1.13	3.20	2.50 to 4.08	13.78	12.30 to 15.41	24.96	20.76 to 29.70
Peru	2003	2856	21.14 (4.44)	1.57	1.11 to 2.24	20.19	17.77 to 22.84	0.71	0.35 to 1.43	2.24	1.70 to 2.94	13.72	11.85 to 15.82	17.32	15.22 to 19.64
Rwanda	1992	742	21.54 (3.57)	10.06	8.07 to 12.48	58.42	53.98 to 62.73	2.91	1.75 to 4.82	19.17	15.79 to 23.07	15.52	12.61 to 18.96		
Rwanda	2000	1209	21.34 (3.32)	10.62	8.96 to 12.54	52.92	49.11 to 56.70	5.24	3.73 to 7.30	17.46	14.78 to 20.52	15.93	13.40 to 18.84		
Rwanda	2005	979	21.54 (3.29)	8.06	6.31 to 10.25	54.14	49.11 to 59.09	5.69	3.72 to 8.59	21.00	17.07 to 25.56	16.34	12.97 to 20.38	35.70	30.54 to 41.20

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Table 1 Continued

	Survey year	Sample size N	Age at first birth Mean (SD)	Infant mortality		Stunting		Wasting		Underweight		Diarrhoea		Anaemia	
				Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Senegal	2005	1260	20.01 (3.91)	7.09	5.61 to 8.93	20.13	15.29 to 26.04	7.46	5.05 to 10.88	13.98	10.29 to 18.71	21.26	16.65 to 26.74	61.98	55.64 to 67.94
Sierra Leone	2008	663	19.85 (4.03)	8.06	6.08 to 10.61	38.25	31.56 to 45.41	11.82	8.30 to 16.57	22.17	16.99 to 28.39	7.80	5.15 to 11.64	46.22	39.35 to 53.23
Swaziland	2006	620	19.48 (3.35)	7.95	5.95 to 10.55	28.69	24.65 to 33.10	1.54	0.72 to 3.29	3.87	2.40 to 6.16	17.15	13.71 to 21.23	21.93	18.07 to 26.34
Tanzania	1996	1058	19.31 (2.81)	9.38	7.62 to 11.50	56.50	52.22 to 60.69	8.52	6.43 to 11.20	26.25	23.01 to 29.77	13.45	11.13 to 16.17		
Tanzania	1999	48	18.50 (2.84)	9.86	3.92 to 22.69	57.16	33.20 to 78.17	6.31	1.43 to 23.83	26.88	13.03 to 47.41	9.32	3.45 to 22.82		
Tanzania	2004	1405	19.58 (3.26)	7.40	5.98 to 9.12	50.22	45.93 to 54.51	3.24	2.22 to 4.69	18.11	15.72 to 20.77	11.54	9.57 to 13.85	43.42	39.87 to 47.05
Togo	1998	801	20.30 (3.60)	8.27	6.47 to 10.53	34.67	29.09 to 40.70	12.53	9.28 to 16.70	25.71	21.19 to 30.81	30.18	25.94 to 34.79		
Turkey	1993	949	21.16 (3.44)	4.73	3.47 to 6.42	17.98	15.20 to 21.15	1.76	1.00 to 3.09	6.15	4.49 to 8.37	14.42	12.09 to 17.12		
Turkey	1998	929	21.59 (3.89)	3.06	2.05 to 4.55	18.36	15.46 to 21.67	1.62	0.88 to 2.99	5.70	4.12 to 7.85	27.06	23.87 to 30.51		
Uganda	1995	1067	18.71 (2.98)	11.14	9.18 to 13.47	52.06	46.60 to 57.47	5.41	3.49 to 8.29	23.09	19.11 to 27.61	25.44	22.03 to 29.17		
Uganda	2000	1035	18.81 (2.98)	10.56	8.68 to 12.78	49.28	45.02 to 53.56	3.10	1.94 to 4.93	14.86	11.93 to 18.34	16.99	13.93 to 20.57	41.11	36.08 to 46.33
Uganda	2006	711	19.26 (2.82)	7.63	5.55 to 10.39	42.30	36.02 to 48.83	6.65	3.81 to 11.35	15.90	11.62 to 21.39	26.83	21.31 to 33.17	41.20	34.42 to 48.33
Uzbekistan	1996	559	20.89 (2.71)	3.80	2.51 to 5.71	35.89	29.30 to 43.06	7.84	4.63 to 13.00	7.63	4.98 to 11.53	6.73	4.11 to 10.84		
Zambia	1996	1188	18.80 (2.81)	13.46	11.48 to 15.72	57.98	54.05 to 61.81	4.49	3.18 to 6.29	21.31	18.40 to 24.55	24.12	21.17 to 27.34		
Zambia	2001	1161	18.59 (2.68)	10.47	8.82 to 12.38	58.17	54.17 to 62.06	5.27	3.70 to 7.44	22.43	19.83 to 25.27	23.77	20.83 to 26.98		
Zambia	2007	972	19.21 (3.12)	7.44	5.85 to 9.42	51.39	47.22 to 55.54	4.36	3.03 to 6.24	15.44	12.74 to 18.59	15.66	12.98 to 18.78		
Zimbabwe	1994	719	19.53 (3.01)	5.81	4.22 to 7.95	31.46	25.99 to 37.50	7.39	4.77 to 11.27	14.70	10.79 to 19.72	25.59	20.64 to 31.26		
Zimbabwe	2005	1261	19.87 (3.19)	5.49	4.08 to 7.35	33.26	30.00 to 36.69	6.32	4.77 to 8.33	12.57	10.49 to 14.98	13.65	11.40 to 16.26	29.68	25.99 to 33.65
Total	2000	176 583	20.18 (3.87)	6.49	6.35 to 6.64	36.20	35.81 to 36.60	7.53	7.32 to 7.74	19.78	19.43 to 20.13	13.64	13.40 to 13.87	32.60	31.87 to 33.34

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Table 2 Weighted frequency and distribution of first-born children within 5 years of the survey aged 12–60 months across age of mother at birth and other covariates

	Infant mortality		Stunting		Underweight		Wasting		Diarrhoea		Moderate anaemia	
	n=176 583		n=119 018		n=122 680		n=120 246		n=135 121		n=31 520	
	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction
Age band in years of the mother at first birth												
12–14	4497	0.026	2301	0.020	2443	0.020	2379	0.020	2851	0.021	514	0.016
15–17	42 233	0.239	25 882	0.219	26 839	0.220	26 335	0.220	30 011	0.222	6531	0.203
18–20	62 091	0.352	41 492	0.351	42 868	0.352	42 054	0.352	47 425	0.351	11 753	0.366
21–23	37 757	0.214	26 427	0.224	27 127	0.223	26 594	0.223	29 927	0.222	7563	0.236
24–26	17 383	0.099	12 669	0.107	12 936	0.106	12 690	0.106	14 258	0.106	3355	0.105
27–29	7648	0.043	5722	0.048	5883	0.048	5771	0.048	6480	0.048	1481	0.046
30–32	3377	0.019	2566	0.022	2616	0.022	2547	0.021	2884	0.021	650	0.020
33–35	1399	0.008	1075	0.009	1085	0.009	1075	0.009	1203	0.009	249	0.008
Sex of child												
Male	90 302	0.512	59 709	0.505	61 867	0.508	60 577	0.507	68 501	0.507	16 438	0.512
Female	86 083	0.488	58 424	0.495	59 929	0.492	58 867	0.493	66 539	0.493	15 658	0.488
Type of birth												
Singleton	174 947	0.992	117 235	0.992	120 853	0.992	118 515	0.992	134 004	0.992	31 850	0.992
Twin	1438	0.008	898	0.008	944	0.008	930	0.008	1036	0.008	247	0.008
Age of child in months												
48–60	44 542	0.253	24 472	0.207	24 780	0.203	24 353	0.204	27 013	0.200	7552	0.235
36–47	42 793	0.243	26 908	0.228	27 694	0.227	27 210	0.228	31 330	0.232	7867	0.245
24–35	43 082	0.244	31 485	0.267	32 603	0.268	31 950	0.267	36 595	0.271	7961	0.248
12–23	45 968	0.261	35 268	0.299	36 718	0.301	35 932	0.301	40 101	0.297	8717	0.272
Educational level of the mother at time of interview												
Secondary or higher	36 152	0.205	27 729	0.235	28 308	0.232	27 757	0.232	31 177	0.231	6562	0.204
Completed primary	57 645	0.327	40 543	0.343	41 341	0.339	40 673	0.341	45 720	0.339	12 739	0.397
No education or incomplete primary	82 589	0.468	49 862	0.422	52 147	0.428	51 015	0.427	58 142	0.431	12 796	0.399
Mother has a partner												
Yes	163 858	0.929	109 350	0.926	112 890	0.927	110 666	0.927	125 468	0.929	30 192	0.941
No	12 527	0.071	8784	0.074	8906	0.073	8779	0.074	9572	0.071	1904	0.059
Educational level of the mother's partner at the time of interview												
Completed secondary or higher	54 943	0.311	39 434	0.334	40 422	0.332	39 640	0.332	44 409	0.329	8891	0.277
Completed primary	56 655	0.321	38 884	0.329	39 920	0.328	39 216	0.328	44 217	0.327	12 180	0.379

Continued

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Table 2 Continued

	Infant mortality		Stunting		Underweight		Wasting		Diarrhoea		Moderate anaemia	
	n=176 583		n=119 018		n=122 680		n=120 246		n=135 121		n=31 520	
	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction
No education or incomplete primary	64 787	0.367	39 815	0.337	41 455	0.340	40 589	0.340	46 414	0.344	11 025	0.344
Age band in years of the mother's partner at the mother's first birth												
12–17	2104	0.012	1224	0.010	1236	0.010	1211	0.010	1409	0.010	373	0.012
18–23	40 271	0.228	27 180	0.230	28 018	0.230	27 483	0.230	30 594	0.227	9132	0.285
24–29	101 722	0.577	66 806	0.566	68 828	0.565	67 569	0.566	77 555	0.574	15 792	0.492
30–35	22 072	0.125	15 954	0.135	16 483	0.135	16 125	0.135	17 661	0.131	4797	0.149
36–41	6768	0.038	4685	0.040	4846	0.040	4724	0.040	5266	0.039	1342	0.042
42–59	3448	0.020	2284	0.019	2385	0.020	2332	0.020	2555	0.019	660	0.021
Wealth quintile of the child's household												
Richest	36 825	0.209	24 886	0.211	25 377	0.208	24 876	0.208	28 741	0.213	6550	0.204
Rich	37 749	0.214	25 955	0.220	26 597	0.218	26 150	0.219	29 413	0.218	6961	0.217
Middle	36 203	0.205	24 554	0.208	25 319	0.208	24 853	0.208	27 932	0.207	6795	0.212
Poorer	34 324	0.195	22 705	0.192	23 517	0.193	23 053	0.193	25 834	0.191	6138	0.191
Poorest	31 285	0.177	20 035	0.170	20 986	0.172	20 512	0.172	23 120	0.171	5653	0.176
Residence of the child's household at the time of interview												
Urban	70 395	0.399	50 428	0.427	51 491	0.423	50 597	0.424	57 358	0.425	12 301	0.383
Rural	105 990	0.601	67 706	0.573	70 305	0.577	68 848	0.576	77 682	0.575	19 796	0.617
Water piped to child's house												
Piped to house	76 844	0.436	55 481	0.470	56 699	0.466	55 714	0.466	62 499	0.463	14 306	0.446
Water not piped to house	99 542	0.564	62 653	0.530	65 097	0.534	63 731	0.534	72 542	0.537	17 790	0.554
Flush toilet at child's house												
Flush toilet at house	54 418	0.309	41 542	0.352	42 402	0.348	41 686	0.349	46 955	0.348	10 511	0.327
No flush toilet at house	121 968	0.691	76 592	0.648	79 394	0.652	77 759	0.651	88 085	0.652	21 586	0.673
Child measles vaccination												
Cluster weighted mean		0.234		0.204		0.208		0.208		0.214		0.211

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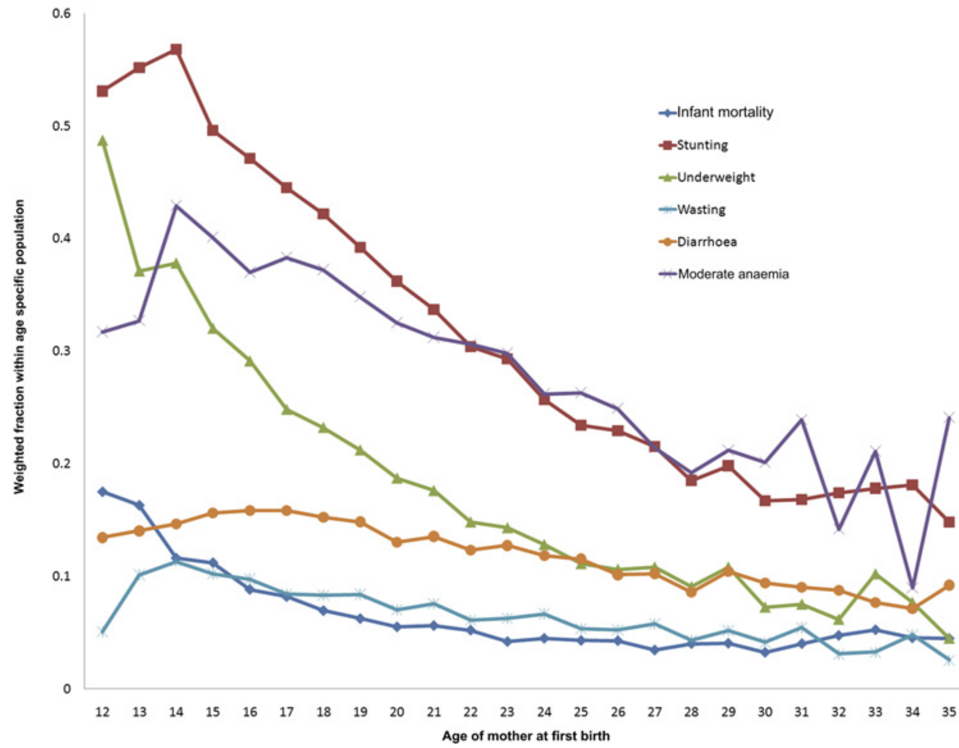

Figure 1 Child health indicator weighted prevalence by age of the mother at first birth.

the ages of 27 and 29 live in rural areas (table 3). Delaying first birth is more likely in urban areas. Women who have their first birth later are also more likely to live in conditions that are more sanitary: 57.3% of women who had their first birth between the ages of 27 and 29 have a flush toilet at the house compared to 16.4% of 15−17-year-old first time mothers (table 3).

Women who delay their first birth are more educated, more likely to have a partner, are richer, more likely to live in an urban area, and more likely to live in better sanitary conditions. Young mothers tend to have lower educational and socioeconomic characteristics. In the following analysis, we present both unadjusted results and results that control for these covariates (table 3).

Unadjusted and adjusted models

The unadjusted pooled results indicate that the risk of infant mortality is lowest for women who have their first birth between the ages of 27 and 29 (online supplementary appendix table A3). The RR ratio declines as age increases between the ages of 12 and 26, and is lowest for 27−29-year-old mothers (table A3). The RR ratio then increases for women who have their first birth at 33−35 years of age (table A3). This same U-shape is exhibited in many of the country-specific unadjusted regressions. Benin, Bolivia, India, Senegal and Tanzania are examples where child survival is maximised if the first birth is delayed to the ages of 27−29, and most countries (38/55) follow this pattern (table A3).

Age of the mother at first birth is a risk factor for infant mortality and adverse child health outcomes in adjusted analysis controlling for maternal, paternal, and household and social characteristics (table 4). The RR ratios of each age group (relative to 27−29 year olds who are the reference group) and 95% CIs are plotted in figure 2. Child health outcomes improve with increasing age of the mother at first birth through to age 27−29 even after controlling for maternal, paternal, household and social factor covariates (table 4, figure 2).

Maternal and paternal age have different effects on child health outcomes (table 4). In the cases of infant mortality, underweight, wasting and anaemia, maternal and paternal age have similar effect sizes, indicating the role of social mechanisms (table 4). In the case of stunting and diarrhoea, while having a very young father increases the RR of poor child health outcomes, the effect is significantly smaller than that of the mother's age, strengthening the case that the effect has a biological component for these two child health outcomes (table 4). There may be concern that the effect of the age of the mother on child health outcomes may be changing over time. Although the year of birth is controlled for, this only controls for year-specific events and not for an interaction between the age of the mother and the year of birth. To explore this possibility, online supplementary table A4 is the same model as that in table 4 but the sample is restricted to surveys between 2000 and 2005. Comparison of results in table A4 and table 4 shows that the effect of the age of the mother on child health is similar across the two samples. This comparison suggests that the effect of age on child health outcomes is not changing over the study period.

The effect of the young age of the mother at first birth on poor child health outcomes reflects a combination of biological and social factors. If the effect were solely social, then we would expect no age gradient for women grouped into high and low socioeconomic status (SES).

Table 3 Weighted frequency and distribution covariates across age of the mother at first birth

Age band in years	12–14		15–17		18–20		21–23		24–26		27–29		30–32		33–35	
	n=4322		n=41 384		n=61 491		n=38 300		n=18 211		n=7939		n=3493		n=1443	
	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction	Population	Weighted fraction
Sex of child																
Male	2323	0.517	21 627	0.512	31 995	0.515	19 017	0.504	8941	0.514	3964	0.518	1731	0.513	705	0.504
Female	2173	0.483	20 607	0.488	30 096	0.485	18 741	0.496	8443	0.486	3685	0.482	1646	0.487	694	0.496
Type of birth																
Singleton	4477	0.996	42 003	0.995	61 701	0.994	37 376	0.990	17 173	0.988	7532	0.985	3317	0.982	1369	0.979
Twin	19	0.004	230	0.005	390	0.006	382	0.010	211	0.012	116	0.015	60	0.018	30	0.021
Age of child in months																
48–60	1380	0.307	11 154	0.264	15 402	0.248	9272	0.246	4269	0.246	1841	0.241	890	0.263	335	0.240
36–47	1260	0.280	10 537	0.249	14 491	0.233	9378	0.248	4176	0.240	1822	0.238	822	0.243	307	0.219
24–35	995	0.221	10 125	0.240	15 252	0.246	9419	0.249	4191	0.241	1885	0.246	839	0.248	376	0.269
12–23	862	0.192	10 418	0.247	16 946	0.273	9687	0.257	4748	0.273	2100	0.275	827	0.245	381	0.272
Educational level of the mother at time of interview																
Secondary or higher	30	0.007	1518	0.036	9263	0.149	11 213	0.297	7607	0.438	3979	0.520	1836	0.544	705	0.504
Completed primary	957	0.213	13 415	0.318	22 837	0.368	12 459	0.330	4961	0.285	1899	0.248	781	0.231	336	0.241
No education or incomplete primary	3509	0.780	27 300	0.646	29 991	0.483	14 085	0.373	4816	0.277	1770	0.231	760	0.225	357	0.256
Mother has a partner																
Yes	4101	0.912	38 606	0.914	57 623	0.928	35 469	0.939	16 378	0.942	7208	0.942	3181	0.942	1291	0.923
No	395	0.088	3627	0.086	4468	0.072	2288	0.061	1006	0.058	440	0.058	196	0.058	108	0.077
Educational level of the mother's partner at the time of interview																
Completed secondary or higher	669	0.149	8265	0.196	17 087	0.275	14 040	0.372	8148	0.469	4113	0.538	1876	0.556	746	0.533
Completed primary	1107	0.246	12 977	0.307	21 683	0.349	12 533	0.332	5193	0.299	2031	0.266	802	0.238	328	0.235
No education or incomplete primary	2721	0.605	20 992	0.497	23 321	0.376	11 184	0.296	4042	0.233	1504	0.197	699	0.207	325	0.232
Age band in years of the mother's partner at the mother's first birth																
12–17	313	0.070	1250	0.030	407	0.007	109	0.003	20	0.001	4	0.001	1	0.000	1	0.000
18–23	1587	0.353	14 655	0.347	17 407	0.280	5426	0.144	898	0.052	227	0.030	55	0.016	17	0.012
24–29	2256	0.502	22 157	0.525	36 519	0.588	24 543	0.650	10 869	0.625	3671	0.480	1220	0.361	487	0.348
30–35	214	0.048	2756	0.065	5480	0.088	5634	0.149	3981	0.229	2491	0.326	1203	0.356	313	0.223
36–41	83	0.019	896	0.021	1467	0.024	1319	0.035	1155	0.066	848	0.111	631	0.187	371	0.265
42–59	44	0.010	520	0.012	812	0.013	727	0.019	461	0.027	407	0.053	267	0.079	211	0.151
Wealth quintile of the child's household																
Richest	366	0.081	4937	0.117	10 572	0.170	9490	0.251	6196	0.356	3283	0.429	1423	0.421	557	0.398
Rich	710	0.158	7659	0.181	13 466	0.217	9088	0.241	3972	0.228	1700	0.222	815	0.241	340	0.243
Middle	950	0.211	9159	0.217	13 772	0.222	7453	0.197	2950	0.170	1185	0.155	517	0.153	216	0.154
Poorer	1194	0.265	10 329	0.245	12 770	0.206	6330	0.168	2354	0.135	838	0.110	350	0.103	160	0.114
Poorest	1277	0.284	10 148	0.240	11 511	0.185	5397	0.143	1911	0.110	642	0.084	273	0.081	126	0.090
Residence of the child's household at the time of interview																
Urban	1033	0.230	12 159	0.288	22 251	0.358	16 999	0.450	9721	0.559	4969	0.650	2315	0.686	949	0.678
Rural	3463	0.770	30 074	0.712	39 840	0.642	20 759	0.550	7663	0.441	2679	0.350	1062	0.314	450	0.322
Water piped to child's house																
Piped to house	1082	0.241	13 530	0.320	25 731	0.414	18 816	0.498	9906	0.570	4736	0.619	2149	0.636	896	0.640
Water not piped to house	3415	0.759	28 704	0.680	36 360	0.586	18 942	0.502	7478	0.430	2912	0.381	1228	0.364	503	0.360
Flush toilet at child's house																
Flush toilet at house	434	0.097	6908	0.164	16 700	0.269	14 506	0.384	8551	0.492	4380	0.573	2080	0.616	859	0.614
No flush toilet at house	4062	0.903	35 325	0.836	45 390	0.731	23 251	0.616	8832	0.508	3269	0.427	1297	0.384	540	0.386
Child measles vaccination																
Cluster weighted mean		0.359		0.298		0.238		0.202		0.166		0.145		0.125		0.139

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Table 4 Adjusted RR (95% CI) of infant mortality and child health outcome by age of the mother at first birth

	Infant mortality	Stunting	Underweight	Wasting	Diarrhoea	Moderate anaemia
Age band in years of the mother at first birth						
27–29 (reference)	1.00	1.00	1.00	1.00	1.00	1.00
12–14	1.703 (1.478 to 1.962)	1.507 (1.416 to 1.603)	1.351 (1.236 to 1.477)	1.027 (0.870 to 1.211)	1.365 (1.216 to 1.533)	1.315 (1.131 to 1.528)
15–17	1.307 (1.160 to 1.474)	1.341 (1.274 to 1.412)	1.218 (1.131 to 1.313)	1.040 (0.923 to 1.170)	1.326 (1.224 to 1.436)	1.357 (1.222 to 1.507)
18–20	1.083 (0.963 to 1.219)	1.272 (1.210 to 1.338)	1.122 (1.043 to 1.207)	1.007 (0.899 to 1.129)	1.244 (1.151 to 1.343)	1.327 (1.200 to 1.468)
21–23	1.018 (0.903 to 1.148)	1.191 (1.132 to 1.254)	1.052 (0.976 to 1.132)	1.018 (0.908 to 1.141)	1.227 (1.135 to 1.326)	1.349 (1.219 to 1.493)
24–26	1.079 (0.948 to 1.228)	1.087 (1.028 to 1.148)	0.989 (0.912 to 1.071)	1.004 (0.889 to 1.135)	1.108 (1.019 to 1.203)	1.239 (1.114 to 1.378)
30–32	1.191 (0.981 to 1.445)	0.925 (0.845 to 1.013)	0.824 (0.717 to 0.947)	0.915 (0.749 to 1.119)	0.979 (0.860 to 1.115)	1.117 (0.947 to 1.317)
33–35	1.340 (1.041 to 1.725)	1.025 (0.908 to 1.156)	0.872 (0.715 to 1.062)	0.976 (0.733 to 1.299)	0.831 (0.687 to 1.006)	1.079 (0.854 to 1.362)
Sex of child						
Male (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Female	0.787 (0.759 to 0.815)	0.900 (0.888 to 0.913)	0.915 (0.895 to 0.935)	0.854 (0.821 to 0.889)	0.927 (0.903 to 0.951)	0.956 (0.927 to 0.985)
Type of birth						
Singleton (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Twin	4.998 (4.609 to 5.421)	1.302 (1.207 to 1.404)	1.627 (1.459 to 1.814)	1.264 (1.018 to 1.570)	0.918 (0.782 to 1.077)	1.135 (0.963 to 1.337)
Age of child in months						
48–59 (reference)		1.00	1.00	1.00	1.00	1.00
36–47		1.146 (1.119 to 1.174)	1.023 (0.986 to 1.062)	0.986 (0.916 to 1.060)	1.392 (1.311 to 1.477)	1.219 (1.147 to 1.296)
24–35		1.246 (1.217 to 1.275)	1.123 (1.083 to 1.164)	1.145 (1.066 to 1.229)	2.446 (2.316 to 2.582)	1.609 (1.513 to 1.711)
12–23		1.169 (1.141 to 1.198)	1.114 (1.073 to 1.156)	1.572 (1.466 to 1.686)	3.818 (3.625 to 4.021)	2.240 (2.102 to 2.386)
Educational level of the mother at time of interview						
Secondary or higher (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Completed primary	1.266 (1.160 to 1.382)	1.286 (1.243 to 1.329)	1.282 (1.214 to 1.354)	1.022 (0.945 to 1.105)	1.143 (1.092 to 1.196)	1.079 (1.009 to 1.154)
No education or incomplete primary	1.626 (1.480 to 1.786)	1.482 (1.429 to 1.536)	1.586 (1.495 to 1.681)	1.243 (1.141 to 1.355)	1.192 (1.131 to 1.256)	1.159 (1.075 to 1.248)
Mother has a partner						
Yes (reference)	1.00	1.00	1.00	1.00	1.00	1.00
No	0.977 (0.881 to 1.084)	1.148 (1.106 to 1.193)	1.237 (1.158 to 1.322)	1.232 (1.101 to 1.379)	1.105 (1.043 to 1.170)	1.110 (1.022 to 1.206)
Educational level of the mother's partner at the time of interview						
Higher (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Completed primary	1.099 (1.027 to 1.176)	1.068 (1.040 to 1.097)	1.097 (1.052 to 1.144)	1.037 (0.969 to 1.109)	1.059 (1.015 to 1.104)	1.053 (0.993 to 1.117)
No education or incomplete primary	1.232 (1.147 to 1.324)	1.131 (1.099 to 1.163)	1.233 (1.180 to 1.288)	1.151 (1.070 to 1.238)	1.068 (1.019 to 1.120)	1.098 (1.029 to 1.172)

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Table 4 Continued

	Infant mortality	Stunting	Underweight	Wasting	Diarrhoea	Moderate anaemia
Age band in years of the mother's partner at the mother's first birth						
24–29 (reference)	1.00	1.00	1.00	1.00	1.00	1.00
12–17	1.410 (1.237 to 1.606)	1.148 (1.081 to 1.219)	1.125 (1.017 to 1.245)	1.008 (0.801 to 1.269)	1.049 (0.932 to 1.181)	1.090 (0.937 to 1.269)
18–23	1.077 (1.026 to 1.130)	1.054 (1.035 to 1.073)	1.026 (0.997 to 1.056)	0.979 (0.927 to 1.034)	1.032 (0.997 to 1.068)	1.050 (1.010 to 1.092)
30–35	0.942 (0.884 to 1.005)	0.964 (0.939 to 0.990)	0.953 (0.918 to 0.990)	0.941 (0.882 to 1.004)	0.958 (0.915 to 1.002)	0.997 (0.949 to 1.046)
36–41	0.996 (0.904 to 1.097)	0.986 (0.945 to 1.028)	0.932 (0.875 to 0.992)	0.929 (0.835 to 1.034)	1.032 (0.960 to 1.108)	1.069 (0.994 to 1.149)
42–59	1.046 (0.932 to 1.173)	1.036 (0.983 to 1.093)	1.030 (0.954 to 1.111)	0.977 (0.855 to 1.118)	1.101 (1.004 to 1.207)	0.962 (0.874 to 1.060)
Wealth quintile of the child's household						
Richest (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Rich	1.138 (1.063 to 1.219)	1.182 (1.148 to 1.216)	1.272 (1.216 to 1.331)	1.110 (1.032 to 1.194)	1.171 (1.117 to 1.227)	1.157 (1.093 to 1.224)
Middle	1.223 (1.136 to 1.316)	1.257 (1.218 to 1.297)	1.416 (1.348 to 1.486)	1.276 (1.176 to 1.384)	1.209 (1.149 to 1.272)	1.246 (1.170 to 1.326)
Poorer	1.268 (1.173 to 1.371)	1.332 (1.289 to 1.376)	1.524 (1.448 to 1.604)	1.344 (1.233 to 1.466)	1.244 (1.177 to 1.314)	1.287 (1.203 to 1.378)
Poorest	1.289 (1.187 to 1.399)	1.445 (1.397 to 1.496)	1.671 (1.585 to 1.762)	1.458 (1.331 to 1.598)	1.289 (1.213 to 1.369)	1.338 (1.245 to 1.438)
Residence of the child's household at the time of interview						
Urban (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Rural	1.043 (0.991 to 1.099)	1.082 (1.059 to 1.106)	1.029 (0.996 to 1.064)	0.943 (0.891 to 0.998)	0.939 (0.905 to 0.974)	0.981 (0.937 to 1.026)
Water piped to the child's house						
Piped to house (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Water not piped to house	1.100 (1.047 to 1.156)	0.956 (0.938 to 0.975)	1.031 (1.000 to 1.063)	1.034 (0.980 to 1.092)	1.002 (0.969 to 1.037)	0.988 (0.950 to 1.029)
Flush toilet at child's house						
Flush toilet at house (reference)	1.00	1.00	1.00	1.00	1.00	1.00
No flush toilet at house	1.137 (1.062 to 1.217)	1.224 (1.191 to 1.259)	1.137 (1.091 to 1.184)	1.045 (0.978 to 1.116)	1.041 (0.997 to 1.087)	1.035 (0.982 to 1.090)
Child measles vaccination						
Vaccinated (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Not vaccinated	1.108 (1.038 to 1.183)	1.070 (1.042 to 1.100)	1.164 (1.120 to 1.209)	1.195 (1.113 to 1.284)	1.072 (1.020 to 1.127)	1.109 (1.051 to 1.170)
Observations	176 583	119 018	122 680	120 246	135 121	31 520

That is, if all women are of the same SES, then any age gradient reflects the biological mechanism. This hypothesis is explored by stratifying low and high SES. For the high SES group, we select children who have mothers who have completed at least primary school, in households that are in one of the top two wealth quintiles and who live in an urban area (table 5). In contrast, we select the children with mothers who have not completed primary school, are in households that are in the bottom two wealth quintiles and live in a rural area into the low SES group. At the top of table 5 we report the absolute prevalence of the child health outcome by this stratification. In the high SES group, 3.0% of the infants die, while in the low SES households, 10.4% of the infants die (table 5). Stunting, underweight, wasting, diarrhoea and anaemia are all much more prevalent

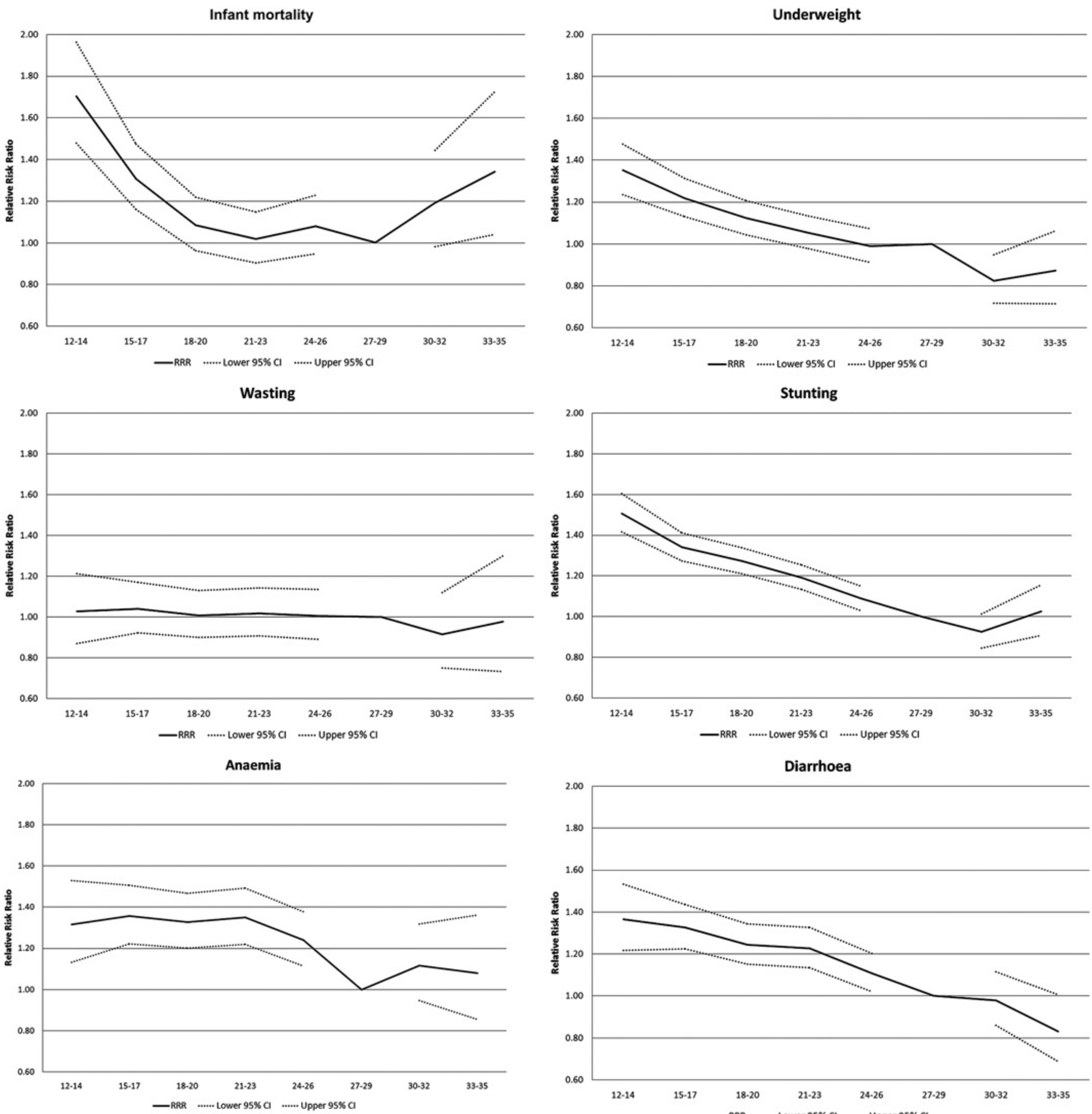

Figure 2 Plot of adjusted RR ratios and 95% CIs as per the results in table 4.

in low SES households than in high SES households (table 5). However, when considering the RR ratios across the age groups for the outcomes of stunting, underweight and diarrhoea, the RR of a poor health outcome for young mothers is higher in the high SES households than in the low SES households (table 5). The difference in the RR of age on these child health outcomes across the two groups indicates that early childbearing is not just a risk factor in lower socioeconomic groups, and that the biological mechanism of young mothers plays a role in determining child health outcomes.

Sensitivity analysis

Recent work by Subramanian *et al*[2] and Ozaltin *et al*[3] indicates that maternal height is a significant predictor of infant mortality, anthropometric failure and anaemia in India. At the cost of a smaller sample (n=101 054), height is included as a control variable in the regression, in addition to the controls used in the adjusted regressions, to examine whether in the sub-set of countries for which the DHS have data on women's height, the age effect that we observe is confounded by maternal height. Household religion is also included as a control variable as in many low- to middle-income countries religion has

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Table 5 Adjusted RR (95% CI) ratios in high SES and low SES households

	Infant mortality		Stunting		Underweight		Wasting		Diarrhoea		Moderate anaemia	
	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES
Prevalence (weighted %)	2.99	10.4	18.6	54.2	7.92	33.6	4.46	11.7	11	15.4	21.4	42.2
Age band in years of the mother at first birth												
27–29 (reference)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12–14	1.757 (1.015 to 3.040)	1.747 (1.338 to 2.283)	1.899 (1.473 to 2.449)	1.244 (1.118 to 1.385)	1.750 (1.169 to 2.619)	1.167 (1.004 to 1.355)	0.875 (0.358 to 2.140)	1.062 (0.776 to 1.452)	1.792 (1.229 to 2.612)	1.342 (1.057 to 1.702)	0.388 (0.108 to 1.400)	1.438 (1.047 to 1.974)
15–17	1.297 (0.984 to 1.710)	1.315 (1.029 to 1.681)	1.474 (1.313 to 1.655)	1.143 (1.040 to 1.257)	1.377 (1.147 to 1.654)	1.066 (0.935 to 1.215)	1.234 (0.950 to 1.602)	0.968 (0.744 to 1.258)	1.377 (1.172 to 1.618)	1.181 (0.964 to 1.446)	1.234 (1.001 to 1.521)	1.504 (1.144 to 1.978)
18–20	1.087 (0.846 to 1.398)	1.104 (0.865 to 1.409)	1.308 (1.179 to 1.452)	1.085 (0.987 to 1.192)	1.260 (1.071 to 1.482)	0.984 (0.863 to 1.121)	1.181 (0.951 to 1.467)	0.964 (0.743 to 1.250)	1.395 (1.214 to 1.603)	1.107 (0.905 to 1.354)	1.154 (0.964 to 1.381)	1.433 (1.092 to 1.880)
21–23	1.020 (0.800 to 1.300)	1.016 (0.790 to 1.307)	1.221 (1.102 to 1.352)	1.065 (0.968 to 1.171)	1.156 (0.985 to 1.357)	0.948 (0.830 to 1.084)	1.198 (0.976 to 1.472)	0.990 (0.759 to 1.292)	1.318 (1.152 to 1.508)	1.126 (0.917 to 1.382)	1.203 (1.008 to 1.437)	1.500 (1.141 to 1.972)
24–26	1.015 (0.783 to 1.315)	1.116 (0.848 to 1.470)	1.083 (0.972 to 1.208)	0.989 (0.890 to 1.100)	1.028 (0.871 to 1.215)	0.941 (0.811 to 1.091)	1.207 (0.979 to 1.489)	1.076 (0.811 to 1.428)	1.206 (1.048 to 1.388)	1.139 (0.911 to 1.425)	1.105 (0.925 to 1.320)	1.424 (1.066 to 1.901)
30–32	1.647 (1.183 to 2.291)	0.710 (0.414 to 1.216)	0.918 (0.771 to 1.093)	0.911 (0.760 to 1.093)	0.875 (0.666 to 1.150)	0.827 (0.624 to 1.097)	0.971 (0.697 to 1.351)	0.832 (0.488 to 1.418)	0.940 (0.757 to 1.167)	1.111 (0.777 to 1.590)	1.151 (0.886 to 1.496)	1.270 (0.820 to 1.966)
33–35	1.407 (0.846 to 2.341)	0.956 (0.525 to 1.740)	1.049 (0.822 to 1.338)	1.222 (1.013 to 1.473)	0.743 (0.471 to 1.170)	0.860 (0.594 to 1.245)	1.128 (0.713 to 1.785)	0.650 (0.287 to 1.473)	0.769 (0.555 to 1.065)	0.821 (0.488 to 1.379)	1.036 (0.686 to 1.565)	1.438 (0.826 to 2.502)
Sex of child												
Male (reference)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Female	0.700 (0.627 to 0.782)	0.829 (0.781 to 0.881)	0.850 (0.814 to 0.888)	0.929 (0.908 to 0.951)	0.911 (0.850 to 0.977)	0.921 (0.890 to 0.954)	0.886 (0.802 to 0.979)	0.843 (0.786 to 0.905)	0.913 (0.859 to 0.969)	0.959 (0.910 to 1.011)	0.942 (0.868 to 1.021)	0.963 (0.910 to 1.019)
Type of birth												
Singleton (reference)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Twin	5.439 (4.278 to 6.916)	4.557 (3.932 to 5.281)	1.212 (0.991 to 1.482)	1.271 (1.111 to 1.454)	1.704 (1.290 to 2.251)	1.448 (1.179 to 1.778)	1.365 (0.898 to 2.074)	1.392 (0.917 to 2.112)	0.768 (0.533 to 1.106)	1.015 (0.716 to 1.437)	1.061 (0.733 to 1.534)	1.183 (0.860 to 1.627)

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Table 5 Continued

	Infant mortality		Stunting		Underweight		Wasting		Diarrhoea		Moderate anaemia	
	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES
Age of child in months												
Age 48–59 (reference)			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
36–47			1.239 (1.145 to 1.341)	1.118 (1.076 to 1.162)	1.037 (0.919 to 1.170)	1.037 (0.976 to 1.102)	0.877 (0.741 to 1.039)	0.994 (0.868 to 1.138)	1.410 (1.229 to 1.617)	1.453 (1.289 to 1.638)	1.258 (1.064 to 1.487)	1.219 (1.095 to 1.357)
24–35			1.415 (1.310 to 1.528)	1.172 (1.129 to 1.216)	1.182 (1.049 to 1.331)	1.142 (1.077 to 1.211)	0.956 (0.806 to 1.133)	1.236 (1.086 to 1.408)	2.466 (2.174 to 2.796)	2.507 (2.246 to 2.799)	1.763 (1.493 to 2.081)	1.469 (1.319 to 1.637)
12–23			1.392 (1.287 to 1.506)	1.081 (1.040 to 1.124)	1.107 (0.977 to 1.254)	1.151 (1.084 to 1.222)	1.156 (0.974 to 1.371)	1.853 (1.632 to 2.104)	3.891 (3.449 to 4.389)	3.720 (3.347 to 4.135)	2.585 (2.163 to 3.090)	1.927 (1.727 to 2.149)
Educational level of the mother at time of interview												
Secondary or higher (reference)	1.00		1.00		1.00		1.00		1.00		1.00	
Completed primary	1.220 (1.049 to 1.420)		1.266 (1.191 to 1.346)		1.208 (1.101 to 1.325)		1.103 (0.969 to 1.255)		1.177 (1.085 to 1.277)		1.099 (0.987 to 1.223)	
Mother has a partner												
Omitted category: yes												
No	1.012 (0.811 to 1.263)	0.960 (0.739 to 1.246)	1.215 (1.108 to 1.332)	1.038 (0.949 to 1.135)	1.333 (1.127 to 1.577)	1.180 (1.012 to 1.377)	1.249 (0.985 to 1.583)	1.608 (1.179 to 2.193)	1.038 (0.926 to 1.163)	1.223 (1.030 to 1.451)	1.100 (0.930 to 1.301)	1.063 (0.814 to 1.388)
Educational level of the mother's partner at the time of interview												
Secondary or higher (reference)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Completed primary	1.046 (0.911 to 1.201)	1.100 (0.902 to 1.341)	1.115 (1.052 to 1.182)	0.997 (0.926 to 1.074)	1.137 (1.041 to 1.242)	1.056 (0.940 to 1.187)	0.910 (0.807 to 1.027)	1.266 (0.994 to 1.613)	1.071 (0.989 to 1.159)	0.989 (0.852 to 1.148)	1.087 (0.979 to 1.208)	0.987 (0.782 to 1.246)
No education or incomplete primary	1.303 (1.059 to 1.602)	1.277 (1.059 to 1.540)	1.206 (1.109 to 1.312)	1.039 (0.968 to 1.116)	1.381 (1.218 to 1.566)	1.224 (1.094 to 1.370)	1.180 (0.981 to 1.420)	1.452 (1.149 to 1.834)	1.209 (1.069 to 1.368)	1.002 (0.869 to 1.156)	1.221 (1.043 to 1.428)	0.974 (0.777 to 1.222)
Age band in years of the mother's partner at the mother's first birth												
24–29 (reference)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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Table 5 Continued

	Infant mortality		Stunting		Underweight		Wasting		Diarrhoea		Moderate anaemia	
	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES
12–17	1.284 (0.668 to 2.470)	1.528 (1.261 to 1.851)	1.010 (0.697 to 1.466)	1.087 (0.996 to 1.186)	1.106 (0.627 to 1.952)	1.085 (0.937 to 1.256)	0.551 (0.141 to 2.147)	0.959 (0.672 to 1.368)	1.206 (0.847 to 1.715)	1.091 (0.883 to 1.349)	1.124 (0.664 to 1.901)	1.005 (0.785 to 1.285)
18–23	1.122 (0.948 to 1.327)	1.090 (1.008 to 1.178)	1.141 (1.070 to 1.217)	1.036 (1.006 to 1.068)	1.072 (0.970 to 1.186)	1.015 (0.970 to 1.063)	1.028 (0.872 to 1.211)	0.977 (0.889 to 1.073)	0.967 (0.881 to 1.061)	1.076 (1.006 to 1.149)	1.069 (0.954 to 1.198)	1.061 (0.989 to 1.138)
30–35	0.907 (0.770 to 1.069)	0.970 (0.863 to 1.090)	0.937 (0.875 to 1.004)	0.964 (0.919 to 1.012)	0.917 (0.825 to 1.019)	0.960 (0.898 to 1.026)	1.012 (0.880 to 1.163)	0.878 (0.767 to 1.004)	0.911 (0.831 to 1.000)	0.990 (0.895 to 1.094)	0.892 (0.795 to 1.000)	1.122 (1.027 to 1.226)
36–41	0.784 (0.587 to 1.048)	0.950 (0.797 to 1.132)	0.962 (0.852 to 1.086)	1.030 (0.963 to 1.101)	0.760 (0.614 to 0.940)	0.970 (0.880 to 1.069)	1.070 (0.842 to 1.360)	0.851 (0.701 to 1.034)	0.994 (0.851 to 1.160)	0.993 (0.855 to 1.152)	0.876 (0.715 to 1.074)	1.180 (1.044 to 1.334)
42–59	0.698 (0.413 to 1.178)	1.100 (0.912 to 1.327)	1.106 (0.907 to 1.349)	1.054 (0.973 to 1.141)	1.119 (0.807 to 1.550)	0.960 (0.854 to 1.079)	1.388 (0.940 to 2.052)	0.885 (0.711 to 1.103)	0.949 (0.731 to 1.233)	1.078 (0.909 to 1.280)	0.910 (0.656 to 1.263)	1.012 (0.869 to 1.178)
Wealth quintile of the child's household												
Richest (reference)	1.00		1.00		1.00		1.00		1.00		1.00	
Rich	1.267 (1.111 to 1.445)		1.223 (1.161 to 1.290)		1.288 (1.187 to 1.398)		1.045 (0.926 to 1.180)		1.143 (1.065 to 1.226)		1.121 (1.023 to 1.228)	
Middle												
Poorer		0.996 (0.938 to 1.057)		0.936 (0.913 to 0.959)		0.923 (0.891 to 0.956)		0.937 (0.870 to 1.008)		0.957 (0.905 to 1.012)		0.977 (0.922 to 1.037)
Poorest (reference)		1.00		1.00		1.00		1.00		1.00		1.00
Water piped to the child's house												
Piped to house (reference)												
Water not piped to house	1.066 (0.924 to 1.229)	1.138 (1.017 to 1.273)	0.936 (0.883 to 0.993)	0.964 (0.925 to 1.004)	1.001 (0.919 to 1.089)	1.066 (0.995 to 1.142)	0.991 (0.874 to 1.123)	1.163 (1.015 to 1.333)	0.966 (0.884 to 1.055)	1.065 (0.979 to 1.159)	0.976 (0.886 to 1.076)	1.028 (0.933 to 1.133)
Flush toilet at child's house												
Flush toilet at house (reference)												

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Table 5 Continued

	Infant mortality		Stunting		Underweight		Wasting		Diarrhoea		Moderate anaemia	
	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES	High SES	Low SES
No flush toilet at house	0.948 (0.818 to 1.098)	1.369 (1.075 to 1.745)	1.158 (1.089 to 1.232)	1.173 (1.064 to 1.294)	1.082 (0.988 to 1.185)	1.239 (1.037 to 1.481)	1.011 (0.879 to 1.164)	0.996 (0.753 to 1.318)	1.088 (0.994 to 1.191)	1.057 (0.889 to 1.257)	0.984 (0.872 to 1.110)	0.982 (0.797 to 1.209)
Child measles vaccination												
Not vaccinated	1.653 (1.309 to 2.088)	1.000 (0.905 to 1.106)	1.190 (1.072 to 1.320)	1.066 (1.022 to 1.111)	1.211 (1.037 to 1.414)	1.200 (1.130 to 1.275)	1.229 (0.969 to 1.559)	1.185 (1.050 to 1.337)	1.045 (0.907 to 1.204)	1.030 (0.940 to 1.129)	1.299 (1.101 to 1.531)	1.127 (1.035 to 1.228)
Observations	40 299	38 612	28 797	23 657	29 345	24 846	28 783	24 251	32 809	27 435	8027	6026

High SES includes children who are in households that are in the rich or richest wealth quintiles, have mothers with completed primary school or higher, and live in an urban area. Low SES includes children who are in households that are in the poor and poorest wealth quintiles, have mothers with incomplete primary or no education, and live in a rural area.
SES, socioeconomic status.

a bearing on household decision-making that may include health seeking behaviour. Moreover, religion may influence the autonomy of women to make decisions over the timing of their first birth. Even after controlling for height and religion, the age of the mother at first birth remains a significant risk factor for infant mortality, anthropometric failure and child health outcomes (online supplementary table A5). When height, which is an additional biological covariate, and religion, which is an additional social covariate, are controlled for, the general relationship between the age of the mother at their first birth and child health outcomes persists (table A5).

DISCUSSION

Principal findings

In this paper we show that, controlling for maternal, paternal and household and social factors, there is an improvement in child health outcomes as the age of the mother at first birth increases to age 27–29. This is a much higher age than has been previously reported, where teen pregnancy is emphasised as a risk factor. In the adjusted model, we show that there is an elevated risk of infant mortality in first-born children to mothers below the ages of 27–29, although the effect is only statistically significant for women below age 18. However, the lack of significance may be because cases of infant mortality in our sample are relatively rare, whereas we find that mothers below age 27–29 have elevated and statistically significant risks for stunting, diarrhoea and anaemia outcomes.

Our results indicate that children to mothers below age 27–29 are at higher risk of poor health outcomes. In our sample of low- to middle-income countries, only 7% of women delay their first birth until the age of 27 or older. The USA has seen a steady rise in the average age at first birth from 21 in 1970 to 25 in 2000.[37] Age at first birth is increasing in some of our sample countries, but is still lagging behind the level seen in the USA. For example, in the 1993 Bangladesh DHS, the mean age for first births in the last 5 years was 18.2, but in 2007 had risen to 18.5. In Ghana, age for first births increased from a mean of 19.8 in 1988 to 21.2 in 2008. In Tanzania, mean age at first birth increased from 19.2 in 1991 to 19.6 in 2004. Bongaarts found that family planning programs can reduce the child mortality rate by delaying the age at first birth, preventing high parity births and improving birth spacing.[38] The results in this paper indicate that delaying the age at first birth even for women in their early 20s reduces infant mortality and improves child health.

Overall, the risk of a poor health outcome dissipates by age 21, but the general trend of improvement continues through to age 27–29. Thus, while the early 20s present a lower risk of a poor child health outcome than a first birth to a teen mother, delaying to the late 20s means that the risk of a poor child health outcome is minimised. Moreover, we find evidence of a paternal age gradient, although it is weaker than the maternal age

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gradient. This indicates that social mechanisms play some role, but the biological maturity of the mother also helps determine child health outcomes. This finding was also supported by the stratification by low and high SES, where we found that the age gradient was not solely reflecting socioeconomic differences across the ages.

Comparisons to other studies

Consistent with country studies, in this paper we show that delaying first birth beyond the teen years and into the 20s has a positive impact on child survival. While from the 2005–2006 India sample, Raj *et al*[13] found that maternal age only has a significant effect on stunting and underweight, in the current study that applies to 55 low- to middle-income countries, we find that older maternal age has a significant effect on reducing infant mortality, stunting, underweight, diarrhoea and moderate to severe anaemia. The broadening of the significant results to include other child health outcomes results from the inclusion of more countries, and also from a wider time span. As the 2005–2006 India National Family Health Survey-3 is one of the 118 surveys within our current study, the comparison between our study and that of Raj *et al*[13] highlights the fact that generalising across countries does not always reflect each country's experience. Thus we include the country-specific examples in the online supplementary appendix (table A3). Even so, for the case of India in our sample we include three National Family Health Surveys (1992, 1998, 2005–2006). Thus, even the country-specific results may differ from the survey-specific results. Taking a broad view, however, the two papers yield the same fundamental conclusion that delaying first birth beyond the teen years is beneficial for child health outcomes.

The results in this paper also compare to those of Subramanian *et al*[39] which tease out the biological from the socioeconomic predictors of child health outcomes. If being a young mother is associated with low SES in ways we have not controlled for, maternal age at first birth may simply be a proxy for SES. However, if this were true, we would expect the effect of young fathers to be similar to that of mothers (Subramanian *et al*[39] put forward this idea of looking at the differential effects of maternal and paternal indicators on child health as a method of distinguishing between biological and social mechanisms).

Limitations of the study

Although this study provides important insights into the benefits to child health of delaying first birth to age 27–29, there are certain limitations that should be considered when interpreting the results. The primary variable of interest, the age of the mother at first birth, is subject to measurement error as data collection of this variable relies on recall by the respondent. The same holds true for identifying the population of children within the 0–11- and 12–60-month age ranges. We already include the 60-month-old children (which would normally be restricted to 12–59 months) as it is common for the mother to round up in her recall of the child's age. The result is that a larger fraction of children are reported to be 60 months rather than 59 months. As this inconsistency is attributed to recall error, we follow the WHO guidelines and include the 60-month-old children in the child group. For the women's age, we assume that measurement error increases with actual age. Given our concern over young mothers, then the measurement error on the age will be minimised for this group of interest.

A further limitation of the model is that the socioeconomic measures of male and female education, along with the wealth index, may not fully capture the SES of the woman and her child. While we include information about location of residence, piped water to the house and flush toilet, these all serve as proxies for actual SES. Any unobserved wealth captured in the residual will confound the current results. Factors such as actual household income and education quality are such variables that we are unable to control for in the regression and may significantly influence child health outcomes and shape our understanding of the role of SES factors.

Observational studies are subject to the limitation of omitted variables. In this case, there may be variables that are correlated with the age of the mother at birth, but for which we do not control. This would mean that the significance attributed to the age of the mother as a significant correlate of child health outcomes, may in fact be a proxy for other omitted factors. Fixed effects on year of birth are included in both the unadjusted and adjusted regressions to control for common factors in a given year, and secular changes over time. Country fixed effects are also included in the unadjusted and adjusted regressions to control for factors that may be common to women within the same country and are unchanging over time. The covariates control for deviations from the country average and the global time trends in the variables included in the adjusted regressions. However, there may be some factors that are correlated to the explanatory variable of interest that is omitted from the regression. In which case, the regression coefficients have omitted variable bias. Omitted variables correlated to the age of the mother could include place of delivery, trained or untrained birth attendance and breastfeeding.

One of the key outcomes of interest in this study is infant mortality. Infant mortality is aggregated across all causes of death. However, it could be reasonably expected that the age of the mother affects infant mortality outcomes by cause of death. Using a range of child health outcomes in this study, we have illustrated how the age of the mother is differentially (or similarly) related to various outcomes. However, an investigation of the vulnerability to death by, say, pneumonia, diarrhoea, malaria or AIDS, by the age of the mother is beyond the scope of this study as cause of death for children is not recorded in the DHS.

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Conclusions and implications

The current study documents that the first-born child of a woman aged <27–29 in low- to middle-income countries, is at a higher risk of infant mortality, stunting, underweight, diarrhoea and moderate to severe anaemia, but not wasting. Children born to women aged 12–14 or 15–17 are significantly more likely to die in their first year of life than children born to women aged 27–29. The risk of stunting, diarrhoea and anaemia diminishes significantly as a woman delays her first birth through to age 27–29, when the risk is minimised. The risk of underweight decreases significantly as a woman delays her first birth and is minimised by age 21. These results offer support to the evidence of the benefits of delaying first birth to offspring. Importantly, beyond just avoiding teen pregnancy, the results in this study show that it is optimal to delay first birth until age 27–29. The results reveal that interventions designed to target adolescents potentially omit a group of women in their early 20s who are also at risk of having children with poor health outcomes. The development of programmes targeting women in general, and not just teen mothers, should provide women and families with the tools to make informed decisions over the timing of their first birth. These programmes can highlight the benefits of delaying the first birth, allowing women to mature biologically, and provide a mechanism for young female family members to improve their knowledge and skills in childcare and family planning, and empowering female autonomy in decision making within the household.

Our results indicated that while the absolute risk of poor child health outcomes is lower when mothers are in a high SES household, there remains a high RR of poor child health outcomes for young mothers even in high SES households. The persistence of the age gradient across the SES groups highlights that child and maternal health issues associated with the age of the mother cut across socioeconomic lines and the children of young rich women are not shielded from the RR of a poor health outcome. This indicates that the biological immaturity of young mothers also affects child health outcomes in addition to the social disadvantage young mothers often face.

When encouraging women to delay their first birth, and encouraging families to permit the delay when the women are not granted autonomy over their reproductive health decisions, this should be accompanied by the provision of viable and valuable alternatives. Education programs aimed at encouraging women to stay in school, take on meaningful employment opportunities, and provide service to the community, relieve the immediacy of the need or desire for childbearing. It also empowers women by demonstrating to themselves and their families that their contribution to society need not only be defined by their reproductive life. By delaying a few years and engaging in other activities the women contribute to society as well as broadening their skills and knowledge to go on to be more informed and better educated mothers. These benefits to the women then trickle down through the generations and benefit their offspring. In this paper, we show what those benefits are in terms of health, but future studies may highlight the educational and social benefits for children if women delay their first birth.

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Competing interests None.

Ethics approval The Demographic and Health Surveys data collection procedures were approved by ICF Macro International (Calverton, Maryland, USA) Institutional Review Board as well as by the relevant body in each country which approves research studies on human subjects. Oral informed consent for the interview/survey was obtained from respondents by interviewers. The current study was reviewed by the Harvard School of Public Health Institutional Review Board (Protocol #20069-101) and was ruled exempt from full review because the study was based on an anonymous public use data set with no identifiable information on the survey participants.

Contributors JEF co-led the conception and interpretation of results in this study. She assisted with drafting the manuscript. She prepared the data, empirical analysis and tables presented in the paper. As guarantor, she accepts full responsibility for this submitted work, had access to the data and controlled the decision to publish. EÖ assisted with conception of the article themes, compilation of the data set and empirical analysis for this study, and critical revision of the paper. DC led the conception of this study and interpretation of study findings as well as assisting with the drafting of the manuscript. All authors have seen and approved the final version of the manuscript.

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REFERENCES

1. United Nations. *We Can End Poverty 2015: Millennium Development Goals*, United Nations, 2011.
2. Subramanian SV, Ackerson LK, Davey Smith G, *et al*. Association of maternal height with child mortality, anthropometric failure, and anemia in India. *JAMA* 2009;301:1691–701.
3. Ozaltin E, Hill K, Subramanian SV. Association of maternal stature with offspring mortality, underweight, and stunting in low- to middle-income countries. *JAMA* 2010;303:1507–16.
4. Temin M, Levine R. *Start with a Girl: A New Agenda for Global Health. A Girls Count Report on Adolescent Girls*. Washington, DC: Center for Global Development, 2009.
5. Kembo J, Van Ginneken JK. Determinants of infant and child mortality in Zimbabwe: results of multivariate hazard analysis. *Demogr Res* 2009;21:367–84.
6. Knodel J, Herman AT. Effects of birth rank, maternal age, birth interval and sibship on infant and child mortality: Evidence from 18th and 19th Century Reproductive Histories. *Am J Public Health* 1984;74:1098–106.
7. Manda SO. Birth intervals, breastfeeding and determinants of childhood mortality in Malawi. *Soc Sci Med* 1999;48:301–12.
8. Reynolds HW, Wong EL, Tucker H. Adolescents' use of maternal and child health services in developing countries. *Int Fam Plann Persp* 2006;32:6–16.
9. Villar J, Belizan J. The relative contribution of prematurity and fetal growth retardation to low birth weight in developing and developed societies. *Am J Obstet Gynecol* 1982;143:793–8.

10. Vitolo MR, Gama CM, Bortolini GA, *et al*. Some risk factors associated with overweight, stunting and wasting among children under 5 years old. *J Pediatr (Rio J)* 2008;84:251−7.
11. Wang SC, Lee SH, Lee MC, *et al*. The effects of age and aboriginality on the incidence of low birth weight in mountain townships of Taiwan. *J Public Health (Oxf)* 2009;31:406−12.
12. Hobcraft J. Fertility patterns and child survival: a comparative analysis. *Popul Bull UN* 1992;33:1−31.
13. Raj A, Saggurti N, Winter M, *et al*. The effect of maternal child marriage on morbidity and mortality of children under 5 in India: cross sectional study of a nationally representative sample. *BMJ* 2010;340:b4258.
14. Trussell J, Hammerslough C. A hazards-model analysis of the covariates of infant and child mortality in Sri Lanka. *Demography* 1983;20:1−26.
15. ICF Macro. DHS final reports. In: DHS M, ed. Calverton 2011.
16. Cooper LG, Leeland NL, Alexander G. Effect of maternal age on birth outcomes among young adolescents. *Soc Biol* 1995;42:22−35.
17. Fraser AM, Brockert JE, Ward RH. Association of young maternal age with adverse reproductive outcomes. *N Engl J Med* 1995;332:1113−18.
18. Geronimus AT. On teenage childbearing and neonatal mortality in the United States. *Popul Dev Rev* 1987;13:245−79.
19. Geronimus AT, Korenman S, Hillemeier MM. Does young maternal age adversely affect child development? Evidence from cousin comparisons in the United States. *Popul Dev Rev* 1994;20:585−609.
20. Horon IL, Strobino DM, MacDonald HM. Birth weights among infants born to adolescent and young adult women. *Am J Obstet Gynecol* 1983;146:444−9.
21. Trussell J. Teenage pregnancy in the United States. *Fam Plann Perspect* 1988;20:262−72.
22. Ventura SJ, Mathews TJ, Hamilton BE. Births to teenagers in the United States, 1940-2000. *Natl Vital Stat Rep* 2001;49:1−23.
23. Alam N. Teenage motherhood and infant mortality in Bangladesh: maternal age-dependent effect of parity one. *J Biosoc Sci* 2000;32:229−36.
24. DHS. *Demographic and Health Surveys*. Calverton, MD: MEASURE DHS, 2009.
25. Rutstein SO, Rojas G. *Guide to DHS Statistics*. Calverton, MD: ORC Macro, MEASURE DHS+, 2003.
26. Wirth ME, Wirth E, Delamonica E, *et al*. *Monitoring Health Equity in the MDGs: A Practical Guide*. New York: CIESIN/UNICEF, 2006.
27. Vaessen M. The potential of the demographic and health surveys (DHS) for the evaluation and monitoring of maternal and child health indicators. In: Khlat M, ed. *Demographic Evaluation of Health Programmes (Proceedings)*. Paris: CICRED/UNFPA 1996.
28. Pullum TW. *An Assessment of the Quality of Data on Health and Nutrition in the DHS Surveys, 1993-2003*. Calverton, MD, USA: Macro International Inc, 2008.
29. ICF Macro. Demographic and health survey interviewer's manual. In: Macro International, ed. Calverton, MD, USA: ICF Macro, 2006.
30. ICF Macro. 2008. Description of the demographic and health surveys individual recode data file. MEASURE DHS Basic Documentation No. 2. Calverton, Maryland, USA: ICF Macro. http://www.measuredhs.com/pubs/search/search_results.cfm?Type=5&srchTp=type&newSrch=1 (accessed 1 Jun 2011).
31. ICF Macro. 2011. Demographic and Health Survey Interviewer's Manual. MEASURE DHS Basic Documentation No. 2. Calverton, Maryland, USA: ICF Macro.
32. ICF Macro. Measure DHS biomarkers inventory. In: DHS M, ed. 2011. http://www.measuredhs.com/aboutsurveys/biomarkers/surveys.cfm (accessed 1 Jun 1 2011).
33. Borghi E, de Onis M, Garza C, *et al*. Construction of the World Health Organization child growth standards: selection of methods for attained growth curves. *Stat Med* 2006;25:247−65.
34. Filmer D, Pritchett LH. Estimating wealth effects without expenditure data−or tears: an application to educational enrollments in states of India. *Demography* 2001;38:115−32.
35. Zou G. A modified Poisson regression approach to prospective studies with binary data. *Am J Epidemiol* 2004;159:702−6.
36. Deaton A. *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*. Baltimore: World Bank, 1997.
37. Mathews TJ, Hamilton BE. Mean age of mother, 1970-2000. *Natl Vital Stat Rep* 2002;51:1−13.
38. Bongaarts J. Does family planning reduce infant mortality rates? *Popul Dev Rev* 1987;13:323−34.
39. Subramanian SV, Ackerson LK, Smith GD. Parental BMI and childhood undernutrition in India: an assessment of intrauterine influence. *Pediatrics* 2010;126:663−71.

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