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Title

Association of Maternal Age with Infant Mortality, Child Anthropometric Failure, Diarrhoea, and Anaemia for First Births in Low- and Middle-Income Countries

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Running head: Maternal Age and Child Health

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

Design: Cross-sectional analysis of nationally representative household samples. A modified Poisson regression model is used to estimate relative risk ratios. Unadjusted relative risk ratios by country and pooled across countries are presented as are ratios after adjusting for maternal, paternal, household and social covariates for the pooled sample.

Setting: Low- and middle-income countries

Population: First births to women aged 12-35 and where this birth occurred 12-60 months prior to the interview. Information on infant mortality in the last five years and current child health was obtained from a personal interview and anthropometric measurement. The sample for analyzing 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: In under 12 months: infant mortality. In under 5s: stunting, underweight, wasting, diarrhoea and anaemia.

Results: The majority of women have their first birth before the age of 24 (83.1%; 146,578/176,583). In adjusted models, the relative risk of infant mortality is minimized if the first birth is between the ages of 18-32, and is higher when the first birth is between the ages of 12-17, and 33-35 (RRR 1.307, 95% CI 1.160 to 1.474 for 15-17 year old mothers compared to the reference group of women aged 27-29). Women who have their first birth aged 12-26 face a higher risk of having a child who is stunted than women who have their first birth age 27-35. For underweight, the risk is lowest for women aged 21-35 (RRR 1.218, 95% CI 1.131 to 1.313 for risk of underweight for 15-17 year old mothers). For child health outcomes of diarrhoea and anaemia the risk is lowest for women aged 27-35 at first birth. Adjusted RRR is 1.357, 95% CI 1.222 to 1.507 for risk of a first born child with moderate or strong anaemia for 15-17 year old mothers compared to the reference group. For wasting, the risk is equal across the age of mother at first birth. Young maternal age worsens child health outcomes. The effects are largest for very young mothers, but child health outcomes continue to improve if first birth is delayed until age 27 (for example, RRR 1.239, 95% CI 1.114 to 1.378 for risk of a first born child with moderate or strong anaemia for mothers age 24-26).

Conclusions: 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 higher risk of having a child who suffers from stunting,

diarrhoea and moderate or strong anaemia. Maternal and child health programs should take account of this increased risk even for mothers in their twenties. Increasing age as first birth in developing countries may have large benefits in terms of child health.

Article summary

Article focus

In this article we used data from 118 Demographic and Health Surveys covering 55 low- to middle- income countries to investigate the effect of age of mother at first birth on infant mortality and child health outcomes.

Using this data, we explore the relative risk of infant mortality and child health by age of mother at birth; the role of biological and socio-economic factors that are captured in the effect of age of mother on child health; and whether high socio-economic status compensates for poor health outcomes of children to young mothers.

Key messages

- In a global sample of women who had their first birth between the ages of 12 and 35, we found the risk of poor child health outcome is lowest for women who have their first birth between the ages of 27-29.
- We attempt to separate out the biological and social mechanisms associated with young age at first birth. The biological mechanism is grounded in the fact that younger women are biologically immature. The social mechanism draws on the hypothesis that younger mothers are more likely to be socio-economically disadvantaged. We find that both biological and social mechanisms play an equal role in explaining why children of young mothers have poorer outcomes in terms of infant mortality, underweight, wasting and anaemia. For the other two outcomes we explore in the paper, stunting and diarrhoea, we find that the biological mechanism is stronger than the social mechanism.
- We find that while the absolute risk of poor child health outcomes is lower for children of high SES mothers than that of children to low SES mothers, the relative risk of a poor child health outcomes to young mothers is higher for high SES mothers.

Strengths and limitations of this study

Strengths

- A large sample representing 176,583 first births across 55 low- to middle- income countries is used.

- A large number of covariates that enable the separation of biological and socio-economic influences on child health are applied.

- A range of child health outcomes rather than just one indicator are explored.

Weaknesses

- Age reporting of mother and child can be inaccurate, especially in low- to middle-income countries.

- Measures for income included in the Demographic and Health Surveys may not represent full income of the household.

Introduction

Progress towards reaching Millennium Development Goal 4 (child health) focuses on the measurable reduction in under-5 mortality. In low- to middle-income countries, this also means "revitalizing efforts against...diarrhoea, while bolstering nutrition...".[1] The risk of under-5 mortality, and the prevalence of diarrheal 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 5.7-6.3) children die before their fifth birthday. In the same population, for children under-5, 42.2% are underweight, 47.8% are stunted, 19.7% are wasted, and 69.1% are anaemic.[2] Cross-country studies highlight 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 Centre for Global Development[4] highlighted the risk to child health associated with young motherhood. When considering child health, the report draws on the intergenerational influence on child health outcomes, rather than a cross sectional observation of children alone. The effect of the age of mother at birth on child health outcomes has been explored in a few country studies in low- to middle-income context. [5-14] In the case of India, Raj *et al*[13] show that children to mothers who were married as minors were at a higher risk of stunting and underweight compared to children of women who had married at majority age. In another study, using the World Fertility Survey Trussell and Hammerslough[14] also found that mothers' age at first birth was a significant risk factors of 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% have it before age 24. Much debate, particularly with US population samples, concerns the social versus physiological influence of young motherhood on child health outcomes.[15-21] Young age can 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"[22] These physiological factors point to vulnerability for 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 outcome. Analysis that generalizes across and within countries, rather than focusing on a sample from a single country, provides standardized analyses and results to assess age as a proxy for physiological immaturity and social disadvantage and the effect on child health outcomes.

Early work by Hobcraft[12] in 1992 examines the effect of age at first birth on child survival in a number of countries using Demographic and Health Surveys 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 MDG4, and its sub-goals relating to child health.

The purpose of the current study to assess the association between maternal age at first birth and child health outcomes: infant mortality, stunting, underweight, wasting, diarrhoea, and moderate or strong anaemia. Taking account of confounding socio-economic factors, the physiological effect of young motherhood on child health can be parsed 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 Demographic and Health Surveys (DHS) conducted in 55 countries between 1990 and 2008 provided the data for the analysis in this study.[23] The DHS are nationally representative household sample surveys that measure population, health, socio-economic, and anthropometric indicators, emphasizing maternal and child health.[24] The DHS are important data source for studying population health across developing countries due to extensive coverage, comparability, and data quality.[25-27] To ensure standardization and comparability across diverse sites and time, DHS research employs intense interviewer training, standardized measurement tools and techniques, an identical core questionnaire, and instrument pretesting.[28] Country reports detail pretesting and quality assurance measures by survey (see www.measuredhs.com/pubs/search/search_results.cfm?Type=5&srchTp=type&newSrch=1). The DHS is modular in structure, and in addition to the core questionnaire, a set of country-relevant sections, and country-specific variables. The DHS provides data with standardized variables across surveys (see www.measuredhs.com/pubs/pdf/DHSG4/Recode4DHS.pdf).

Sampling Plan

The DHS involves stratified cluster randomized samples of households.[29] Every survey population is stratified by urban and rural status and additionally by country-specific geographic or administrative regions. Within each stratified area random clusters of households are 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 are selected by equal probability systematic sampling to be surveyed. Detailed sampling plans are available from survey final reports at www.measuredhs.com/pubs/search/search_results.cfm?Type=5&srchTp=type&newSrch=1. Within each sampled household a household questionnaire is administered and women eligible for a more detailed women's survey are identified. In most surveys all women between the ages of 15-49 are interviewed. In a limited number of surveys the target group it is women aged 10-49, or 15-45, or ever-married women. The child anthropometry module was conducted in a selection of the Standard Demographic and Health Surveys http://www.measuredhs.com/aboutsurveys/biomarkers/surveys.cfm. The DHS provides weights that can be used to make the sample nationally representative.

Study Population and Sample Size

Our sample consists of children born to women who have had their first birth in the period 12-60 months before the survey. The lower bound of 12 months is applied so that each child has equal exposure to one year of life and we can accurately calculate the infant mortality (children who die within the first year of life). Detailed child health measures are only taken for children up to 60 months which establishes our upper bound. Note the upper bound is to 60 months rather than 59 to conform to the World Health Organization norm. Only the first birth is in the sample for each woman, for multiply births we only use data from the first recorded birth, though we control for this being a part of a multiple birth. The initial sample is 288,752 children across 72 countries from 181 surveys. Infant mortality status is not available for 5,313 of these children reducing the sample to 283,439. Not all mothers' age at the first birth is recorded (1,564 missing) reducing the sample to 280,146 children. The age of mother is restricted to 12-35 as only 13 of the mothers had their children at age less than 12 and 1716 had their first birth at 36 or older. This leaves the sample at 280,146. We lose a significant number of observations due to missing covariates since not all surveys collect data on all

our covariate (103,563 observations lost), yielding the final sample of 176,583 children across 55 countries and 118 surveys for our mortality study. Details of the samples for the child health outcomes are given in the appendix Table A1, these samples are smaller due to child anthropometric module not conducted in a number of surveys. The stunting data set is based on 119,018 children, the wasting data set is based on 120,246 children, the underweight data set is based on 122,680 children, the diarrhoea data set is based on 135,121 children, and the anaemia data set is based on 31,520 children.

Outcome Measures

In this study, we focus on six outcomes: infant mortality, child stunting, underweight, wasting, diarrhoea, and moderate anaemia. All measures are for children born 12-60 months prior to the interview. Infant mortality is a measure of whether or not the child survived to age 1 year. 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 divided by the standard deviation of this group in the reference population. We use the World Health Organization reference population of health children in developing countries.[30] Stunting is defined as a height z-score of less than minus two. Similarly, underweight is defined as a z-score less than minus two for weight relative to children of the same sex and age in the reference population. Wasting is defined as a z-score less than minus two for weight-to-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. These observations with biologically impossible values are dropped from our samples.

The outcome of child diarrhoea is based on the mother's recall of whether their child has had diarrhoea within the two weeks prior to interview. Anaemia is 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 analyzed using the HemoCue system. Adjustments for altitude are taken into account, and children with a haemoglobin concentration less than 11 grams per decilitre are considered has having 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 child in months. The covariate for the age of child is not included in the infant mortality model (which depends only on survival to age one year) but is included in all other models. Children's age in months is categorized 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 in mother's age at the first birth. Age is categorized into three-year intervals: ages 12-14, 15-17, 18-20, 21-23, 24-26, 27-29, 30-32 and 33-35. 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,[31] 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 mother's height is available. The height of the mother is in five categories: 100-144cm, 145-149cm, 150-154cm, 155-159cm and 160-200cm. 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 and if so the partner's age and education level. Partners are typically older than the women are and partner's age is split into six categories: 12-17, 18-23, 24-29, 30-35, 36-41, 42-59. Partner's education follows the same groupings as coded for 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. We also include indicators for piped water to the house, and a flush toilet in 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.

Statistical Analysis

To measure the relative risk of a given outcome we applied a modified Poisson regression following Zou's[9] methodology. We estimate the unadjusted model only controlling for country fixed effects and survey-year 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.[32]

Results

Results: Summary Statistics

In the infant mortality model (n=176,583 children) 23.9% of the women are between the ages of 15 and 17 at first birth and 35.2% are between the ages of 18 and 20 (Table 1). The reference group in the regression analysis is children whose mothers were aged 27-29 year old at first birth. This group represents 4.3% of the population with 7,648 children. Children of multiple births are rare (0.8%), most women (92.9%) have partners, 60% of the children were born in rural areas, 43.6% have piped water to the house the remainder has 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 1).

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 1** of child health outcomes by age band. We see that, in general, the prevalence of poor child health outcomes declines with 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.

Table 1: Weighted Frequency and Distribution of First Born Children within Five 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	
	Population	Weighted Fraction	Population	Weighted Fraction	Population	Weighted Fraction	Population	Weighted Fraction	Population	Weighted Fraction	Population	Weighted Fraction
	n=176,583		n=119,018		n=122,680		n=120,246		n=135,121		n=31,520	
Age Band of the Mother at First Birth												
12-14	4,497	0.026	2,301	0.020	2443	0.020	2,379	0.020	2,851	0.021	514	0.016
15-17	42,233	0.239	25,882	0.219	26839	0.220	26,335	0.220	30,011	0.222	6,531	0.203
18-20	62,091	0.352	41,492	0.351	42868	0.352	42,054	0.352	47,425	0.351	11,753	0.366
21-23	37,757	0.214	26,427	0.224	27127	0.223	26,594	0.223	29,927	0.222	7,563	0.236
24-26	17,383	0.099	12,669	0.107	12936	0.106	12,690	0.106	14,258	0.106	3,355	0.105
27-29	7,648	0.043	5,722	0.048	5883	0.048	5,771	0.048	6,480	0.048	1,481	0.046
30-32	3,377	0.019	2,566	0.022	2616	0.022	2,547	0.021	2,884	0.021	650	0.020
33-35	1,399	0.008	1,075	0.009	1085	0.009	1,075	0.009	1,203	0.009	249	0.008
Sex of Child												
Male	90,302	0.512	59,709	0.505	61867	0.508	60,577	0.507	68,501	0.507	16,438	0.512
Female	86,083	0.488	58,424	0.495	59929	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	120853	0.992	118,515	0.992	134,004	0.992	31,850	0.992
Twin	1,438	0.008	898	0.008	944	0.008	930	0.008	1,036	0.008	247	0.008
Age of Child in Months												
48-60 months	44,542	0.253	24,472	0.207	24780	0.203	24,353	0.204	27,013	0.200	7,552	0.235
36-47 months	42,793	0.243	26,908	0.228	27694	0.227	27,210	0.228	31,330	0.232	7,867	0.245
24-35 months	43,082	0.244	31,485	0.267	32603	0.268	31,950	0.267	36,595	0.271	7,961	0.248
12-23 months	45,968	0.261	35,268	0.299	36718	0.301	35,932	0.301	40,101	0.297	8,717	0.272
Education Level of the Mother at Time of Interview												
Secondary or higher	36,152	0.205	27,729	0.235	28308	0.232	27,757	0.232	31,177	0.231	6,562	0.204
Completed primary	57,645	0.327	40,543	0.343	41341	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	52147	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	112890	0.927	110,666	0.927	125,468	0.929	30,192	0.941
No	12,527	0.071	8,784	0.074	8906	0.073	8,779	0.074	9,572	0.071	1,904	0.059
Education Level of the Mother's Partner at the Time of Interview												
Completed Secondary or Higher	54,943	0.311	39,434	0.334	40422	0.332	39,640	0.332	44,409	0.329	8,891	0.277
Completed primary	56,655	0.321	38,884	0.329	39920	0.328	39,216	0.328	44,217	0.327	12,180	0.379
No education or incomplete primary	64,787	0.367	39,815	0.337	41455	0.340	40,589	0.340	46,414	0.344	11,025	0.344

Age Band of the Mother's Partner at the Birth of the Mother's First Birth												
12-17	2,104	0.012	1,224	0.010	1236	0.010	1,211	0.010	1,409	0.010	373	0.012
18-23	40,271	0.228	27,180	0.230	28018	0.230	27,483	0.230	30,594	0.227	9,132	0.285
24-29	101,722	0.577	66,806	0.566	68828	0.565	67,569	0.566	77,555	0.574	15,792	0.492
30-35	22,072	0.125	15,954	0.135	16483	0.135	16,125	0.135	17,661	0.131	4,797	0.149
36-41	6,768	0.038	4,685	0.040	4846	0.040	4,724	0.040	5,266	0.039	1,342	0.042
42-59	3,448	0.020	2,284	0.019	2385	0.020	2,332	0.020	2,555	0.019	660	0.021
Wealth Quintile of the Child's Household												
Richest	36,825	0.209	24,886	0.211	25377	0.208	24,876	0.208	28,741	0.213	6,550	0.204
Rich	37,749	0.214	25,955	0.220	26597	0.218	26,150	0.219	29,413	0.218	6,961	0.217
Middle	36,203	0.205	24,554	0.208	25319	0.208	24,853	0.208	27,932	0.207	6,795	0.212
Poorer	34,324	0.195	22,705	0.192	23517	0.193	23,053	0.193	25,834	0.191	6,138	0.191
Poorest	31,285	0.177	20,035	0.170	20986	0.172	20,512	0.172	23,120	0.171	5,653	0.176
Residence of the Child's Household at the Time of Interview												
Urban	70,395	0.399	50,428	0.427	51491	0.423	50,597	0.424	57,358	0.425	12,301	0.383
Rural	105,990	0.601	67,706	0.573	70305	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	56699	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	65097	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	42402	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	79394	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

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 olds mothers do not have a partner compared to 5.8% of women in the 27-29 year old category (Table 2). Young mothers have lower education than older mothers do: 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 27-29 had only incomplete primary or no schooling (Table 2). Older mothers tend to be in a higher wealth quintile: 42.9% of women who had their first birth between the ages of 27-29 are in the richest quintile while 11.7% of mothers age 15-17 are in the richest quintile (Table 2). 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 have their first birth between the ages of 27-29 live in rural areas (Table 2). 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 have 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 2).

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 socio-economic characteristics. In the following analysis, we present both unadjusted results and results that control for these covariates (Table 2).

Table 2: Weighted Frequency and Distribution Covariates Across Age of Mother at Birth

Age Band	12-14		15-17		18-20		21-23		24-26		**27-29**		30-32		33-35	
	Pop.	W'ted Frac.	Pop.	W'ted Frac.	Pop.	W'ted Frac.	Pop.	W'ted Frac.	Pop.	W'ted Frac.	Pop.	W'ted Frac.	Pop.	W'ted Frac.	Pop.	W'ted Frac.
	n=4,322		n=41,384		n=61,491		n=38,300		n=18,211		n=7,939		n=3,493		n=1,443	
Sex of Child																
Male	2,323	0.517	21,627	0.512	31,995	0.515	19,017	0.504	8,941	0.514	3,964	0.518	1,731	0.513	705	0.504
Female	2,173	0.483	20,607	0.488	30,096	0.485	18,741	0.496	8,443	0.486	3,685	0.482	1,646	0.487	694	0.496
Type of Birth																
Singleton	4,477	0.996	42,003	0.995	61,701	0.994	37,376	0.990	17,173	0.988	7,532	0.985	3,317	0.982	1,369	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 months	1,380	0.307	11,154	0.264	15,402	0.248	9,272	0.246	4,269	0.246	1,841	0.241	890	0.263	335	0.240
36-47 months	1,260	0.280	10,537	0.249	14,491	0.233	9,378	0.248	4,176	0.240	1,822	0.238	822	0.243	307	0.219
24-35 months	995	0.221	10,125	0.240	15,252	0.246	9,419	0.249	4,191	0.241	1,885	0.246	839	0.248	376	0.269
12-23 months	862	0.192	10,418	0.247	16,946	0.273	9,687	0.257	4,748	0.273	2,100	0.275	827	0.245	381	0.272
Education Level of the Mother at Time of Interview																
Secondary or higher	30	0.007	1,518	0.036	9,263	0.149	11,213	0.297	7,607	0.438	3,979	0.520	1,836	0.544	705	0.504
Completed primary	957	0.213	13,415	0.318	22,837	0.368	12,459	0.330	4,961	0.285	1,899	0.248	781	0.231	336	0.241
No education or incomplete primary	3,509	0.780	27,300	0.646	29,991	0.483	14,085	0.373	4,816	0.277	1,770	0.231	760	0.225	357	0.256
Mother has a Partner																
Yes	4,101	0.912	38,606	0.914	57,623	0.928	35,469	0.939	16,378	0.942	7,208	0.942	3,181	0.942	1,291	0.923
No	395	0.088	3,627	0.086	4,468	0.072	2,288	0.061	1,006	0.058	440	0.058	196	0.058	108	0.077
Education Level of the Mother's Partner at the Time of Interview																
Completed Secondary or Higher	669	0.149	8,265	0.196	17,087	0.275	14,040	0.372	8,148	0.469	4,113	0.538	1,876	0.556	746	0.533
Completed primary	1,107	0.246	12,977	0.307	21,683	0.349	12,533	0.332	5,193	0.299	2,031	0.266	802	0.238	328	0.235
No education or incomplete primary	2,721	0.605	20,992	0.497	23,321	0.376	11,184	0.296	4,042	0.233	1,504	0.197	699	0.207	325	0.232
Age Band of the Mother's Partner at the Birth of the Mother's First Birth																
12-17	313	0.070	1,250	0.030	407	0.007	109	0.003	20	0.001	4	0.001	1	0.000	1	0.000
18-23	1,587	0.353	14,655	0.347	17,407	0.280	5,426	0.144	898	0.052	227	0.030	55	0.016	17	0.012
24-29	2,256	0.502	22,157	0.525	36,519	0.588	24,543	0.650	10,869	0.625	3,671	0.480	1,220	0.361	487	0.348
30-35	214	0.048	2,756	0.065	5,480	0.088	5,634	0.149	3,981	0.229	2,491	0.326	1,203	0.356	313	0.223
36-41	83	0.019	896	0.021	1,467	0.024	1,319	0.035	1,155	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	4,937	0.117	10,572	0.170	9,490	0.251	6,196	0.356	3,283	0.429	1,423	0.421	557	0.398
Rich	710	0.158	7,659	0.181	13,466	0.217	9,088	0.241	3,972	0.228	1,700	0.222	815	0.241	340	0.243
Middle	950	0.211	9,159	0.217	13,772	0.222	7,453	0.197	2,950	0.170	1,185	0.155	517	0.153	216	0.154
Poorer	1,194	0.265	10,329	0.245	12,770	0.206	6,330	0.168	2,354	0.135	838	0.110	350	0.103	160	0.114
Poorest	1,277	0.284	10,148	0.240	11,511	0.185	5,397	0.143	1,911	0.110	642	0.084	273	0.081	126	0.090

Residence of the Child's Household at the Time of Interview								
Urban	1,033 0.230	12,159 0.288	22,251 0.358	16,999 0.450	9,721 0.559	4,969 0.650	2,315 0.686	949 0.678
Rural	3,463 0.770	30,074 0.712	39,840 0.642	20,759 0.550	7,663 0.441	2,679 0.350	1,062 0.314	450 0.322
Water Piped to Child's House								
Piped to House	1,082 0.241	13,530 0.320	25,731 0.414	18,816 0.498	9,906 0.570	4,736 0.619	2,149 0.636	896 0.640
Water not piped to house	3,415 0.759	28,704 0.680	36,360 0.586	18,942 0.502	7,478 0.430	2,912 0.381	1,228 0.364	503 0.360
Flush Toilet at Child's House								
Flush Toilet at House	434 0.097	6,908 0.164	16,700 0.269	14,506 0.384	8,551 0.492	4,380 0.573	2,080 0.616	859 0.614
No Flush Toilet at House	4,062 0.903	35,325 0.836	45,390 0.731	23,251 0.616	8,832 0.508	3,269 0.427	1,297 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

Results: 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 27-29 (Table A2). The relative risk ratio declines as age increases between the ages of 12 and 26, and comes to a minimum for 27-29 year olds (Table A2). The relative risk ratio then increases for women who have their first birth at 33-35 (Table A2). This same U-shape is exhibited in many of the country specific unadjusted regressions. Benin, Bolivia, India, Senegal and Tanzania are examples where the child survival is maximized if the first birth is delayed to the ages of 27-29, and most countries follow this pattern (Table A2).

Age of the mother at first birth is a risk factor for infant mortality and adverse child health outcomes even when we control for maternal, paternal, and household and social characteristics (Table 3). The relative risk ratios of each age group (relative to 27-29 year olds who are the reference group) and 95% confidence intervals are plotted in **Figure 2**. Child health outcomes improve in age of the mother at first birth through to age 27-29 and in some cases 30-32 (except for wasting) even after controlling for maternal, paternal, household and social factor covariates (Table 3, Figure 2).

Maternal and paternal age have different effects on child health outcomes (Table 3). If being a young mother is associated with low socioeconomic status in ways we have not controlled for, maternal age at first birth may simply be a proxy for socioeconomic status. However if this were true, we would expect the effect of young fathers to be similar to that of mothers (Subramanian *et al*. [33] 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). In the cases of infant mortality, underweight, wasting, and anaemia, maternal and paternal age have approximately equal relative risk indicating the role of social mechanisms (Table 3). In the case of stunting and diarrhoea, while having a very young father increases the relative risk 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 3).

Table 3: Adjusted Relative Risk of Infant Mortality and Child Health Outcome by Age of Mother at First Birth

	Infant Mortality	Stunting	Underweight	Wasting	Diarrhoea	Moderate Anaemia
Age Band 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	1.507	1.351	1.027	1.365	1.315
	(1.478 - 1.962)	(1.416 - 1.603)	(1.236 - 1.477)	(0.870 - 1.211)	(1.216 - 1.533)	(1.131 - 1.528)
15-17	1.307	1.341	1.218	1.040	1.326	1.357
	(1.160 - 1.474)	(1.274 - 1.412)	(1.131 - 1.313)	(0.923 - 1.170)	(1.224 - 1.436)	(1.222 - 1.507)
18-20	1.083	1.272	1.122	1.007	1.244	1.327
	(0.963 - 1.219)	(1.210 - 1.338)	(1.043 - 1.207)	(0.899 - 1.129)	(1.151 - 1.343)	(1.200 - 1.468)
21-23	1.018	1.191	1.052	1.018	1.227	1.349
	(0.903 - 1.148)	(1.132 - 1.254)	(0.976 - 1.132)	(0.908 - 1.141)	(1.135 - 1.326)	(1.219 - 1.493)
24-26	1.079	1.087	0.989	1.004	1.108	1.239
	(0.948 - 1.228)	(1.028 - 1.148)	(0.912 - 1.071)	(0.889 - 1.135)	(1.019 - 1.203)	(1.114 - 1.378)
30-32	1.191	0.925	0.824	0.915	0.979	1.117
	(0.981 - 1.445)	(0.845 - 1.013)	(0.717 - 0.947)	(0.749 - 1.119)	(0.860 - 1.115)	(0.947 - 1.317)
33-35	1.340	1.025	0.872	0.976	0.831	1.079
	(1.041 - 1.725)	(0.908 - 1.156)	(0.715 - 1.062)	(0.733 - 1.299)	(0.687 - 1.006)	(0.854 - 1.362)
Sex of Child						
Male (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Female	0.787	0.900	0.915	0.854	0.927	0.956
	(0.759 - 0.815)	(0.888 - 0.913)	(0.895 - 0.935)	(0.821 - 0.889)	(0.903 - 0.951)	(0.927 - 0.985)
Type of Birth						
Singleton (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Twin	4.998	1.302	1.627	1.264	0.918	1.135
	(4.609 - 5.421)	(1.207 - 1.404)	(1.459 - 1.814)	(1.018 - 1.570)	(0.782 - 1.077)	(0.963 - 1.337)
Age of Child in Months						
48-59 months (Reference)		1.00	1.00	1.00	1.00	1.00
36-47 months		1.146	1.023	0.986	1.392	1.219
		(1.119 - 1.174)	(0.986 - 1.062)	(0.916 - 1.060)	(1.311 - 1.477)	(1.147 - 1.296)
24-35 months		1.246	1.123	1.145	2.446	1.609
		(1.217 - 1.275)	(1.083 - 1.164)	(1.066 - 1.229)	(2.316 - 2.582)	(1.513 - 1.711)
12-23 months		1.169	1.114	1.572	3.818	2.240
		(1.141 - 1.198)	(1.073 - 1.156)	(1.466 - 1.686)	(3.625 - 4.021)	(2.102 - 2.386)
Education 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	1.286	1.282	1.022	1.143	1.079
	(1.160 - 1.382)	(1.243 - 1.329)	(1.214 - 1.354)	(0.945 - 1.105)	(1.092 - 1.196)	(1.009 - 1.154)
No education or incomplete primary	1.626	1.482	1.586	1.243	1.192	1.159
	(1.480 - 1.786)	(1.429 - 1.536)	(1.495 - 1.681)	(1.141 - 1.355)	(1.131 - 1.256)	(1.075 - 1.248)
Mother has a Partner						
Yes (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
No	0.977	1.148	1.237	1.232	1.105	1.110
	(0.881 - 1.084)	(1.106 - 1.193)	(1.158 - 1.322)	(1.101 - 1.379)	(1.043 - 1.170)	(1.022 - 1.206)
Education 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	1.068	1.097	1.037	1.059	1.053
	(1.027 - 1.176)	(1.040 - 1.097)	(1.052 - 1.144)	(0.969 - 1.109)	(1.015 - 1.104)	(0.993 - 1.117)
No education or incomplete primary	1.232	1.131	1.233	1.151	1.068	1.098
	(1.147 - 1.324)	(1.099 - 1.163)	(1.180 - 1.288)	(1.070 - 1.238)	(1.019 - 1.120)	(1.029 - 1.172)
Age Band of the Mother's Partner at the Birth of the Mother's First Birth						
24-29 (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
12-17	1.410	1.148	1.125	1.008	1.049	1.090
	(1.237 - 1.606)	(1.081 - 1.219)	(1.017 - 1.245)	(0.801 - 1.269)	(0.932 - 1.181)	(0.937 - 1.269)
18-23	1.077	1.054	1.026	0.979	1.032	1.050
	(1.026 - 1.130)	(1.035 - 1.073)	(0.997 - 1.056)	(0.927 - 1.034)	(0.997 - 1.068)	(1.010 - 1.092)
30-35	0.942	0.964	0.953	0.941	0.958	0.997
	(0.884 - 1.005)	(0.939 - 0.990)	(0.918 - 0.990)	(0.882 - 1.004)	(0.915 - 1.002)	(0.949 - 1.046)
36-41	0.996	0.986	0.932	0.929	1.032	1.069

	(0.904 - 1.097)	(0.945 - 1.028)	(0.875 - 0.992)	(0.835 - 1.034)	(0.960 - 1.108)	(0.994 - 1.149)
42-59	1.046	1.036	1.030	0.977	1.101	0.962
	(0.932 - 1.173)	(0.983 - 1.093)	(0.954 - 1.111)	(0.855 - 1.118)	(1.004 - 1.207)	(0.874 - 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	1.182	1.272	1.110	1.171	1.157
	(1.063 - 1.219)	(1.148 - 1.216)	(1.216 - 1.331)	(1.032 - 1.194)	(1.117 - 1.227)	(1.093 - 1.224)
Middle	1.223	1.257	1.416	1.276	1.209	1.246
	(1.136 - 1.316)	(1.218 - 1.297)	(1.348 - 1.486)	(1.176 - 1.384)	(1.149 - 1.272)	(1.170 - 1.326)
Poorer	1.268	1.332	1.524	1.344	1.244	1.287
	(1.173 - 1.371)	(1.289 - 1.376)	(1.448 - 1.604)	(1.233 - 1.466)	(1.177 - 1.314)	(1.203 - 1.378)
Poorest	1.289	1.445	1.671	1.458	1.289	1.338
	(1.187 - 1.399)	(1.397 - 1.496)	(1.585 - 1.762)	(1.331 - 1.598)	(1.213 - 1.369)	(1.245 - 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	1.082	1.029	0.943	0.939	0.981
	(0.991 - 1.099)	(1.059 - 1.106)	(0.996 - 1.064)	(0.891 - 0.998)	(0.905 - 0.974)	(0.937 - 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	0.956	1.031	1.034	1.002	0.988
	(1.047 - 1.156)	(0.938 - 0.975)	(1.000 - 1.063)	(0.980 - 1.092)	(0.969 - 1.037)	(0.950 - 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	1.224	1.137	1.045	1.041	1.035
	(1.062 - 1.217)	(1.191 - 1.259)	(1.091 - 1.184)	(0.978 - 1.116)	(0.997 - 1.087)	(0.982 - 1.090)
Child Measles Vaccination						
Vaccinated (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Not vaccinated	1.108	1.070	1.164	1.195	1.072	1.109
	(1.038 - 1.183)	(1.042 - 1.100)	(1.120 - 1.209)	(1.113 - 1.284)	(1.020 - 1.127)	(1.051 - 1.170)
Observations	176,583	119,018	122,680	120,246	135,121	31,520

Viewed another way, the social and biological mechanisms can be disentangled by stratifying regressions by socio-economic status. For the high SES group we select children who have mothers who have at least completed primary school, in households that are in one of the top two wealth quintiles and who live in an urban area (Table 4). We contrast this group of 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. At the top of **Table 4** we report the absolute prevalence of the child health outcome by this stratification. In the high SES group 2.99% of the infants die, while in the low SES households 10.4% of the infants die (Table 4). Stunting, underweight, wasting diarrhoea and anaemia are all much more prevalent in low SES households than in the high SES households (Table 4). However, when considering the relative risk ratios across the age groups for outcomes of stunting, underweight and diarrhoea, the relative risk of a poor health outcome for young mothers is higher in the high SES households than in the low SES households (Table 4). The difference in the relative risk of age on these child health outcomes across the two groups indicates that early childbearing is not just a problem in lower socioeconomic groups.

Table 4: Adjusted Relative Risk 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 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	1.747	1.899	1.244	1.750	1.167	0.875	1.062	1.792	1.342	0.388	1.438
	(1.015 - 3.040)	(1.338 - 2.283)	(1.473 - 2.449)	(1.118 - 1.385)	(1.169 - 2.619)	(1.004 - 1.355)	(0.358 - 2.140)	(0.776 - 1.452)	(1.229 - 2.612)	(1.057 - 1.702)	(0.108 - 1.400)	(1.047 - 1.974)
15-17	1.297	1.315	1.474	1.143	1.377	1.066	1.234	0.968	1.377	1.181	1.234	1.504
	(0.984 - 1.710)	(1.029 - 1.681)	(1.313 - 1.655)	(1.040 - 1.257)	(1.147 - 1.654)	(0.935 - 1.215)	(0.950 - 1.602)	(0.744 - 1.258)	(1.172 - 1.618)	(0.964 - 1.446)	(1.001 - 1.521)	(1.144 - 1.978)
18-20	1.087	1.104	1.308	1.085	1.260	0.984	1.181	0.964	1.395	1.107	1.154	1.433
	(0.846 - 1.398)	(0.865 - 1.409)	(1.179 - 1.452)	(0.987 - 1.192)	(1.071 - 1.482)	(0.863 - 1.121)	(0.951 - 1.467)	(0.743 - 1.250)	(1.214 - 1.603)	(0.905 - 1.354)	(0.964 - 1.381)	(1.092 - 1.880)
21-23	1.020	1.016	1.221	1.065	1.156	0.948	1.198	0.990	1.318	1.126	1.203	1.500
	(0.800 - 1.300)	(0.790 - 1.307)	(1.102 - 1.352)	(0.968 - 1.171)	(0.985 - 1.357)	(0.830 - 1.084)	(0.976 - 1.472)	(0.759 - 1.292)	(1.152 - 1.508)	(0.917 - 1.382)	(1.008 - 1.437)	(1.141 - 1.972)
24-26	1.015	1.116	1.083	0.989	1.028	0.941	1.207	1.076	1.206	1.139	1.105	1.424
	(0.783 - 1.315)	(0.848 - 1.470)	(0.972 - 1.208)	(0.890 - 1.100)	(0.871 - 1.215)	(0.811 - 1.091)	(0.979 - 1.489)	(0.811 - 1.428)	(1.048 - 1.388)	(0.911 - 1.425)	(0.925 - 1.320)	(1.066 - 1.901)
30-32	1.647	0.710	0.918	0.911	0.875	0.827	0.971	0.832	0.940	1.111	1.151	1.270
	(1.183 - 2.291)	(0.414 - 1.216)	(0.771 - 1.093)	(0.760 - 1.093)	(0.666 - 1.150)	(0.624 - 1.097)	(0.697 - 1.351)	(0.488 - 1.418)	(0.757 - 1.167)	(0.777 - 1.590)	(0.886 - 1.496)	(0.820 - 1.966)
33-35	1.407	0.956	1.049	1.222	0.743	0.860	1.128	0.650	0.769	0.821	1.036	1.438
	(0.846 - 2.341)	(0.525 - 1.740)	(0.822 - 1.338)	(1.013 - 1.473)	(0.471 - 1.170)	(0.594 - 1.245)	(0.713 - 1.785)	(0.287 - 1.473)	(0.555 - 1.065)	(0.488 - 1.379)	(0.686 - 1.565)	(0.826 - 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	0.829	0.850	0.929	0.911	0.921	0.886	0.843	0.913	0.959	0.942	0.963
	(0.627 - 0.782)	(0.781 - 0.881)	(0.814 - 0.888)	(0.908 - 0.951)	(0.850 - 0.977)	(0.890 - 0.954)	(0.802 - 0.979)	(0.786 - 0.905)	(0.859 - 0.969)	(0.910 - 1.011)	(0.868 - 1.021)	(0.910 - 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	4.557	1.212	1.271	1.704	1.448	1.365	1.392	0.768	1.015	1.061	1.183
	(4.278 - 6.916)	(3.932 - 5.281)	(0.991 - 1.482)	(1.111 - 1.454)	(1.290 - 2.251)	(1.179 - 1.778)	(0.898 - 2.074)	(0.917 - 2.112)	(0.533 - 1.106)	(0.716 - 1.437)	(0.733 - 1.534)	(0.860 - 1.627)
Age of Child in Months												
48-59 months (Reference)			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
36-47 months			1.239	1.118	1.037	1.037	0.877	0.994	1.410	1.453	1.258	1.219
			(1.145 - 1.341)	(1.076 - 1.162)	(0.919 - 1.170)	(0.976 - 1.102)	(0.741 - 1.039)	(0.868 - 1.138)	(1.229 - 1.617)	(1.289 - 1.638)	(1.064 - 1.487)	(1.095 - 1.357)
24-35 months			1.415	1.172	1.182	1.142	0.956	1.236	2.466	2.507	1.763	1.469
			(1.310 - 1.528)	(1.129 - 1.216)	(1.049 - 1.331)	(1.077 - 1.211)	(0.806 - 1.133)	(1.086 - 1.408)	(2.174 - 2.796)	(2.246 - 2.799)	(1.493 - 2.081)	(1.319 - 1.637)

12-23 months			1.392	1.081	1.107	1.151	1.156	1.853	3.891	3.720	2.585	1.927
			(1.287 - 1.506)	(1.040 - 1.124)	(0.977 - 1.254)	(1.084 - 1.222)	(0.974 - 1.371)	(1.632 - 2.104)	(3.449 - 4.389)	(3.347 - 4.135)	(2.163 - 3.090)	(1.727 - 2.149)
Education Level of the Mother at Time of Interview												
Secondary or Higher (Reference)	1.00		1.00		1.00				1.00		1.00	
Completed Primary	1.220		1.266		1.208		1.103		1.177		1.099	
	(1.049 - 1.420)		(1.191 - 1.346)		(1.101 - 1.325)		(0.969 - 1.255)		(1.085 - 1.277)		(0.987 - 1.223)	
Mother has a Partner												
Yes (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
No	1.012	0.960	1.215	1.038	1.333	1.180	1.249	1.608	1.038	1.223	1.100	1.063
	(0.811 - 1.263)	(0.739 - 1.246)	(1.108 - 1.332)	(0.949 - 1.135)	(1.127 - 1.577)	(1.012 - 1.377)	(0.985 - 1.583)	(1.179 - 2.193)	(0.926 - 1.163)	(1.030 - 1.451)	(0.930 - 1.301)	(0.814 - 1.388)
Education 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	1.00	1.00	1.00	1.00	1.00	1.00
Completed primary	1.046	1.100	1.115	0.997	1.137	1.056	0.910	1.266	1.071	0.989	1.087	0.987
	(0.911 - 1.201)	(0.902 - 1.341)	(1.052 - 1.182)	(0.926 - 1.074)	(1.041 - 1.242)	(0.940 - 1.187)	(0.807 - 1.027)	(0.994 - 1.613)	(0.989 - 1.159)	(0.852 - 1.148)	(0.979 - 1.208)	(0.782 - 1.246)
No education or incomplete primary	1.303	1.277	1.206	1.039	1.381	1.224	1.180	1.452	1.209	1.002	1.221	0.974
	(1.059 - 1.602)	(1.059 - 1.540)	(1.109 - 1.312)	(0.968 - 1.116)	(1.218 - 1.566)	(1.094 - 1.370)	(0.981 - 1.420)	(1.149 - 1.834)	(1.069 - 1.368)	(0.869 - 1.156)	(1.043 - 1.428)	(0.777 - 1.222)
Age Band of the Mother's Partner at the Birth of 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
12-17	1.284	1.528	1.010	1.087	1.106	1.085	0.551	0.959	1.206	1.091	1.124	1.005
	(0.668 - 2.470)	(1.261 - 1.851)	(0.697 - 1.466)	(0.996 - 1.186)	(0.627 - 1.952)	(0.937 - 1.256)	(0.141 - 2.147)	(0.672 - 1.368)	(0.847 - 1.715)	(0.883 - 1.349)	(0.664 - 1.901)	(0.785 - 1.285)
18-23	1.122	1.090	1.141	1.036	1.072	1.015	1.028	0.977	0.967	1.076	1.069	1.061
	(0.948 - 1.327)	(1.008 - 1.178)	(1.070 - 1.217)	(1.006 - 1.068)	(0.970 - 1.186)	(0.970 - 1.063)	(0.872 - 1.211)	(0.889 - 1.073)	(0.881 - 1.061)	(1.006 - 1.149)	(0.954 - 1.198)	(0.989 - 1.138)
30-35	0.907	0.970	0.937	0.964	0.917	0.960	1.012	0.878	0.911	0.990	0.892	1.122
	(0.770 - 1.069)	(0.863 - 1.090)	(0.875 - 1.004)	(0.919 - 1.012)	(0.825 - 1.019)	(0.898 - 1.026)	(0.880 - 1.163)	(0.767 - 1.004)	(0.831 - 1.000)	(0.895 - 1.094)	(0.795 - 1.000)	(1.027 - 1.226)
36-41	0.784	0.950	0.962	1.030	0.760	0.970	1.070	0.851	0.994	0.993	0.876	1.180
	(0.587 - 1.048)	(0.797 - 1.132)	(0.852 - 1.086)	(0.963 - 1.101)	(0.614 - 0.940)	(0.880 - 1.069)	(0.842 - 1.360)	(0.701 - 1.034)	(0.851 - 1.160)	(0.855 - 1.152)	(0.715 - 1.074)	(1.044 - 1.334)
42-59	0.698	1.100	1.106	1.054	1.119	0.960	1.388	0.885	0.949	1.078	0.910	1.012
	(0.413 - 1.178)	(0.912 - 1.327)	(0.907 - 1.349)	(0.973 - 1.141)	(0.807 - 1.550)	(0.854 - 1.079)	(0.940 - 2.052)	(0.711 - 1.103)	(0.731 - 1.233)	(0.909 - 1.280)	(0.656 - 1.263)	(0.869 - 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		1.223		1.288		1.045		1.143		1.121	
	(1.111 - 1.445)		(1.161 - 1.290)		(1.187 - 1.398)		(0.926 - 1.180)		(1.065 - 1.226)		(1.023 - 1.228)	
Poorer		0.996		0.936		0.923		0.937		0.957		0.977
		(0.938 - 1.057)		(0.913 - 0.959)		(0.891 - 0.956)		(0.870 - 1.008)		(0.905 - 1.012)		(0.922 - 1.037)

Water Piped to the Child's House												
Piped to house (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
Water not piped to house	1.066	1.138	0.936	0.964	1.001	1.066	0.991	1.163	0.966	1.065	0.976	1.028
	(0.924 - 1.229)	(1.017 - 1.273)	(0.883 - 0.993)	(0.925 - 1.004)	(0.919 - 1.089)	(0.995 - 1.142)	(0.874 - 1.123)	(1.015 - 1.333)	(0.884 - 1.055)	(0.979 - 1.159)	(0.886 - 1.076)	(0.933 - 1.133)
Flush Toilet at Child's House												
Flush toilet at house (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
No flush toilet at house	0.948	1.369	1.158	1.173	1.082	1.239	1.011	0.996	1.088	1.057	0.984	0.982
	(0.818 - 1.098)	(1.075 - 1.745)	(1.089 - 1.232)	(1.064 - 1.294)	(0.988 - 1.185)	(1.037 - 1.481)	(0.879 - 1.164)	(0.753 - 1.318)	(0.994 - 1.191)	(0.889 - 1.257)	(0.872 - 1.110)	(0.797 - 1.209)
Child Measles Vaccination												
Vaccinated (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
Not vaccinated	1.653	1.000	1.190	1.066	1.211	1.200	1.229	1.185	1.045	1.030	1.299	1.127
	(1.309 - 2.088)	(0.905 - 1.106)	(1.072 - 1.320)	(1.022 - 1.111)	(1.037 - 1.414)	(1.130 - 1.275)	(0.969 - 1.559)	(1.050 - 1.337)	(0.907 - 1.204)	(0.940 - 1.129)	(1.101 - 1.531)	(1.035 - 1.228)
Observations	40,299	38,612	28,797	23,657	29,345	24,846	28,783	24,251	32,809	27,435	8,027	6,026

Note: 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.

Results: Sensitivity Analysis

Recent work by Subramanian et al[2] and Ozaltin et al[31] indicates that maternal height is a significant predictor of infant mortality, anthropometric failure and anaemia. At the cost of a smaller sample (n=101,054) height is included as a control variable in the regression to examine whether in the sub-set of countries for which the Demographic and Health Surveys have data on women's height, the age effect that we observe confounded by maternal height. Household religion is also included as a control variable. Even after controlling for height and religion, the age of the mother is a significant risk factor for infant mortality, anthropometric failure and child health outcomes (Table 5). Controlling for height, which is an additional biological indicator, and religion, which is an additional social indicator, the general relationship between the age of mother at first birth and child health outcomes does not change (Table 5).

Table 5: Sensitivity Analysis: Adjusted Relative Risk Ratios including Height and Religion as Covariates

	Infant Mortality	Stunting	Underweight	Wasting	Diarrhoea	Moderate Anaemia
Age Band of the Mother at First Birth						
27-29 (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
12-14	1.654	1.356	1.293	1.005	1.270	1.217
	(1.379 - 1.983)	(1.259 - 1.460)	(1.167 - 1.434)	(0.832 - 1.212)	(1.091 - 1.480)	(1.031 - 1.436)
15-17	1.283	1.276	1.187	1.014	1.227	1.316
	(1.096 - 1.502)	(1.198 - 1.358)	(1.087 - 1.296)	(0.881 - 1.166)	(1.102 - 1.367)	(1.169 - 1.482)
18-20	1.064	1.216	1.110	0.995	1.202	1.306
	(0.911 - 1.243)	(1.144 - 1.293)	(1.018 - 1.210)	(0.869 - 1.139)	(1.083 - 1.335)	(1.165 - 1.463)
21-23	1.015	1.154	1.058	1.018	1.189	1.343
	(0.867 - 1.187)	(1.085 - 1.228)	(0.970 - 1.154)	(0.890 - 1.165)	(1.070 - 1.321)	(1.198 - 1.505)
24-26	1.101	1.044	1.016	1.042	1.058	1.226
	(0.930 - 1.303)	(0.976 - 1.117)	(0.925 - 1.116)	(0.903 - 1.203)	(0.945 - 1.185)	(1.087 - 1.383)
30-32	1.252	0.925	0.810	0.918	0.878	1.118
	(0.973 - 1.611)	(0.829 - 1.033)	(0.688 - 0.952)	(0.723 - 1.166)	(0.726 - 1.062)	(0.927 - 1.349)
33-35	1.482	1.006	0.875	1.064	0.804	1.095
	(1.070 - 2.052)	(0.861 - 1.175)	(0.689 - 1.110)	(0.757 - 1.497)	(0.607 - 1.064)	(0.838 - 1.430)
Sex of Child						
Male (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Female	0.803	0.907	0.919	0.865	0.926	0.965
	(0.768 - 0.839)	(0.893 - 0.922)	(0.897 - 0.942)	(0.828 - 0.905)	(0.896 - 0.957)	(0.933 - 0.997)
Type of Birth						
Singleton (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Twin	4.794	1.311	1.561	1.205	0.943	1.023
	(4.325 - 5.315)	(1.201 - 1.430)	(1.378 - 1.768)	(0.934 - 1.554)	(0.771 - 1.153)	(0.841 - 1.244)
Age of Child in Months						
48-59 months (Reference)		1.00	1.00	1.00	1.00	1.00
36-47 months		1.154	1.021	0.972	1.466	1.240
		(1.122 - 1.187)	(0.981 - 1.064)	(0.896 - 1.055)	(1.351 - 1.590)	(1.160 - 1.326)
24-35 months		1.253	1.135	1.167	2.651	1.603
		(1.219 - 1.288)	(1.090 - 1.181)	(1.078 - 1.263)	(2.460 - 2.857)	(1.496 - 1.718)
12-23 months		1.168	1.133	1.633	4.261	2.109
		(1.134 - 1.202)	(1.087 - 1.182)	(1.508 - 1.768)	(3.962 - 4.581)	(1.963 - 2.265)
Education 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	1.268	1.173	1.186	0.990	1.143	1.106
	(1.132 - 1.420)	(1.126 - 1.221)	(1.115 - 1.261)	(0.905 - 1.083)	(1.068 - 1.224)	(1.022 - 1.197)
No education or incomplete primary	1.605	1.287	1.389	1.155	1.201	1.180
	(1.423 - 1.810)	(1.232 - 1.344)	(1.301 - 1.484)	(1.047 - 1.273)	(1.115 - 1.295)	(1.082 - 1.287)
Mother has a Partner						
Yes (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
No	0.952	1.115	1.214	1.277	1.127	1.122
	(0.835 - 1.084)	(1.065 - 1.168)	(1.125 - 1.310)	(1.123 - 1.451)	(1.040 - 1.222)	(1.017 - 1.239)
Education 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	1.109	1.069	1.122	1.069	1.022	1.091
	(1.019 - 1.208)	(1.035 - 1.105)	(1.069 - 1.178)	(0.989 - 1.157)	(0.964 - 1.083)	(1.020 - 1.166)
No education or incomplete primary	1.229	1.136	1.238	1.169	1.051	1.121
	(1.122 - 1.345)	(1.098 - 1.175)	(1.176 - 1.304)	(1.073 - 1.273)	(0.986 - 1.119)	(1.041 - 1.207)
Age Band of the Mother's Partner at the Birth of the Mother's First Birth						
24-29 (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
12-17	1.388	1.071	1.138	0.987	1.161	1.104
	(1.182 - 1.631)	(1.000 - 1.148)	(1.024 - 1.266)	(0.764 - 1.274)	(0.986 - 1.366)	(0.932 - 1.307)

18-23	1.067	1.043	1.036	1.016	1.060	1.061
	(1.007 - 1.129)	(1.023 - 1.065)	(1.006 - 1.067)	(0.959 - 1.076)	(1.014 - 1.107)	(1.017 - 1.108)
30-35	0.923	0.952	0.943	0.929	0.965	0.984
	(0.857 - 0.994)	(0.925 - 0.979)	(0.907 - 0.980)	(0.868 - 0.995)	(0.913 - 1.020)	(0.934 - 1.037)
36-41	1.007	0.973	0.925	0.912	1.045	1.091
	(0.903 - 1.122)	(0.930 - 1.018)	(0.867 - 0.988)	(0.814 - 1.021)	(0.958 - 1.140)	(1.010 - 1.179)
42-59	1.034	1.037	1.022	0.927	1.112	0.966
	(0.906 - 1.180)	(0.980 - 1.097)	(0.945 - 1.107)	(0.805 - 1.069)	(0.998 - 1.239)	(0.875 - 1.067)
Wealth Quintile of the Child's Household						
Richest (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Rich	1.167	1.203	1.294	1.132	1.157	1.134
	(1.072 - 1.269)	(1.164 - 1.244)	(1.230 - 1.361)	(1.042 - 1.229)	(1.091 - 1.226)	(1.067 - 1.204)
Middle	1.258	1.263	1.420	1.274	1.152	1.196
	(1.148 - 1.378)	(1.218 - 1.310)	(1.345 - 1.500)	(1.162 - 1.397)	(1.078 - 1.230)	(1.118 - 1.280)
Poorer	1.273	1.297	1.487	1.348	1.174	1.224
	(1.156 - 1.403)	(1.249 - 1.348)	(1.403 - 1.575)	(1.222 - 1.487)	(1.094 - 1.259)	(1.137 - 1.318)
Poorest	1.299	1.334	1.585	1.444	1.207	1.299
	(1.174 - 1.437)	(1.282 - 1.388)	(1.493 - 1.682)	(1.303 - 1.601)	(1.120 - 1.301)	(1.202 - 1.403)
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	1.050	1.066	1.037	0.949	0.963	0.987
	(0.983 - 1.121)	(1.040 - 1.094)	(1.000 - 1.076)	(0.891 - 1.012)	(0.917 - 1.011)	(0.939 - 1.037)
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	1.105	0.983	1.043	1.023	0.984	0.993
	(1.036 - 1.180)	(0.960 - 1.007)	(1.006 - 1.082)	(0.961 - 1.089)	(0.940 - 1.030)	(0.949 - 1.039)
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	1.106	1.177	1.123	1.090	1.037	1.056
	(1.012 - 1.210)	(1.138 - 1.217)	(1.071 - 1.176)	(1.010 - 1.178)	(0.976 - 1.102)	(0.996 - 1.119)
Child Measles Vaccination						
Vaccinated (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Not vaccinated	1.076	1.083	1.152	1.145	1.167	1.108
	(0.990 - 1.170)	(1.050 - 1.118)	(1.102 - 1.204)	(1.053 - 1.245)	(1.095 - 1.242)	(1.047 - 1.173)
Religion						
Christian (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Muslim	1.025	1.042	1.283	1.385	1.066	1.060
	(0.951 - 1.104)	(1.012 - 1.073)	(1.227 - 1.341)	(1.277 - 1.501)	(1.004 - 1.131)	(0.996 - 1.128)
Other	1.096	1.032	1.242	1.290	0.988	1.158
	(1.017 - 1.181)	(1.003 - 1.061)	(1.187 - 1.299)	(1.186 - 1.402)	(0.929 - 1.050)	(1.090 - 1.230)
Height of respondent (metres)						
160-200cm (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
155-159cm	1.128	1.249	1.267	1.007	1.002	1.008
	(1.062 - 1.199)	(1.216 - 1.282)	(1.217 - 1.319)	(0.942 - 1.076)	(0.959 - 1.047)	(0.963 - 1.055)
150-154cm	1.172	1.456	1.512	1.096	1.044	0.994
	(1.097 - 1.252)	(1.417 - 1.495)	(1.452 - 1.574)	(1.024 - 1.174)	(0.996 - 1.094)	(0.946 - 1.045)
145-149cm	1.289	1.698	1.807	1.180	1.023	0.971
	(1.191 - 1.396)	(1.648 - 1.749)	(1.728 - 1.890)	(1.090 - 1.278)	(0.962 - 1.087)	(0.914 - 1.031)
100-144cm	1.586	2.013	2.123	1.248	1.002	1.100
	(1.433 - 1.754)	(1.944 - 2.085)	(2.015 - 2.236)	(1.127 - 1.382)	(0.915 - 1.098)	(1.016 - 1.190)
Observations	101,054	71,218	73,793	72,007	78,226	22,143

Discussion

Principal Findings

In this paper we show that there is an improvement in child health outcomes as the age of mother at first birth rises up to ages 27, controlling for maternal, paternal and household and social factors. This is a much higher age than usually found in the literature, where teen pregnancy is emphasized as a risk factor. In the adjusted model, infant mortality shows an elevated risk for mother's below age 27, though the effect is only statistically significant for women below age 18. However, the lack of significance may be because infant mortality is relatively rare and when we turn to models for stunting, diarrhoea, and anaemia outcomes, we find all of these have elevated risk for all mothers below age 27, and this higher risk is statistically significant.

Our results indicate that children to mothers below age 27 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 United States has seen a steady rise in the average age at first birth from 21 in 1970 to 25 in 2000.[34] Age at first birth is increasing in some of our sample countries, but still lags behind the level seen in United States. For example, in the 1993 Bangladesh DHS the mean age for first births in the last five 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.[35] The results in this paper indicate that there are benefits to reducing infant mortality and improving child health by delaying the age at first birth even for women in their early twenties.

Comparisons to other studies

Consistent with country studies, in this paper we show that delaying first birth beyond the teen years and into the twenties has a positive impact on child survival. Unlike the Raj *et al*.[13] study that focused on the case of India, in the current study that applies 55 low- to middle-income countries we find that in general in the low- to middle-income countries young maternal age has a significant effect of reducing infant mortality, stunting, underweight, diarrhoea and moderate to strong anaemia. In the 2005-6 India sample, Raj *et al*.[13] find that maternal age only has a significant effect on stunting and underweight. The broadening of the significant results to include other child health outcomes can stem

from the inclusion of a greater number of countries, and also from a wider time horizon. As the 2005-6 India National Family Health Survey-3 is one of the 118 surveys within our current study, the comparison between our study and the Raj *et al* [13] study highlights that generalizing across countries is not mirrored in each country experience. Thus we include the country specific examples in the appendix (Table A2). Even so, for the case of India in our sample there are three National Family Health Surveys (1992, 1998, 2005-6) and not just the one. Thus, even the country specific results can differ from the survey specific results. Taking a broad view, however, the two papers yield the same fundamental conclusion and that is, delaying first birth beyond the teen years is beneficial for child health outcomes. Changing the date range and countries within the study creates subtle differences in the finer points of the results, but the fundamental result remains consistent.

Limitations of the study

Although this study provides important insights in 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, age of mother, is subject to measurement error as collection of this variable relies on recall by the respondent. The same holds true for identifying the population of children within a 0-11 and 12-60 month age range. 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 their recall of the child's age. The result is that a larger fraction of children are reported to be 60 months than 59 months. As this inconsistency is attributed to recall error, we follow the World Health Organization guidelines and include the 60 month olds 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 minimized for this group of interest.

A further limitation of the model is that the socio-economic measures of male and female education, along with the wealth index, may not fully capture the socio-economic status 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.

Conclusions and implications

The current study documents that for the first born child who is born to a woman aged less than 27-29 in low- to middle-income countries, it is at a higher risk of infant mortality, stunting, underweight, diarrhoea, and moderate to strong anaemia, but at no significantly different risk of wasting. Children born to women aged 12-14 or 15-17 are significantly more likely to suffer mortality in their first year of life than children born to women aged 27-29. For children born to women aged 19-26, the risk of mortality declines as she ages each year, but this risk is not significantly different from the risk to 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 minimized. The risk of underweight decreases significantly as a woman delays her first birth and is minimized by age 21. These results offer support to the evidence of the benefits to offspring of delaying first birth. Importantly, the results in this study show that it is optimal to delay first birth until age 27-29, and not just avoiding teen pregnancy. The results reveal that interventions designed to target adolescents potentially omit an group of women in their early twenties who are also at risk of having children with poor health outcomes. Development of programs targeting women in general, and not just targeting teen mothers, should provide women and families with tools to make informed decisions over the timing of their first birth and the benefits of delaying the birth. Highlighting the benefits of delaying first birth to the child's health, provides a mechanism for young female family members have time to build their own education and skills to empower their autonomy and to better care for their children.

Our results indicated that while the absolute risk of poor child health outcomes is lower when the mother is in a high-SES household, there remains a high relative risk 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 age of the mother cut across SES lines and the children of young-rich women are not shielded from the relative risk of a poor health outcome.

Encouraging women to delay their first birth, and encouraging families to permit the delay when the woman is not granted autonomy over her reproductive health decisions, come through providing women with viable and valuable alternatives. Education programs to encourage women to stay in school, take on meaningful employment opportunities, and provide service to the community, relieves the immediacy of child bearing. It also provides empowerment to

women in illustrating to herself and her family that her contribution to society need not only be defined by her reproductive life. By delaying a few years and engaging in other activities she contributes to society as well as broadening her skills and knowledge to go on to be a more informed and more highly educated mother. These benefits to the women, then trickle through the generations and benefit her offspring. In this paper, we showed that those benefits are in terms of health, but future studies may highlight the educational and social benefits for a child if a woman delays her first birth.

References

1. We Can End Poverty 2015: Millennium Development Goals. 2011. (Accessed June 15 2011, at http://www.un.org/millenniumgoals/childhealth.shtml.)
2. Subramanian SV, Ackerson LK, Davey Smith G, John NA. 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. Washington D.C.: Center for Global Development; 2009.
5. Kembo J, Van Ginneken JK. Determinants of Infant and Child Mortality in Zimbabwe: Results of Multivariate Hazard Analysis. Demographic Research 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. American Journal of Public Health 1984;74:1098-106.
7. Manda SOM. Birth intervals, breastfeeding and determinants of childhood mortality in Malawi. Social Science & Medicine 1999;48:301-12.
8. Reynolds HW, Wong EL, Tucker H. Adolescents' Use of Maternal and Child Health Services In Developing Countries. International Family Planning Perspectives 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. American Journal of Obstetrics and Gynecology 1982;143:793-8.
10. Vitolo MR, Gama CM, Bortolini GA, Campagnolo PD, Drachler ML. 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, Wang L. The effects of age and aboriginality on the incidence of low birth weight in mountain townships of Taiwan. Journal of Public Health 2009;31:406-12.
12. Hobcraft J. Fertility patterns and child survival: a comparative analysis. Population Bullitin of the United Nations 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. Br Med J (Clin Res Ed) 2010;340.
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. Cooper LG, Leeland NL, Alexander G. Effect of maternal age on birth outcomes among young adolescents. Social Biology 1995;42:22-35.
16. Fraser AM, Brockert JE, Ward RH. Association of Young Maternal Age with Adverse Reproductive Outcomes. N Engl J Med 1995;332:1113-8.
17. Geronimus AT. On Teenage Childbearing and Neonatal Mortality in the United States. Population and Development Review 1987;13:245-79.
18. Geronimus AT, Korenman S, Hillemeier MM. Does Young Maternal Age Adversely Affect Child Development? Evidence from Cousin Comparisons in the United States. Population and Development Review 1994;20:585-609.
19. Horon IL, Strobino DM, MacDonald HM. Birth weights among infants born to adolescent and young adult women. American Journal of Obstetrics and Gynecology 1983;146:444-9.
20. Trussell J. Teenage pregnancy in the United States. Family Planning Perspectives 1988;20:262-72.
21. Ventura SJ, Mathews TJ, Hamilton BE. Births to teenagers in the United States, 1940-2000. National Vital Statistics Report 2001;49.
22. Alam N. Teenage motherhood and infant mortality in Bangladesh: Maternal age-dependent effect of parity one. Journal of biosocial science 2000;32:229-36.
23. Demographic and Health Surveys. MEASURE DHS, 2009. (Accessed October 3, 2009, 2009, at http://www.measuredhs.com/start.cfm.)

24. Rutstein SO, Rojas G. Guide to DHS Statistics. Calverton, Maryland: ORC Macro, MEASURE DHS+; 2003.
25. Wirth ME, Wirth E, Delamonica E, Sacks D, Balk A, Minujin A. Monitoring health equity in the MDGs: A practical guide. New York: CIESIN/UNICEF; 2006.
26. 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.
27. Pullum TW. An Assessment of the Quality of Data on Health and Nutrition in the DHS Surveys, 1993-2003. Calverton, Maryland, USA: Macro International Inc; 2008.
28. Macro O. Demographic and Health Survey Interviewer's Manual. Calverton, Maryland, U.S.A.: : ORC Macro; 2006.
29. Survey DaH. Sampling Manual. DHS-III. Calverton, MD: Macro International; 1996.
30. 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. Statistics in Medicine 2006;25:247-65.
31. 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.
32. Deaton A. The Analysis of Household Surveys: A Microeconometric Approach to Development Policy. Baltimore: World Bank; 1997.
33. Subramanian SV, Ackerson LK, Smith GD. Parental BMI and Childhood Undernutrition in India: An Assessment of Intrauterine Influence. Pediatrics 2010;126:663-71.
34. Mathews TJ, Hamilton BE. Mean age of mother, 1970-2000. National Vital Statistics Report 2002;51.
35. Bongaarts J. Does Family Planning Reduce Infant Mortality Rates? Population and Development Review 1987;13:323-34.

Appendix
Table A1: Sample Deduction

		Infant Mortality		Stunting		Underweight		Wasting		Diarrhoea		Anaemia	
		Lost	Cumulative Total	Lost	Cumulative Total	Lost	Cumulative Total	Lost	Cumulative Total	Lost	Cumulative Total	Lost	Cumulative Total
Starting	countries		72		57		57		57		57		33
	surveys		181		140		140		140		139		46
	children		288,752		232,676		232,676		232,676		231,211		81,706
Missing Data on Outcome Variable		5,313	283,439	84,445	148,231	84,445	148,231	84,445	148,231	66,033	165,178	45,585	36,121
Mis-coded Data on Outcome Variables				6,365	141,866	1,780	146,451	4,701	143,530	2,242	162,936	0	36,121
Missing Data on Mother's Age at First Birth		1,564	281,875	0	141,866	0	146,451	0	143,530	0	162,936	352	35,769
Mother's Age at First Birth <12		13	281,862	4	141,862	4	146,447	4	143,526	5	162,931	1	35,768
Mother's Age at First Birth >35		1,716	280,146	848	141,014	857	145,590	840	142,686	974	161,957	248	35,520
Lost Due to Missing Covariates		103,563	176,583	21,996	119,018	22,910	122,680	22,440	120,246	26,836	135,121	4,000	31,520
Final Total	Countries		55		55		55		55		55		30
	Surveys		118		118		118		118		118		38
	Children		**176,583**		**119,018**		**122,680**		**120,246**		**135,121**		**31,520**
	Years		1990-2008		1990-2008		1990-2008		1990-2008		1990-2008		2000-2008

Table A2: Unadjusted Relative Risk Ratios: The Effect of Age At First Birth on Infant Mortality

Country Name	Age Band	12-14	15-17	18-20	21-23	24-26	27-29	30-32	33-35
	N								
Pooled	176,583	4,322 0.128	41,384 0.087	61,491 0.061	38,300 0.048	18,211 0.044	7939 0.037	3,493 0.040	1,443 0.047
		2.557 (2.227 - 2.935)	1.814 (1.613 - 2.039)	1.375 (1.224 - 1.544)	1.168 (1.037 - 1.316)	1.126 (0.988 - 1.282)		1.185 (0.975 - 1.440)	1.408 (1.092 - 1.817)
Armenia	1,014	68 0	387 0.012	338 0.014	137 0.007	20 0.05	50 0.02	14 0.071	
			2.02e-07 (2.10e-08 - 1.94e-06)	0.642 (0.0611 - 6.754)	0.758 (0.0782 - 7.336)	0.392 (0.0215 - 7.151)		3.194 (0.181 - 56.26)	2.907 (0.145 - 58.34)
Azerbaijan	719	36 0.111	214 0.023	233 0.025	127 0.023	29 0	58 0	22 0.136	
Bangladesh	6,175	589 0.108	2520 0.092	1863 0.074	750 0.062	285 0.077	114 0.078	37 0.054	17 0.176
		1.282 (0.652 - 2.521)	1.137 (0.600 - 2.155)	0.946 (0.492 - 1.818)	0.780 (0.396 - 1.535)	0.972 (0.464 - 2.037)		0.723 (0.164 - 3.187)	2.334 (0.723 - 7.541)
Benin	3,487	55 0.145	704 0.117	1,262 0.061	934 0.072	332 0.078	141 0.042	41 0.097	18 0
		3.343 (1.190 - 9.391)	2.715 (1.216 - 6.062)	1.474 (0.652 - 3.333)	1.749 (0.783 - 3.904)	1.945 (0.827 - 4.578)		2.398 (0.721 - 7.971)	9.00e-07 (3.61e-07 - 2.24e-06)
Bolivia	4,024	65 0.076	829 0.059	1,402 0.042	855 0.031	493 0.022	223 0.031	102 0.039	55 0
		2.448 (0.795 - 7.534)	1.937 (0.884 - 4.242)	1.400 (0.647 - 3.031)	1.031 (0.458 - 2.324)	0.709 (0.278 - 1.810)		1.252 (0.379 - 4.133)	2.04e-06 (8.92e-07 - 4.69e-06)
Brazil	1,280	23 0.130	280 0.032	361 0.024	260 0.023	178 0.016	106 0.018	55 0.018	17 0
		6.770 (1.640 - 27.95)	1.698 (0.371 - 7.759)	1.305 (0.291 - 5.858)	1.211 (0.247 - 5.946)	0.884 (0.145 - 5.374)		0.952 (0.0866 - 10.47)	8.75e-06 (2.07e-06 - 3.69e-05)
Burkina Faso	2,915	47 0.234	789 0.125	1349 0.107	510 0.082	145 0.096	51 0.156	18 0.055	6 0.333
		1.430 (0.623 - 3.278)	0.788 (0.401 - 1.551)	0.671 (0.345 - 1.305)	0.513 (0.257 - 1.022)	0.607 (0.263 - 1.399)		0.351 (0.0491 - 2.512)	2.095 (0.605 - 7.254)
Cameroon	2,186	91 0.054	742 0.091	789 0.045	343 0.072	147 0.040	51 0.117	21 0.047	2 0
		0.399 (0.131 - 1.212)	0.723 (0.325 - 1.605)	0.365 (0.159 - 0.834)	0.559 (0.232 - 1.347)	0.320 (0.102 - 1.007)		0.369 (0.0476 - 2.866)	2.30e-05 (4.46e-06 - 0.000119)
Central African Republic	653	30 0.133	247 0.153	231 0.116	87 0.160	28 0.142	20 0.15	6 0	4 0
		0.928 (0.216 - 3.983)	1.048 (0.350 - 3.137)	0.797 (0.265 - 2.394)	1.074 (0.331 - 3.484)	0.966 (0.242 - 3.867)		1.25e-06 (2.98e-07 - 5.28e-06)	1.43e-06 (3.34e-07 - 6.12e-06)
Chad	1,763	104 0.153	742 0.141	555 0.104	249 0.092	88 0.136	19 0.157	5 0	1 0
		0.957 (0.307 - 2.987)	0.857 (0.300 - 2.447)	0.627 (0.221 - 1.779)	0.564 (0.180 - 1.767)	0.836 (0.252 - 2.766)		4.82e-09 (1.23e-09 - 1.88e-08)	4.01e-09 (3.81e-10 - 4.22e-08)
Colombia	6,761	142 0.035	1436 0.019	2098 0.016	1400 0.012	804 0.009	469 0.008	260 0.019	152 0.006
		3.995 (1.069 - 14.94)	2.253 (0.790 - 6.426)	1.842 (0.653 - 5.195)	1.481 (0.498 - 4.406)	1.105 (0.335 - 3.646)		2.046 (0.554 - 7.564)	0.736 (0.0827 - 6.557)
Comoros	234	5 0	42 0.142	64 0.031	63 0.079	30 0	18 0.055	7 0.142	5 0.2
		6.58e-07 (4.90e-08 - 8.84e-06)	2.041 (0.261 - 15.99)	0.444 (0.0329 - 5.999)	1.129 (0.109 - 11.75)	4.88e-07 (6.34e-08 - 3.76e-06)		1.794 (0.114 - 28.26)	2.603 (0.206 - 32.86)
Congo Dem. Rep.	1,180	27 0.148	262 0.099	467 0.104	276 0.072	87 0.126	38 0.052	14 0	9 0.111
		2.739 (0.508 - 14.78)	1.868 (0.442 - 7.902)	1.999 (0.485 - 8.234)	1.373 (0.324 - 5.814)	2.379 (0.545 - 10.38)		2.99e-06 (6.89e-07 - 1.30e-05)	2.095 (0.192 - 22.84)

Congo Rep.	940	15	0.066	261	0.091	370	0.081	165	0.054	72	0.055	37	0.054	11	0.090	9	0.111
		1.238	(0.122 - 12.55)	1.655	(0.402 - 6.818)	1.493	(0.373 - 5.972)	0.991	(0.221 - 4.457)	1.067	(0.202 - 5.641)			1.773	(0.172 - 18.27)	1.925	(0.203 - 18.25)
Cote d'Ivoire	1,023	70	0.171	424	0.129	325	0.104	134	0.067	41	0.073	23	0.043	4	0.25	2	0
		3.618	(0.478 - 27.41)	2.860	(0.388 - 21.07)	2.428	(0.334 - 17.64)	1.503	(0.189 - 11.98)	1.638	(0.177 - 15.18)			9.130	(0.787 - 105.9)	3.38e-06	(3.14e-07 - 3.65e-05)
Dominican Republic	6,442	204	0.058	1,806	0.023	2,027	0.022	1,202	0.022	638	0.021	308	0.009	173	0.017	84	0.011
		5.922	(1.697 - 20.67)	2.485	(0.773 - 7.984)	2.313	(0.719 - 7.444)	2.292	(0.726 - 7.231)	2.270	(0.656 - 7.853)			1.734	(0.347 - 8.674)	1.198	(0.128 - 11.24)
Egypt Arab Rep.	11,852	40	0.15	1187	0.064	3862	0.036	3482	0.022	1990	0.033	820	0.028	335	0.032	136	0.029
		4.268	(1.887 - 9.655)	2.064	(1.304 - 3.268)	1.294	(0.840 - 1.993)	0.792	(0.499 - 1.256)	1.165	(0.729 - 1.862)			1.173	(0.580 - 2.372)	1.032	(0.362 - 2.946)
Ethiopia	2,895	60	0.166	788	0.109	968	0.088	646	0.058	281	0.110	88	0.102	49	0.142	15	0.066
		1.889	(0.828 - 4.309)	1.147	(0.613 - 2.147)	0.894	(0.473 - 1.690)	0.592	(0.298 - 1.176)	1.072	(0.535 - 2.149)			1.420	(0.580 - 3.473)	0.649	(0.0845 - 4.979)
Gabon	709	41	0.097	292	0.051	238	0.050	88	0.034	28	0.035	16	0	6	0		
Ghana	1,949	11	0.272	322	0.059	732	0.049	477	0.046	252	0.035	91	0.043	43	0.093	21	0.047
		5.705	(1.384 - 23.52)	1.411	(0.487 - 4.089)	1.154	(0.410 - 3.248)	1.061	(0.380 - 2.958)	0.841	(0.262 - 2.699)			2.305	(0.597 - 8.899)	1.264	(0.143 - 11.17)
Guatemala	1,454	38	0.105	428	0.058	538	0.055	270	0.048	104	0.038	42	0.071	26	0.038	8	0
		1.550	(0.383 - 6.276)	0.845	(0.269 - 2.656)	0.809	(0.262 - 2.501)	0.688	(0.204 - 2.317)	0.541	(0.128 - 2.282)			0.518	(0.0536 - 5.010)	7.68e-06	(2.06e-06 - 2.86e-05)
Guinea	1,409	104	0.105	556	0.100	410	0.080	205	0.092	88	0.102	29	0.034	13	0.153	4	0
		3.039	(0.418 - 22.09)	2.966	(0.431 - 20.44)	2.329	(0.333 - 16.30)	2.825	(0.390 - 20.48)	3.310	(0.445 - 24.59)			5.347	(0.549 - 52.12)	1.99e-05	(2.25e-06 - 0.000176)
Haiti	1,514	16	0.062	295	0.105	485	0.068	330	0.042	188	0.063	110	0.054	64	0.031	26	0.076
		1.084	(0.143 - 8.197)	1.874	(0.790 - 4.447)	1.211	(0.519 - 2.826)	0.752	(0.294 - 1.920)	1.097	(0.425 - 2.833)			0.613	(0.125 - 2.997)	1.514	(0.332 - 6.904)
Honduras	2,390	56	0.035	689	0.024	866	0.021	434	0.018	203	0	70	0.014	47	0	25	0.08
		2.440	(0.225 - 26.49)	1.695	(0.230 - 12.48)	1.499	(0.203 - 11.06)	1.267	(0.156 - 10.32)	9.79e-07	(1.38e-07 - 6.95e-06)			9.96e-07	(1.39e-07 - 7.13e-06)	5.147	(0.458 - 57.85)
India	38,794	842	0.136	7641	0.098	13868	0.062	9293	0.048	4464	0.044	1767	0.030	684	0.036	235	0.063
		4.200	(3.067 - 5.750)	3.063	(2.335 - 4.017)	1.977	(1.511 - 2.586)	1.559	(1.184 - 2.053)	1.438	(1.074 - 1.924)			1.223	(0.765 - 1.957)	2.064	(1.191 - 3.576)
Jordan	3,007	1	0	284	0.010	843	0.028	911	0.026	579	0.018	251	0.015	105	0.009	33	0.030
		1.84e-07	(1.79e-08 - 1.89e-06)	0.627	(0.144 - 2.741)	1.641	(0.597 - 4.514)	1.544	(0.579 - 4.117)	1.092	(0.362 - 3.291)			0.567	(0.0646 - 4.974)	1.931	(0.249 - 14.98)
Kazakhstan	801	48	0.020	279	0.032	262	0.045	117	0.042	29	0	54	0.037	12	0		
				0.468	(0.0471 - 4.656)	0.838	(0.178 - 3.942)	1.167	(0.258 - 5.286)	1.158	(0.234 - 5.714)			1.50e-07	(3.47e-08 - 6.51e-07)	1.35e-07	(2.77e-08 - 6.57e-07)
Kenya	3,040	62	0.064	683	0.067	1196	0.042	666	0.036	281	0.046	103	0.029	41	0.048	8	0
		2.561	(0.585 - 11.21)	2.349	(0.757 - 7.286)	1.532	(0.493 - 4.765)	1.247	(0.401 - 3.877)	1.560	(0.463 - 5.259)			1.646	(0.285 - 9.509)	4.80e-06	(1.27e-06 - 1.82e-05)
Kyrgyz Republic	388	20	0.1	188	0.053	114	0.026	39	0.025	2	0	21	0.047	4	0.25		

				1.586	(0.146 - 17.26)	0.883	(0.113 - 6.895)	0.431	(0.0458 - 4.067)	0.395	(0.0242 - 6.458)			1.72e-06	(1.38e-07 - 2.14e-05)	3.645	(0.289 - 46.05)
Lesotho	749	4	0.5	165	0.054	339	0.073	170	0.070	37	0.027	18	0.055	12	0.083	4	0
		4.978	(0.582 - 42.61)	0.770	(0.101 - 5.877)	1.098	(0.166 - 7.254)	0.965	(0.136 - 6.850)	0.358	(0.0245 - 5.225)			1.226	(0.102 - 14.82)	6.84e-06	(7.88e-07 - 5.94e-05)
Liberia	940	30	0.266	280	0.075	351	0.059	174	0.051	64	0.015	19	0.105	17	0.117	5	0.2
		2.732	(0.639 - 11.69)	0.736	(0.185 - 2.931)	0.616	(0.152 - 2.493)	0.544	(0.124 - 2.385)	0.160	(0.0156 - 1.649)			1.115	(0.175 - 7.122)	2.044	(0.223 - 18.78)
Madagascar	3,753	203	0.152	1179	0.067	1196	0.051	645	0.049	287	0.048	141	0.078	60	0.083	42	0.095
		1.732	(0.926 - 3.240)	0.817	(0.447 - 1.493)	0.617	(0.333 - 1.145)	0.638	(0.331 - 1.230)	0.594	(0.278 - 1.267)			1.063	(0.375 - 3.013)	1.315	(0.471 - 3.675)
Malawi	4,557	69	0.159	1346	0.135	2149	0.111	759	0.115	170	0.105	44	0.045	14	0.214	6	0.166
		3.622	(0.828 - 15.85)	3.079	(0.775 - 12.24)	2.590	(0.651 - 10.31)	2.629	(0.652 - 10.59)	2.455	(0.578 - 10.42)			4.957	(0.889 - 27.64)	3.441	(0.356 - 33.23)
Mali	4,481	223	0.255	1801	0.147	1438	0.131	625	0.129	244	0.106	100	0.07	32	0.187	18	0.055
		3.850	(1.867 - 7.939)	2.145	(1.054 - 4.366)	1.946	(0.950 - 3.986)	1.911	(0.924 - 3.953)	1.551	(0.705 - 3.412)			2.835	(1.052 - 7.644)	0.774	(0.102 - 5.864)
Moldova	630	34	0.029	187	0.021	224	0.004	108	0	21	0	50	0	6	0		
Morocco	2,064	10	0.3	212	0.066	587	0.059	539	0.048	316	0.041	218	0.050	119	0.008	63	0
		5.342	(1.108 - 25.77)	1.325	(0.622 - 2.822)	1.176	(0.605 - 2.283)	0.969	(0.490 - 1.916)	0.790	(0.349 - 1.787)			0.183	(0.0238 - 1.410)	4.05e-07	(2.03e-07 - 8.07e-07)
Mozambique	2,617	108	0.277	947	0.126	947	0.102	399	0.092	141	0.134	42	0.071	29	0	4	0.25
		3.760	(1.211 - 11.68)	1.932	(0.647 - 5.766)	1.557	(0.513 - 4.726)	1.362	(0.435 - 4.264)	1.984	(0.644 - 6.113)			1.01e-06	(3.18e-07 - 3.18e-06)	3.180	(0.465 - 21.77)
Namibia	2,715	34	0.058	559	0.055	995	0.041	602	0.039	298	0.033	143	0.013	56	0.053	28	0.035
		3.788	(0.569 - 25.21)	4.094	(1.012 - 16.57)	2.998	(0.753 - 11.93)	2.843	(0.694 - 11.66)	2.573	(0.582 - 11.37)			3.971	(0.690 - 22.86)	2.688	(0.261 - 27.71)
Nicaragua	3,296	127	0.023	1153	0.052	1100	0.026	494	0.026	246	0.020	113	0.008	49	0.020	14	0.071
		2.591	(0.270 - 24.89)	5.875	(0.813 - 42.45)	2.949	(0.401 - 21.68)	3.004	(0.394 - 22.92)	2.322	(0.273 - 19.77)			2.253	(0.142 - 35.64)	8.007	(0.520 - 123.3)
Niger	1,793	89	0.134	767	0.134	546	0.122	257	0.085	84	0.035	29	0.068	17	0.058	4	0
		1.746	(0.420 - 7.262)	1.751	(0.463 - 6.622)	1.646	(0.431 - 6.282)	1.165	(0.295 - 4.607)	0.502	(0.0894 - 2.820)			0.851	(0.0803 - 9.023)	1.20e-08	(2.30e-09 - 6.24e-08)
Nigeria	5,825	206	0.155	1630	0.108	1571	0.081	1246	0.077	699	0.055	314	0.073	117	0.085	42	0.142
		2.100	(1.254 - 3.517)	1.451	(0.958 - 2.198)	1.098	(0.720 - 1.674)	1.046	(0.682 - 1.605)	0.755	(0.464 - 1.228)			1.142	(0.566 - 2.307)	2.013	(0.867 - 4.676)
Pakistan	874	19	0.105	157	0.050	261	0.091	244	0.098	118	0.076	56	0.089	13	0.153	6	0
		1.078	(0.220 - 5.290)	0.563	(0.178 - 1.775)	0.989	(0.396 - 2.467)	1.090	(0.433 - 2.744)	0.846	(0.297 - 2.411)			1.629	(0.351 - 7.557)	2.49e-06	(7.75e-07 - 7.98e-06)
Paraguay	696	10	0	126	0.055	238	0.033	148	0.020	87	0.034	58	0.017	21	0	8	0
		2.74e-06	(3.47e-07 - 2.16e-05)	3.320	(0.415 - 26.59)	1.955	(0.246 - 15.57)	1.246	(0.131 - 11.89)	2.073	(0.215 - 20.00)			3.26e-06	(4.32e-07 - 2.46e-05)	2.85e-06	(3.41e-07 - 2.39e-05)
Peru	11,259	172	0.087	2114	0.038	3680	0.027	2568	0.022	1346	0.020	778	0.021	431	0.016	170	0.005
		3.902	(1.989 - 7.654)	1.707	(1.018 - 2.861)	1.242	(0.748 - 2.061)	0.987	(0.582 - 1.673)	0.895	(0.492 - 1.630)			0.729	(0.305 - 1.745)	0.263	(0.0350 - 1.985)

Rwanda	2,930	15	0.133	243	0.106	1032	0.105	948	0.081	451	0.082	164	0.103	61	0.081	16	0.25		
		1.220	(0.306 - 4.873)	0.996	(0.551 - 1.801)	0.999	(0.615 - 1.623)	0.792	(0.482 - 1.302)	0.790	(0.455 - 1.371)			0.785	(0.265 - 2.326)	2.203	(0.774 - 6.270)		
Senegal	1,260	41	0.121	329	0.103	398	0.062	292	0.041	114	0.061	55	0.036	20	0.1	11	0.272		
		3.306	(0.679 - 16.10)	2.870	(0.690 - 11.93)	1.705	(0.414 - 7.032)	1.139	(0.259 - 5.018)	1.673	(0.353 - 7.933)			2.799	(0.412 - 19.01)	7.708	(1.553 - 38.25)		
Sierra Leone	663	29	0.103	184	0.081	190	0.094	157	0.082	55	0.054	31	0.064	9	0	8	0		
		1.703	(0.294 - 9.846)	1.325	(0.314 - 5.583)	1.563	(0.369 - 6.614)	1.364	(0.308 - 6.045)	0.904	(0.161 - 5.067)			4.49e-07	(9.69e-08 - 2.08e-06)	4.02e-07	(8.67e-08 - 1.87e-06)		
Swaziland	620	10	0.1	177	0.101	251	0.043	106	0.103	50	0.08	16	0.125	8	0.125	2	0		
		0.679	(0.0697 - 6.608)	0.730	(0.186 - 2.864)	0.321	(0.0750 - 1.376)	0.804	(0.198 - 3.268)	0.607	(0.126 - 2.924)			0.850	(0.0868 - 8.325)	3.22e-06	(4.68e-07 - 2.22e-05)		
Tanzania	2,511	27	0.222	675	0.094	1,085	0.088	476	0.056	162	0.086	59	0.050	22	0.090	5	0		
		4.229	(1.138 - 15.71)	1.754	(0.567 - 5.430)	1.648	(0.534 - 5.091)	1.060	(0.330 - 3.399)	1.636	(0.483 - 5.543)			1.769	(0.318 - 9.844)	1.80e-06	(4.28e-07 - 7.54e-06)		
Togo	801	13	0.076	158	0.132	310	0.070	179	0.089	95	0.042	31	0.032	11	0.181	4	0.5		
		2.139	(0.139 - 32.95)	4.081	(0.544 - 30.59)	2.152	(0.287 - 16.14)	2.625	(0.357 - 19.33)	1.238	(0.139 - 10.99)			5.772	(0.566 - 58.89)	15.67	(1.863 - 131.8)		
Turkey	1,878	4	0	229	0.052	659	0.039	530	0.033	272	0.025	115	0.034	52	0.057	17	0		
		8.48e-06	(2.05e-06 - 3.51e-05)	1.470	(0.480 - 4.502)	1.137	(0.401 - 3.222)	0.975	(0.327 - 2.909)	0.747	(0.210 - 2.665)			1.713	(0.405 - 7.246)	7.86e-06	(2.45e-06 - 2.52e-05)		
Uganda	2,813	68	0.117	916	0.117	1165	0.089	438	0.075	170	0.076	41	0	13	0.230	2	0		
Uzbekistan	559	27	0	263	0.03	205	0.058	38	0.105	5	0	18	0	3	0				
Zambia	3,321	52	0.134	1116	0.128	1428	0.095	497	0.09	153	0.078	54	0.07	16	0.125	5	0.2		
		1.799	(0.541 - 5.984)	1.631	(0.614 - 4.333)	1.242	(0.467 - 3.300)	1.204	(0.441 - 3.288)	1.033	(0.342 - 3.121)			1.460	(0.295 - 7.218)	3.706	(0.432 - 31.78)		
Zimbabwe	1,980	21	0.142	439	0.052	888	0.057	401	0.047	160	0.05	44	0.05	21	0.047	6	0		
		3.018	(0.534 - 17.07)	1.053	(0.267 - 4.159)	1.184	(0.310 - 4.525)	0.980	(0.246 - 3.904)	1.011	(0.230 - 4.441)			1.004	(0.0980 - 10.29)	1.12e-05	(2.35e-06 - 5.31e-05)		

Note: Each country/age group have four statistics associated with it: number of observations (top right), the fraction of children who died (top left), the relative risk ration (bottom right), and the 95% CI of that RRR (bottom left). Azerbaijan, Gabon, Moldova, Uganda and Uzbekistan excluded from country specific examples as convergence was not achieved for the country specific regressions.

Contributors: Jocelyn E. Finlay co-led the conception and interpretation of results in this study. She assisted with drafting the manuscript. She prepared all of 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. Emre Özaltin assisted with preliminary empirical analysis for this study. David Canning led the conception of this study and interpretation of study findings as well as assisting with the drafting of the manuscript. Authors have seen and approved this final submitted version of the manuscript. All authors will provide final approval of the version to be published.

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Competing Interests: None declared

Ethical Review

The DHS data collection procedures were approved by the ICF Macro International (Calverton, Maryland) 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 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.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

All items below are included in the study entitled: Association of Maternal Age with Infant Mortality, Child Anthropometric Failure, Diarrhoea, and Anaemia for First Births in Low- and Middle-Income Countries

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

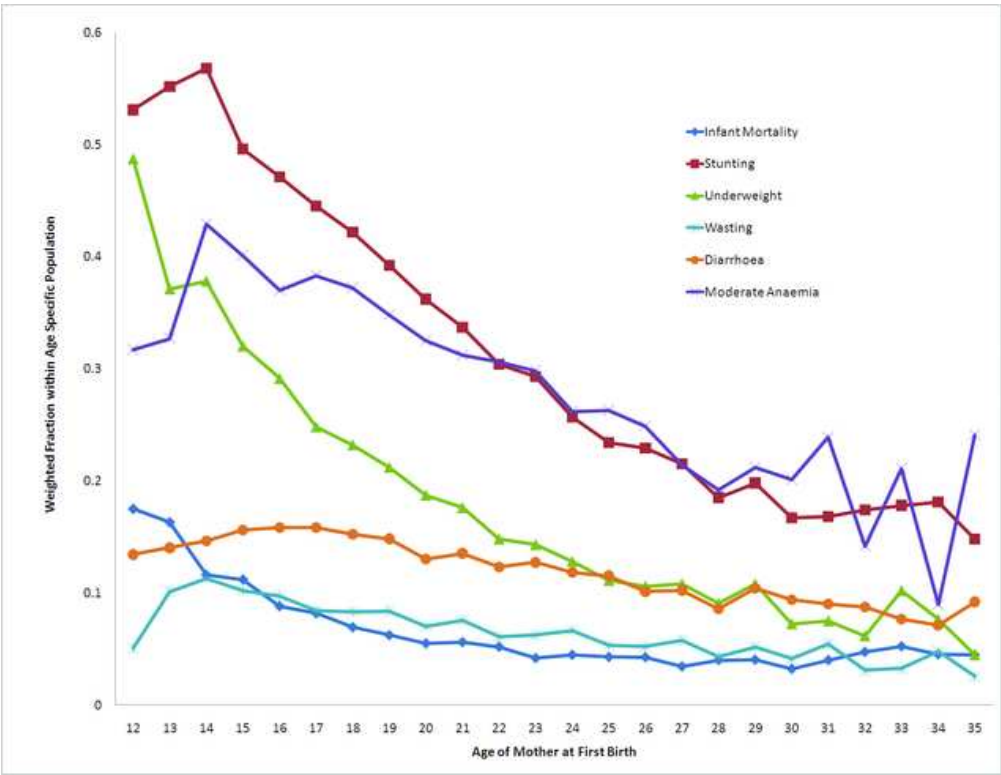

Figure 1: Child Health Indicator Weighted Prevalence by Age of Mother at First Birth
53x41mm (300 x 300 DPI)

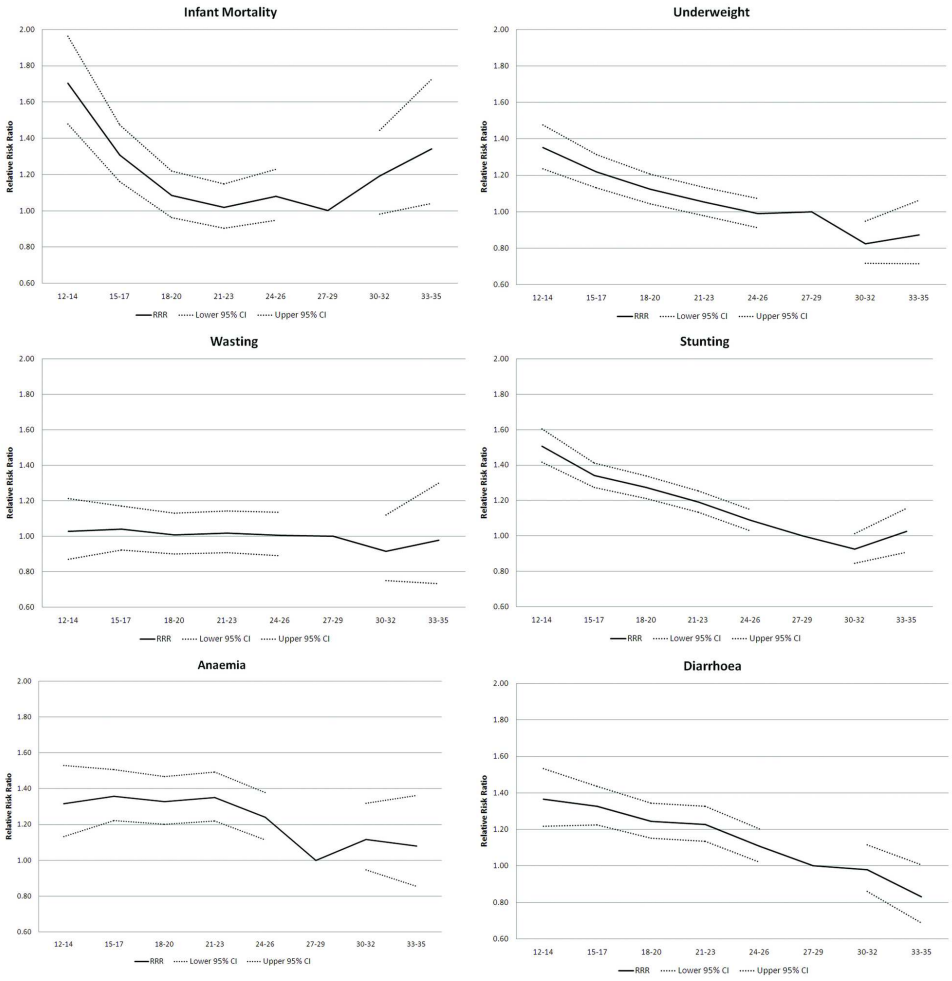

Figure 2: Plot of Adjusted Relative Risk Ratios and 95% Confidence Intervals as per the results tabulated in Table 4
174x176mm (300 x 300 DPI)

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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Keywords:	PUBLIC HEALTH, PREVENTIVE MEDICINE, Community child health < PAEDIATRICS

Title

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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Running head: Maternal Age and Child Health

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

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

Setting: Low- and middle-income countries

Population: First births to women aged 12-35 where this birth occurred 12-60 months prior to the 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: In children under 12 months: infant mortality. In children under 5 years: stunting, underweight, wasting, diarrhoea and anaemia.

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 27-29. Secondly, the results indicate that both biological and social mechanisms play a role in explaining why children of young mothers have poorer outcomes.

Conclusions: First borns 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 higher risk of having a child who suffers from stunting, diarrhoea and moderate or strong anaemia.Maternal and child health programs should take account of this increased risk even for mothers in their early twenties. Increasing age as first birth in developing countries may have large benefits in terms of child health.

Introduction

Progress towards reaching Millennium Development Goal 4 focuses on the measurable reduction in under-5 mortality. In low- to middle-income countries, this also means "revitalizing efforts against...diarrhoea, while bolstering nutrition...".[1] The risk of under-5 mortality, and the prevalence of diarrheal 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 5.7-6.3) of children die before their fifth birthday. In the same 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 highlight 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 Centre for Global Development[4] highlighted the risk to child health associated with young motherhood. When considering child health, the report draws on the intergenerational influence on child health outcomes, rather than a cross sectional observation of children alone. The effect of the age of 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] show that children born to mothers who were married under 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 mothers' age at first birth was a significant risk factors of 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% have it before age 24.[15] Much debate, particularly with US population samples, concerns the social versus physiological influence of young motherhood on child health outcomes.[16-22] Young age can 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 generalizes across and within countries, rather than focusing on a sample from a single country, provides standardized analyses and results to assess age as a proxy for physiological immaturity and social disadvantage and

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its effect on child health outcomes. Earlier work by Hobcraft[12] in 1992 examines the effect of age at first birth on child survival in a number of countries using Demographic and Health Surveys 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 socio-economic factors, the physiological effect of young motherhood on child health can be parsed 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 Demographic and Health Surveys (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, socio-economic, and anthropometric indicators, emphasizing on maternal and child health.[25] The DHS are important data source for studying population health across developing countries due to extensive coverage, comparability, and data quality.[26-28] To ensure standardization and comparability across diverse sites and time, In conducting the Demographic and Health Surveys, Macro ICF employs intense interviewer training, standardized measurement tools and techniques, an identical core questionnaire, and instrument pretesting.[29] Each participating country reports detail 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 standardized variables across surveys.[30]

Sampling Plan

The DHS involves stratified cluster randomized 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

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area, random clusters of households weredrawn 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 wereselected 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 are identified. In most surveys all women between the ages of 15-49 wereinterviewed. In a limited number of surveys the target group it is women aged 10-49, or 15-45, or ever-married women. The child anthropometry module was conducted in a selection of the Standard Demographic and Health Surveys.[32] The DHS provides weights forcalculating nationally representative statistics.

Study Population and Sample Size

Our sample consists of children born to women who have had their first birth in the period 12-60 months before the survey. The lower bound of 12 months is applied so that each child has equal exposure to one year of life and we can accurately calculate the infant mortality (children who die within the first year of life). Detailed child health measures are only taken for children up to 60 months which establishes our upper bound.[1] Only the first birth for each woman is included in our sample, for multiple births we only use data from the first recorded birth, though we control for this for 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 5,313 of these, mothers' age at the first birth is missing in 1,564; 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 mother is restricted to 12-35 as only 13 of the mothers had their children at age less than 12 and 1,716 had their first birth at 36 or older. Details of the samples for the child health outcomes are given in the appendix Table A1. These samples are smaller becausethe child anthropometric module wasnot conducted in a number of surveys. The stunting data comprises 119,018, wasting 120,246, underweight 122,680, diarrhoea 135,121, and anaemia 31,520 children.

[1] Note the upper bound is 60 months rather than 59 months to conform to the World Health Organization age categories.

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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 prior to the interview. Infant mortality is a measure of whether or not the child survived to age 1 year. The birth history in the Demographic and Health Surveys Individual Recode records the survival status of a woman's (respondent's) child. A child's death and age of death is reported by the mother. For the measure of infant mortality, we count infants who passed away 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 by the standard deviation of the same age and sex in the World Health Organization reference population of healthy children in developing countries.[33] Stunting is defined as a height z-score of less than minus two. Similarly, underweight is defined as a z-score less than minus two for weight relative to children of the same sex and age in the reference population. Wasting is defined as a z-score less than minus two for weight-to-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 has had diarrhoea within the two 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 analyzed using the HemoCue system. Adjustments for altitude were taken into account, and children with a haemoglobin concentration less than 10grams per decilitre were considered has 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 child in months. The covariate for the age of child is not included in the infant

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mortality model (which depends only on survival to age one year) but is included in all other models. Child age in months is categorized 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 mother's age at the first birth. The age of the mother at first birth is a variable reported in the Demographic and Health Surveys recode manual[30] and is calculated as from the CMC (century month code) of the date of the first birth and the CMC of the date of birth of the mother. Age is categorized into three-year intervals: ages 12-14, 15-17, 18-20, 21-23, 24-26, 27-29, 30-32 and 33-35. Appendix Table A2 shows the effect of age of the mother at first birth, and age squared, are 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 in age may not capture all the potential heterogeneity in the effect of maternal age on child health outcomes. Furthermore, we use age grouped into three year intervals, as opposed to single year age groups, due to the small number of infant deaths occurring for single age groups. Grouping three years together providesa sufficient group size to minimize 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,[34] 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 mother's height is available. The height of the mother is in five categories: 100-144cm, 145-149cm, 150-154cm, 155-159cm and 160-200cm. 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 and if so the partner's age and education level. Partners are typically older than the women are and partner's age is split into six categories: 12-17, 18-23, 24-29, 30-35, 36-41, 42-59. Partner's education follows the same groupings as coded for 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, generated by Filmer and Pritchett,[35] is a linear index of asset ownership indicators using principal component analysis to derive

weights. This measure has been standardised by Measure DHS across most of the Demographic and Health Surveys and is widely used as a measure of relative wealth within a country. Given we have country fixed effects 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 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 9-12 months of age and is likely to have only a limited direct effect on infant mortality (deaths between 0-12 months). Rather, we think of the vaccine coverage as being a proxy for health care provision, though there may also be a herd-immunity effect on younger children due to lower overall prevalence.

Statistical Analysis

To measure the relative risk of a given outcome we apply a modified Poisson regression following Zou's[36] methodology. We estimate the unadjusted model only controlling for country fixed effects and survey-year 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.[37]

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Results

Results: Summary Statistics

Average age at first birth across the 118 Demographic and Health Surveys 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 borns in Mali in 1995. In 30 of the 118 surveys, average stunting is 50% or higher, 79 of the 118 survey country/years have stunting rates of 30% or higher. Madagascar in 1997

hasthe highest average stunting rate with 65.46% of the first borns being classified as stunted according to the WHO standards. Wasting, weight-for-height, does not measure 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. In terms of underweight, 32 of the 118 surveys record a prevalence of 25% or more. An average of 36.91% of first borns in Niger in 1998 isreported to have suffered diarrhoea within the two 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 of the 38 surveys that do record anaemia average rates range from a low of 7.99% of first borns in Egypt in 2000, to 71.55% in Burkina Faso in 2003. The average is32.6% 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 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 year old at first birth. This group represents 4.3% of the population with 7,648 children. Children of multiple births are rare (0.8%), most women (92.9%) have partners, 60.1% of the children areborn in rural areas, 43.6% have piped water to the house, the remainder has 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 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.

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Table 1:Weighted Mean Child Health Outcomes and Confidence Intervals by Survey

	Survey Year	Sample Size	Age at first birth		Infant Mortality		Stunting		Wasting		Underweight		Diarrhea		Anemia	
		N	Mean	SD	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Armenia	2000	510	21.04	(3.61)	1.51	[0.77,2.93]	16.17	[12.27,21.00]	1.40	[0.55,3.56]	1.02	[0.38,2.65]	8.53	[6.20,11.63]	8.29	[5.92,11.49]
Armenia	2005	504	21.90	(3.15)	1.47	[0.51,4.15]	17.19	[11.07,25.72]	3.12	[1.63,5.88]	3.57	[1.96,6.41]	15.60	[12.00,20.05]	15.78	[10.21,23.57]
Azerbaijan	2006	719	22.54	(3.97)	3.11	[1.73,5.55]	25.32	[20.80,30.45]	3.93	[2.31,6.61]	7.40	[4.81,11.21]	9.79	[7.00,13.53]	17.82	[13.55,23.07]
Bangladesh	1996	1,309	17.65	(3.24)	9.60	[8.11,11.33]	57.25	[53.52,60.89]	16.80	[14.37,19.53]	48.81	[45.41,52.22]	8.13	[6.43,10.23]		
Bangladesh	1999	1,596	18.20	(3.49)	9.86	[8.45,11.48]	56.07	[52.65,59.44]	10.46	[8.69,12.53]	40.37	[37.31,43.51]	6.30	[5.04,7.85]		
Bangladesh	2004	1,633	18.04	(3.29)	7.80	[6.49,9.35]	52.60	[49.58,55.60]	14.43	[12.29,16.87]	42.73	[39.70,45.81]	5.89	[4.70,7.37]		
Bangladesh	2007	1,637	18.48	(3.35)	6.14	[4.82,7.79]	43.55	[40.14,47.01]	15.12	[12.90,17.64]	40.91	[37.40,44.52]	9.98	[8.24,12.03]		
Benin	1996	594	19.57	(3.02)	8.40	[6.46,10.86]	38.94	[32.70,45.58]	14.76	[10.67,20.08]	27.60	[22.44,33.45]	27.46	[21.91,33.80]		
Benin	2001	781	20.25	(3.55)	8.27	[6.49,10.48]	40.96	[36.75,45.31]	7.25	[5.53,9.46]	21.17	[17.80,24.99]	14.54	[11.70,17.92]	55.57	[49.74,61.26]
Benin	2006	2,112	20.42	(3.57)	7.34	[6.23,8.63]	45.43	[42.40,48.48]	5.43	[4.25,6.91]	17.54	[15.58,19.69]	9.41	[8.06,10.95]	48.72	[44.21,53.26]
Bolivia	1993	813	20.82	(4.05)	3.36	[2.29,4.90]	29.95	[25.21,35.16]	4.17	[2.47,6.96]	10.60	[7.75,14.34]	31.69	[27.25,36.50]		
Bolivia	1998	1,224	20.85	(4.16)	4.54	[3.42,6.00]	24.24	[21.38,27.35]	0.56	[0.24,1.32]	3.43	[2.47,4.73]	18.66	[16.17,21.44]		
Bolivia	2003	1,987	20.48	(4.03)	3.65	[2.75,4.83]	26.30	[23.44,29.38]	0.81	[0.48,1.39]	2.68	[1.94,3.69]	22.07	[19.78,24.53]	22.67	[18.54,27.40]
Brazil	1996	1,280	21.12	(4.53)	2.15	[1.48,3.13]	8.76	[7.11,10.73]	2.43	[1.48,3.96]	2.60	[1.76,3.82]	9.62	[7.96,11.58]		
Burkina Faso	1992	771	19.12	(2.91)	12.50	[10.06,15.44]	45.86	[41.34,50.46]	15.69	[12.40,19.66]	33.99	[29.51,38.78]	12.85	[10.33,15.87]		
Burkina Faso	1998	730	19.21	(3.00)	14.94	[12.25,18.09]	53.12	[48.15,58.03]	13.36	[10.62,16.67]	39.39	[35.29,43.64]	12.64	[10.02,15.83]		
Burkina Faso	2003	1,414	19.19	(2.87)	9.07	[7.48,10.95]	48.54	[44.36,52.74]	17.97	[15.29,21.00]	33.47	[29.58,37.60]	20.82	[17.94,24.02]	71.55	[65.66,76.78]
Cameroon	1991	498	18.62	(3.16)	6.67	[4.50,9.78]	35.90	[29.95,42.33]	4.38	[2.41,7.86]	16.73	[11.94,22.96]	12.10	[8.78,16.45]		
Cameroon	1998	542	18.87	(3.18)	7.27	[5.29,9.91]	43.56	[37.05,50.30]	4.52	[2.21,9.03]	17.92	[12.98,24.22]	20.23	[15.66,25.74]		
Cameroon	2004	1,146	19.13	(3.45)	6.26	[4.90,7.97]	35.95	[31.39,40.79]	6.20	[4.23,9.00]	13.57	[10.26,17.73]	16.99	[13.40,21.29]	45.37	[40.19,50.65]
Central African Rep.	1994	653	18.78	(3.44)	13.62	[11.25,16.41]	49.09	[43.70,54.50]	7.51	[4.83,11.48]	22.06	[17.35,27.62]	28.00	[23.40,33.12]		
Chad	1996	1,030	18.30	(2.98)	12.37	[10.37,14.70]	50.36	[46.24,54.47]	13.68	[11.22,16.58]	33.95	[30.05,38.08]	21.38	[18.25,24.89]		
Chad	2004	733	18.18	(3.09)	14.00	[10.86,17.85]	42.26	[37.35,47.34]	11.23	[8.51,14.68]	36.86	[29.66,44.69]	22.83	[18.16,28.29]		
Colombia	1995	1,405	21.60	(4.43)	1.58	[1.05,2.38]	15.73	[13.68,18.01]	0.92	[0.50,1.68]	4.54	[3.42,6.01]	12.44	[10.75,14.35]		
Colombia	2000	1,358	21.32	(4.70)	1.85	[1.26,2.70]	15.38	[13.06,18.03]	0.49	[0.22,1.09]	3.19	[2.21,4.59]	12.77	[10.94,14.85]		
Colombia	2004	3,998	20.70	(4.49)	1.04	[0.75,1.44]	12.36	[10.92,13.96]	0.85	[0.59,1.24]	3.15	[2.50,3.98]	14.14	[12.63,15.79]		
Comoros	1996	234	21.20	(4.42)	6.84	[4.40,10.47]	47.27	[37.21,57.56]	10.81	[6.25,18.05]	19.64	[12.36,29.77]	16.81	[10.75,25.30]		
Congo, Dem. Rep.	2007	1,180	19.86	(3.50)	9.97	[7.87,12.55]	45.30	[38.16,52.65]	8.54	[5.39,13.26]	25.79	[21.49,30.61]	17.11	[12.48,23.00]	45.44	[38.80,52.25]
Congo, Rep.	2005	940	19.66	(3.63)	8.85	[6.69,11.63]	36.58	[31.42,42.07]	5.64	[3.85,8.20]	12.69	[9.38,16.94]	13.49	[10.72,16.84]	34.19	[27.82,41.19]
Cote d'Ivoire	1994	927	18.28	(3.21)	11.83	[9.50,14.63]	45.40	[40.31,50.60]	8.55	[6.03,12.00]	24.23	[19.89,29.17]	17.89	[14.34,22.10]		
Cote d'Ivoire	1998	96	18.50	(3.18)	6.75	[2.85,15.16]	36.39	[23.85,51.09]	4.53	[1.49,12.96]	17.29	[10.34,27.47]	20.92	[13.39,31.16]		
Dominican Republic	1996	1,035	20.31	(4.34)	3.42	[2.35,4.97]	8.21	[6.30,10.65]	1.79	[0.88,3.60]	2.85	[1.85,4.38]	10.81	[8.59,13.51]		
Dominican Republic	2002	2,611	19.99	(4.19)	2.00	[1.41,2.84]	8.13	[6.56,10.04]	1.11	[0.66,1.86]	2.35	[1.66,3.31]	13.91	[12.04,16.02]		
Dominican Republic	2007	2,632	20.14	(4.29)	2.00	[1.38,2.88]	7.59	[6.03,9.52]	1.40	[0.93,2.10]	2.67	[1.68,4.20]	14.66	[12.74,16.82]		
Dominican Republic	2007	164	18.72	(3.27)	1.99	[0.58,6.52]	15.18	[9.25,23.93]	1.08	[0.27,4.28]	4.03	[1.85,8.55]	22.09	[15.04,31.24]		
Egypt, Arab Rep.	1995	2,136	21.41	(3.95)	4.92	[3.94,6.14]	30.90	[27.95,34.01]	3.67	[2.70,4.97]	7.48	[6.11,9.11]	13.87	[12.04,15.93]		
Egypt, Arab Rep.	2000	2,370	21.81	(3.73)	3.20	[2.55,3.99]	21.40	[19.35,23.61]	2.19	[1.58,3.03]	2.40	[1.82,3.17]	5.85	[4.88,7.00]	7.99	[6.40,9.94]
Egypt, Arab Rep.	2003	1,502	21.45	(3.70)	3.94	[3.01,5.16]	16.87	[14.65,19.36]	4.17	[3.03,5.72]	7.18	[5.75,8.93]	19.40	[17.10,21.92]		

Egypt, Arab Rep.	2005	3,226	21.78	(3.69)	2.53	[1.99,3.21]	19.10	[17.35,20.97]	4.15	[3.29,5.23]	3.39	[2.72,4.21]	16.20	[14.67,17.86]	20.08	[17.18,23.32]
Egypt, Arab Rep.	2008	2,618	21.91	(3.72)	1.88	[1.41,2.51]	30.29	[28.01,32.67]	7.28	[6.05,8.73]	5.26	[4.31,6.39]	6.63	[5.66,7.74]		
Ethiopia	2000	1,689	20.09	(3.64)	11.37	[9.40,13.70]	58.70	[54.76,62.53]	9.29	[7.17,11.95]	37.03	[33.21,41.03]	22.00	[18.84,25.53]		
Ethiopia	2005	1,206	19.55	(3.63)	7.59	[5.67,10.08]	48.86	[42.72,55.04]	10.38	[7.47,14.26]	33.03	[27.97,38.53]	15.79	[12.11,20.34]	28.82	[23.44,34.88]
Gabon	2000	709	18.31	(3.21)	5.10	[3.60,7.19]	30.15	[25.72,34.99]	2.40	[1.31,4.34]	7.57	[5.60,10.16]	21.01	[17.52,24.98]		
Ghana	1993	427	20.45	(3.51)	3.04	[1.75,5.24]	42.36	[35.78,49.22]	8.70	[5.69,13.07]	20.09	[15.52,25.58]	14.10	[10.22,19.15]		
Ghana	1998	531	20.72	(3.52)	4.76	[3.22,6.96]	33.92	[29.21,38.98]	7.52	[5.46,10.26]	20.99	[17.56,24.88]	16.21	[13.12,19.86]		
Ghana	2003	492	20.92	(3.71)	5.81	[4.03,8.31]	36.27	[31.08,41.79]	6.36	[4.35,9.21]	19.35	[15.61,23.73]	15.96	[12.40,20.29]	52.42	[46.87,57.91]
Ghana	2008	499	21.19	(4.19)	4.51	[3.05,6.63]	35.08	[29.58,41.00]	6.80	[4.47,10.21]	14.88	[11.24,19.44]	20.50	[16.69,24.92]	50.44	[44.47,56.40]
Guatemala	1995	1,454	19.52	(3.67)	5.38	[4.15,6.95]	50.10	[45.63,54.57]	3.90	[2.75,5.52]	16.96	[14.31,20.00]	21.36	[18.19,24.92]		
Guinea	1999	743	18.32	(3.36)	10.82	[8.73,13.35]	37.23	[32.89,41.79]	6.31	[4.47,8.83]	19.86	[16.59,23.58]	22.56	[19.45,26.00]		
Guinea	2005	666	18.77	(3.72)	7.40	[5.59,9.74]	43.81	[37.73,50.09]	10.06	[6.85,14.54]	26.52	[21.40,32.36]	17.18	[13.55,21.53]	58.57	[52.14,64.73]
Haiti	1994	514	21.19	(4.18)	9.24	[6.84,12.39]	33.89	[28.47,39.78]	5.65	[3.83,8.26]	20.68	[16.67,25.36]	24.12	[19.99,28.80]		
Haiti	2005	1,000	21.19	(4.44)	5.52	[4.09,7.41]	23.71	[19.13,29.00]	9.22	[6.50,12.92]	16.45	[12.85,20.82]	17.80	[13.50,23.12]	34.56	[29.27,40.26]
Honduras	2005	2,390	19.70	(3.82)	1.68	[1.22,2.32]	23.09	[20.90,25.43]	1.26	[0.80,1.96]	6.73	[5.55,8.13]	15.76	[14.10,17.57]	12.30	[10.69,14.12]
India	1992	12,919	19.93	(3.55)	8.02	[7.44,8.64]	58.80	[56.94,60.63]	18.02	[16.66,19.47]	48.55	[46.72,50.37]	5.34	[4.79,5.95]		
India	1998	12,763	20.12	(3.66)	7.11	[6.58,7.68]	52.52	[50.67,54.36]	15.99	[14.77,17.29]	41.41	[39.66,43.18]	17.38	[16.22,18.61]		
India	2005	13,112	21.13	(3.86)	6.27	[5.71,6.87]	44.60	[43.17,46.04]	16.23	[15.25,17.26]	38.76	[37.35,40.18]	7.60	[6.97,8.30]	38.38	[36.96,39.81]
Jordan	1990	1,035	21.22	(3.59)	1.90	[1.18,3.02]	18.53	[15.85,21.55]	3.05	[1.97,4.70]	4.97	[3.45,7.11]	9.21	[7.48,11.29]		
Jordan	1997	1,074	22.17	(3.73)	2.98	[2.11,4.20]	8.55	[6.88,10.59]	1.60	[0.94,2.71]	2.92	[2.05,4.14]	15.63	[13.37,18.19]		
Jordan	2007	898	23.02	(3.90)	1.83	[0.77,4.30]	12.20	[9.05,16.26]	5.89	[3.66,9.35]	5.23	[3.55,7.64]	16.98	[13.21,21.55]	12.29	[9.25,16.16]
Kazakhstan	1995	406	21.93	(3.62)	3.68	[2.17,6.20]	17.89	[11.91,25.99]	2.59	[1.07,6.14]	5.77	[2.97,10.91]	17.56	[11.77,25.39]		
Kazakhstan	1999	395	21.99	(3.69)	4.48	[2.69,7.38]	12.66	[8.15,19.15]	2.56	[0.97,6.54]	3.86	[1.53,9.42]	17.49	[13.32,22.63]		
Kenya	1998	867	19.92	(3.20)	3.95	[2.71,5.71]	38.01	[33.54,42.69]	5.98	[3.97,8.90]	14.11	[11.53,17.14]	18.73	[14.95,23.21]		
Kenya	2003	1,114	19.95	(3.43)	5.61	[4.29,7.30]	35.33	[31.70,39.14]	5.42	[3.87,7.54]	14.99	[12.43,17.97]	16.14	[13.63,19.00]		
Kenya	2008	1,059	19.91	(3.60)	4.75	[3.34,6.71]	35.46	[30.78,40.43]	5.24	[3.67,7.41]	14.39	[11.36,18.06]	13.55	[10.69,17.02]		
Kyrgyz Republic	1997	388	20.97	(3.14)	5.05	[3.22,7.83]	32.43	[24.30,41.77]	2.02	[0.73,5.49]	6.77	[3.51,12.64]	19.38	[14.01,26.20]		
Lesotho	2004	749	19.81	(3.24)	6.82	[5.09,9.09]	48.43	[41.99,54.93]	2.81	[1.50,5.18]	16.97	[13.00,21.84]	13.53	[9.92,18.19]	28.47	[22.99,34.65]
Liberia	2006	940	19.38	(3.52)	7.12	[5.23,9.63]	45.57	[40.86,50.35]	5.85	[4.08,8.32]	25.72	[20.96,31.13]	21.03	[17.16,25.50]		
Madagascar	1997	915	19.22	(3.94)	10.61	[8.51,13.14]	65.46	[60.10,70.45]	7.12	[5.03,10.00]	34.37	[29.41,39.70]	29.95	[25.50,34.81]		
Madagascar	2003	951	20.19	(4.40)	5.36	[3.70,7.69]	56.18	[50.85,61.36]	12.83	[9.76,16.70]	37.42	[32.05,43.13]	7.33	[5.31,10.05]	34.48	[26.54,43.39]
Madagascar	2008	1,887	19.11	(3.82)	4.78	[3.78,6.02]	44.72	[40.11,49.42]					9.11	[6.96,11.84]	14.62	[11.89,17.85]
Malawi	1992	564	18.84	(2.98)	17.00	[13.63,20.98]	64.28	[58.09,70.03]	6.08	[3.88,9.41]	22.30	[17.79,27.57]	11.15	[8.10,15.17]		
Malawi	2000	2,121	18.95	(2.61)	13.71	[12.13,15.46]	62.66	[59.57,65.66]	4.79	[3.64,6.27]	22.42	[19.99,25.05]	16.49	[14.48,18.71]		
Malawi	2004	1,872	18.80	(2.53)	8.53	[7.15,10.15]	58.00	[54.61,61.31]	5.87	[4.55,7.55]	18.31	[15.91,20.98]	21.50	[18.90,24.34]	39.83	[34.10,45.84]
Mali	1995	1,042	18.48	(3.32)	17.01	[14.74,19.55]	48.29	[42.85,53.77]	23.45	[19.14,28.41]	39.96	[34.73,45.43]	25.17	[20.64,30.32]		
Mali	2001	1,595	18.70	(3.44)	15.56	[13.36,18.04]	45.95	[42.17,49.77]	12.23	[9.96,14.94]	33.63	[30.07,37.38]	19.06	[15.93,22.64]	63.91	[56.77,70.49]
Mali	2006	1,844	18.55	(3.43)	14.17	[11.74,17.01]	42.24	[38.58,45.99]	14.98	[12.97,17.24]	31.23	[28.23,34.40]	14.47	[12.11,17.20]	62.99	[57.58,68.08]
Moldova	2005	630	22.18	(3.56)	0.93	[0.40,2.15]	8.89	[6.70,11.70]	5.19	[3.59,7.44]	3.22	[1.95,5.26]	7.01	[5.28,9.26]	9.04	[6.38,12.66]
Morocco	1992	788	22.21	(4.38)	6.22	[4.55,8.45]	23.49	[20.13,27.23]	1.94	[1.10,3.41]	4.29	[2.86,6.39]	6.20	[4.48,8.53]		
Morocco	2003	1,276	22.57	(4.54)	3.96	[3.00,5.21]	19.72	[17.10,22.64]	8.67	[7.00,10.70]	8.32	[6.80,10.15]	7.30	[5.72,9.26]		
Mozambique	1997	938	18.80	(3.27)	14.62	[10.35,20.26]	56.14	[48.14,63.83]	9.74	[6.09,15.20]	28.54	[20.40,38.36]	22.39	[14.69,32.59]		
Mozambique	2003	1,679	18.73	(3.26)	11.68	[9.88,13.75]	51.77	[47.94,55.58]	4.75	[3.40,6.60]	21.41	[18.50,24.65]	14.41	[12.22,16.91]		
Namibia	1992	762	20.32	(3.71)	5.10	[3.75,6.89]	38.83	[34.12,43.76]	8.02	[5.73,11.13]	21.24	[17.21,25.91]	16.28	[12.91,20.33]		
Namibia	2000	830	20.44	(3.83)	3.05	[1.95,4.72]	27.82	[23.92,32.10]	8.74	[6.18,12.22]	18.69	[14.28,24.08]	12.63	[9.55,16.53]		
Namibia	2006	1,123	20.76	(4.00)	3.31	[2.44,4.50]	28.69	[24.81,32.90]	5.96	[4.41,8.02]	17.92	[14.58,21.84]	16.00	[12.96,19.59]		

Nicaragua	1997	1,633	19.06	(3.64)	3.75	[2.86,4.90]	25.74	[23.01,28.66]	2.18	[1.39,3.40]	8.07	[6.33,10.23]	12.33	[10.57,14.34]		
Nicaragua	2001	1,663	19.26	(3.75)	2.43	[1.78,3.30]	20.84	[18.42,23.48]	1.59	[0.88,2.85]	5.03	[3.84,6.56]	12.33	[10.48,14.45]		
Niger	1998	871	18.16	(3.15)	16.42	[13.68,19.58]	56.49	[50.91,61.91]	24.52	[19.95,29.75]	50.01	[44.60,55.42]	36.91	[31.70,42.44]		
Niger	2006	922	18.64	(3.42)	9.45	[7.42,11.96]	60.64	[55.35,65.69]	9.47	[6.85,12.95]	45.40	[40.09,50.81]	18.74	[14.93,23.26]	59.43	[53.08,65.49]
Nigeria	1990	1,023	19.80	(3.88)	7.65	[5.64,10.30]	55.63	[51.25,59.92]	13.60	[8.01,22.17]	38.01	[32.01,44.40]	10.97	[8.23,14.47]		
Nigeria	2003	850	19.82	(3.89)	10.00	[7.71,12.87]	46.78	[40.28,53.39]	9.13	[6.60,12.50]	31.67	[26.27,37.61]	16.72	[13.26,20.87]		
Nigeria	2008	3,952	20.29	(4.24)	8.17	[7.26,9.19]	39.08	[36.76,41.46]	12.00	[10.61,13.53]	24.74	[22.65,26.96]	10.41	[9.20,11.77]		
Pakistan	1990	874	20.81	(3.88)	9.97	[7.64,12.90]	53.38	[47.78,58.89]	11.52	[7.41,17.49]	33.03	[27.96,38.54]	7.11	[4.90,10.21]		
Paraguay	1990	696	21.07	(4.21)	3.09	[2.02,4.69]	12.87	[10.24,16.06]	0.34	[0.07,1.55]	1.83	[0.98,3.38]	4.93	[3.27,7.35]		
Peru	1991	1,747	21.13	(4.22)	2.50	[1.87,3.35]	30.63	[27.83,33.57]	1.21	[0.73,1.99]	6.08	[4.88,7.56]	7.93	[6.57,9.55]		
Peru	1996	3,505	20.96	(4.15)	3.05	[2.45,3.80]	22.42	[20.35,24.65]	0.79	[0.51,1.22]	3.17	[2.59,3.88]	15.06	[13.51,16.75]		
Peru	2000	3,151	21.02	(4.33)	2.21	[1.70,2.87]	24.09	[21.85,26.48]	0.68	[0.41,1.13]	3.20	[2.50,4.08]	13.78	[12.30,15.41]	24.96	[20.76,29.70]
Peru	2003	2,856	21.14	(4.44)	1.57	[1.11,2.24]	20.19	[17.77,22.84]	0.71	[0.35,1.43]	2.24	[1.70,2.94]	13.72	[11.85,15.82]	17.32	[15.22,19.64]
Rwanda	1992	742	21.54	(3.57)	10.06	[8.07,12.48]	58.42	[53.98,62.73]	2.91	[1.75,4.82]	19.17	[15.79,23.07]	15.52	[12.61,18.96]		
Rwanda	2000	1,209	21.34	(3.32)	10.62	[8.96,12.54]	52.92	[49.11,56.70]	5.24	[3.73,7.30]	17.46	[14.78,20.52]	15.93	[13.40,18.84]		
Rwanda	2005	979	21.54	(3.29)	8.06	[6.31,10.25]	54.14	[49.11,59.09]	5.69	[3.72,8.59]	21.00	[17.07,25.56]	16.34	[12.97,20.38]	35.70	[30.54,41.20]
Senegal	2005	1,260	20.01	(3.91)	7.09	[5.61,8.93]	20.13	[15.29,26.04]	7.46	[5.05,10.88]	13.98	[10.29,18.71]	21.26	[16.65,26.74]	61.98	[55.64,67.94]
Sierra Leone	2008	663	19.85	(4.03)	8.06	[6.08,10.61]	38.25	[31.56,45.41]	11.82	[8.30,16.57]	22.17	[16.99,28.39]	7.80	[5.15,11.64]	46.22	[39.35,53.23]
Swaziland	2006	620	19.48	(3.35)	7.95	[5.95,10.55]	28.69	[24.65,33.10]	1.54	[0.72,3.29]	3.87	[2.40,6.16]	17.15	[13.71,21.23]	21.93	[18.07,26.34]
Tanzania	1996	1,058	19.31	(2.81)	9.38	[7.62,11.50]	56.50	[52.22,60.69]	8.52	[6.43,11.20]	26.25	[23.01,29.77]	13.45	[11.13,16.17]		
Tanzania	1999	48	18.50	(2.84)	9.86	[3.92,22.69]	57.16	[33.20,78.17]	6.31	[1.43,23.83]	26.88	[13.03,47.41]	9.32	[3.45,22.82]		
Tanzania	2004	1,405	19.58	(3.26)	7.40	[5.98,9.12]	50.22	[45.93,54.51]	3.24	[2.22,4.69]	18.11	[15.72,20.77]	11.54	[9.57,13.85]	43.42	[39.87,47.05]
Togo	1998	801	20.30	(3.60)	8.27	[6.47,10.53]	34.67	[29.09,40.70]	12.53	[9.28,16.70]	25.71	[21.19,30.81]	30.18	[25.94,34.79]		
Turkey	1993	949	21.16	(3.44)	4.73	[3.47,6.42]	17.98	[15.20,21.15]	1.76	[1.00,3.09]	6.15	[4.49,8.37]	14.42	[12.09,17.12]		
Turkey	1998	929	21.59	(3.89)	3.06	[2.05,4.55]	18.36	[15.46,21.67]	1.62	[0.88,2.99]	5.70	[4.12,7.85]	27.06	[23.87,30.51]		
Uganda	1995	1,067	18.71	(2.98)	11.14	[9.18,13.47]	52.06	[46.60,57.47]	5.41	[3.49,8.29]	23.09	[19.11,27.61]	25.44	[22.03,29.17]		
Uganda	2000	1,035	18.81	(2.98)	10.56	[8.68,12.78]	49.28	[45.02,53.56]	3.10	[1.94,4.93]	14.86	[11.93,18.34]	16.99	[13.93,20.57]	41.11	[36.08,46.33]
Uganda	2006	711	19.26	(2.82)	7.63	[5.55,10.39]	42.30	[36.02,48.83]	6.65	[3.81,11.35]	15.90	[11.62,21.39]	26.83	[21.31,33.17]	41.20	[34.42,48.33]
Uzbekistan	1996	559	20.89	(2.71)	3.80	[2.51,5.71]	35.89	[29.30,43.06]	7.84	[4.63,13.00]	7.63	[4.98,11.53]	6.73	[4.11,10.84]		
Zambia	1996	1,188	18.80	(2.81)	13.46	[11.48,15.72]	57.98	[54.05,61.81]	4.49	[3.18,6.29]	21.31	[18.40,24.55]	24.12	[21.17,27.34]		
Zambia	2001	1,161	18.59	(2.68)	10.47	[8.82,12.38]	58.17	[54.17,62.06]	5.27	[3.70,7.44]	22.43	[19.83,25.27]	23.77	[20.83,26.98]		
Zambia	2007	972	19.21	(3.12)	7.44	[5.85,9.42]	51.39	[47.22,55.54]	4.36	[3.03,6.24]	15.44	[12.74,18.59]	15.66	[12.98,18.78]		
Zimbabwe	1994	719	19.53	(3.01)	5.81	[4.22,7.95]	31.46	[25.99,37.50]	7.39	[4.77,11.27]	14.70	[10.79,19.72]	25.59	[20.64,31.26]		
Zimbabwe	2005	1,261	19.87	(3.19)	5.49	[4.08,7.35]	33.26	[30.00,36.69]	6.32	[4.77,8.33]	12.57	[10.49,14.98]	13.65	[11.40,16.26]	29.68	[25.99,33.65]
Total	2000	176,583	20.18	(3.87)	6.49	[6.35,6.64]	36.20	[35.81,36.60]	7.53	[7.32,7.74]	19.78	[19.43,20.13]	13.64	[13.40,13.87]	32.60	[31.87,33.34]

Table 2: Weighted Frequency and Distribution of First Born Children within Five 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	
	Population	Weighted Fraction	Population	Weighted Fraction	Population	Weighted Fraction	Population	Weighted Fraction	Population	Weighted Fraction	Population	Weighted Fraction
	n=176,583		n=119,018		n=122,680		n=120,246		n=135,121		n=31,520	
Age Band of the Mother at First Birth												
12-14	4,497	0.026	2,301	0.020	2443	0.020	2,379	0.020	2,851	0.021	514	0.016
15-17	42,233	0.239	25,882	0.219	26839	0.220	26,335	0.220	30,011	0.222	6,531	0.203
18-20	62,091	0.352	41,492	0.351	42868	0.352	42,054	0.352	47,425	0.351	11,753	0.366
21-23	37,757	0.214	26,427	0.224	27127	0.223	26,594	0.223	29,927	0.222	7,563	0.236
24-26	17,383	0.099	12,669	0.107	12936	0.106	12,690	0.106	14,258	0.106	3,355	0.105
27-29	7,648	0.043	5,722	0.048	5883	0.048	5,771	0.048	6,480	0.048	1,481	0.046
30-32	3,377	0.019	2,566	0.022	2616	0.022	2,547	0.021	2,884	0.021	650	0.020
33-35	1,399	0.008	1,075	0.009	1085	0.009	1,075	0.009	1,203	0.009	249	0.008
Sex of Child												
Male	90,302	0.512	59,709	0.505	61867	0.508	60,577	0.507	68,501	0.507	16,438	0.512
Female	86,083	0.488	58,424	0.495	59929	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	120853	0.992	118,515	0.992	134,004	0.992	31,850	0.992
Twin	1,438	0.008	898	0.008	944	0.008	930	0.008	1,036	0.008	247	0.008
Age of Child in Months												
48-60 months	44,542	0.253	24,472	0.207	24780	0.203	24,353	0.204	27,013	0.200	7,552	0.235
36-47 months	42,793	0.243	26,908	0.228	27694	0.227	27,210	0.228	31,330	0.232	7,867	0.245
24-35 months	43,082	0.244	31,485	0.267	32603	0.268	31,950	0.267	36,595	0.271	7,961	0.248
12-23 months	45,968	0.261	35,268	0.299	36718	0.301	35,932	0.301	40,101	0.297	8,717	0.272
Education Level of the Mother at Time of Interview												
Secondary or higher	36,152	0.205	27,729	0.235	28308	0.232	27,757	0.232	31,177	0.231	6,562	0.204
Completed primary	57,645	0.327	40,543	0.343	41341	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	52147	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	112890	0.927	110,666	0.927	125,468	0.929	30,192	0.941
No	12,527	0.071	8,784	0.074	8906	0.073	8,779	0.074	9,572	0.071	1,904	0.059
Education Level of the Mother's Partner at the Time of Interview												
Completed Secondary or Higher	54,943	0.311	39,434	0.334	40422	0.332	39,640	0.332	44,409	0.329	8,891	0.277
Completed primary	56,655	0.321	38,884	0.329	39920	0.328	39,216	0.328	44,217	0.327	12,180	0.379
No education or incomplete primary	64,787	0.367	39,815	0.337	41455	0.340	40,589	0.340	46,414	0.344	11,025	0.344

Age Band of the Mother's Partner at the Birth of the Mother's First Birth												
12-17	2,104	0.012	1,224	0.010	1236	0.010	1,211	0.010	1,409	0.010	373	0.012
18-23	40,271	0.228	27,180	0.230	28018	0.230	27,483	0.230	30,594	0.227	9,132	0.285
24-29	101,722	0.577	66,806	0.566	68828	0.565	67,569	0.566	77,555	0.574	15,792	0.492
30-35	22,072	0.125	15,954	0.135	16483	0.135	16,125	0.135	17,661	0.131	4,797	0.149
36-41	6,768	0.038	4,685	0.040	4846	0.040	4,724	0.040	5,266	0.039	1,342	0.042
42-59	3,448	0.020	2,284	0.019	2385	0.020	2,332	0.020	2,555	0.019	660	0.021
Wealth Quintile of the Child's Household												
Richest	36,825	0.209	24,886	0.211	25377	0.208	24,876	0.208	28,741	0.213	6,550	0.204
Rich	37,749	0.214	25,955	0.220	26597	0.218	26,150	0.219	29,413	0.218	6,961	0.217
Middle	36,203	0.205	24,554	0.208	25319	0.208	24,853	0.208	27,932	0.207	6,795	0.212
Poorer	34,324	0.195	22,705	0.192	23517	0.193	23,053	0.193	25,834	0.191	6,138	0.191
Poorest	31,285	0.177	20,035	0.170	20986	0.172	20,512	0.172	23,120	0.171	5,653	0.176
Residence of the Child's Household at the Time of Interview												
Urban	70,395	0.399	50,428	0.427	51491	0.423	50,597	0.424	57,358	0.425	12,301	0.383
Rural	105,990	0.601	67,706	0.573	70305	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	56699	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	65097	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	42402	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	79394	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

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 olds 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 27-29 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 27-29 are in the richest quintile while 11.7% of mothers age 15-17 are in the richest quintile (Table 3). 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 have their first birth between the ages of 27-29 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 have 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).

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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 socio-economic characteristics. In the following analysis, we present both unadjusted results and results that control for these covariates (Table 3).

Table 3: Weighted Frequency and Distribution Covariates Across Age of Mother at Birth

Age Band	12-14 Pop. W'tedFrac. n=4,322	15-17 Pop. W'tedFrac. n=41,384	18-20 Pop. W'tedFrac. n=61,491	21-23 Pop. W'tedFrac. n=38,300	24-26 Pop. W'tedFrac. n=18,211	**27-29** Pop. W'tedFrac. n=7,939	30-32 Pop. W'tedFrac. n=3,493	33-35 Pop. W'tedFrac. n=1,443
Sex of Child								
Male	2,323 0.517	21,627 0.512	31,995 0.515	19,017 0.504	8,941 0.514	3,964 0.518	1,731 0.513	705 0.504
Female	2,173 0.483	20,607 0.488	30,096 0.485	18,741 0.496	8,443 0.486	3,685 0.482	1,646 0.487	694 0.496
Type of Birth								
Singleton	4,477 0.996	42,003 0.995	61,701 0.994	37,376 0.990	17,173 0.988	7,532 0.985	3,317 0.982	1,369 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 months	1,380 0.307	11,154 0.264	15,402 0.248	9,272 0.246	4,269 0.246	1,841 0.241	890 0.263	335 0.240
36-47 months	1,260 0.280	10,537 0.249	14,491 0.233	9,378 0.248	4,176 0.240	1,822 0.238	822 0.243	307 0.219
24-35 months	995 0.221	10,125 0.240	15,252 0.246	9,419 0.249	4,191 0.241	1,885 0.246	839 0.248	376 0.269
12-23 months	862 0.192	10,418 0.247	16,946 0.273	9,687 0.257	4,748 0.273	2,100 0.275	827 0.245	381 0.272
Education Level of the Mother at Time of Interview								
Secondary or higher	30 0.007	1,518 0.036	9,263 0.149	11,213 0.297	7,607 0.438	3,979 0.520	1,836 0.544	705 0.504
Completed primary	957 0.213	13,415 0.318	22,837 0.368	12,459 0.330	4,961 0.285	1,899 0.248	781 0.231	336 0.241
No education or incomplete primary	3,509 0.780	27,300 0.646	29,991 0.483	14,085 0.373	4,816 0.277	1,770 0.231	760 0.225	357 0.256
Mother has a Partner								
Yes	4,101 0.912	38,606 0.914	57,623 0.928	35,469 0.939	16,378 0.942	7,208 0.942	3,181 0.942	1,291 0.923
No	395 0.088	3,627 0.086	4,468 0.072	2,288 0.061	1,006 0.058	440 0.058	196 0.058	108 0.077
Education Level of the Mother's Partner at the Time of Interview								
Completed Secondary or Higher	669 0.149	8,265 0.196	17,087 0.275	14,040 0.372	8,148 0.469	4,113 0.538	1,876 0.556	746 0.533
Completed primary	1,107 0.246	12,977 0.307	21,683 0.349	12,533 0.332	5,193 0.299	2,031 0.266	802 0.238	328 0.235
No education or incomplete primary	2,721 0.605	20,992 0.497	23,321 0.376	11,184 0.296	4,042 0.233	1,504 0.197	699 0.207	325 0.232
Age Band of the Mother's Partner at the Birth of the Mother's First Birth								
12-17	313 0.070	1,250 0.030	407 0.007	109 0.003	20 0.001	4 0.001	1 0.000	1 0.000
18-23	1,587 0.353	14,655 0.347	17,407 0.280	5,426 0.144	898 0.052	227 0.030	55 0.016	17 0.012
24-29	2,256 0.502	22,157 0.525	36,519 0.588	24,543 0.650	10,869 0.625	3,671 0.480	1,220 0.361	487 0.348
30-35	214 0.048	2,756 0.065	5,480 0.088	5,634 0.149	3,981 0.229	2,491 0.326	1,203 0.356	313 0.223
36-41	83 0.019	896 0.021	1,467 0.024	1,319 0.035	1,155 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	4,937 0.117	10,572 0.170	9,490 0.251	6,196 0.356	3,283 0.429	1,423 0.421	557 0.398
Rich	710 0.158	7,659 0.181	13,466 0.217	9,088 0.241	3,972 0.228	1,700 0.222	815 0.241	340 0.243
Middle	950 0.211	9,159 0.217	13,772 0.222	7,453 0.197	2,950 0.170	1,185 0.155	517 0.153	216 0.154
Poorer	1,194 0.265	10,329 0.245	12,770 0.206	6,330 0.168	2,354 0.135	838 0.110	350 0.103	160 0.114
Poorest	1,277 0.284	10,148 0.240	11,511 0.185	5,397 0.143	1,911 0.110	642 0.084	273 0.081	126 0.090

Residence of the Child's Household at the Time of Interview								
Urban	1,033 0.230	12,159 0.288	22,251 0.358	16,999 0.450	9,721 0.559	4,969 0.650	2,315 0.686	949 0.678
Rural	3,463 0.770	30,074 0.712	39,840 0.642	20,759 0.550	7,663 0.441	2,679 0.350	1,062 0.314	450 0.322
Water Piped to Child's House								
Piped to House	1,082 0.241	13,530 0.320	25,731 0.414	18,816 0.498	9,906 0.570	4,736 0.619	2,149 0.636	896 0.640
Water not piped to house	3,415 0.759	28,704 0.680	36,360 0.586	18,942 0.502	7,478 0.430	2,912 0.381	1,228 0.364	503 0.360
Flush Toilet at Child's House								
Flush Toilet at House	434 0.097	6,908 0.164	16,700 0.269	14,506 0.384	8,551 0.492	4,380 0.573	2,080 0.616	859 0.614
No Flush Toilet at House	4,062 0.903	35,325 0.836	45,390 0.731	23,251 0.616	8,832 0.508	3,269 0.427	1,297 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

Results: 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 27-29 (Table A3). The relative risk ratio declines as age increases between the ages of 12 and 26, and is lowest for 27-29 year olds (Table A3). The relative risk ratio then increases for women who have their first birth at 33-35 (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 the child survival is maximized 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 relative risk ratios of each age group (relative to 27-29 year olds who are the reference group) and 95% confidence intervals are plotted in **Figure 2**. Child health outcomes improve with increasingage 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 relative risk 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 age of 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 age of the mother and the year of birth. To explore this possibility, Table A4 is the same model as that in Table 4 but the sample is restricted surveys between 2000 and 2005. Comparison ofresults in Table A4 and Table4 shows that the effect of age of mother on child health is similar across the two samples. This comparison suggests that the effect of age on child health outcomes is changing over the study period.

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Table 4: Adjusted Relative Risk of Infant Mortality and Child Health Outcome by Age of Mother at First Birth

	Infant Mortality	Stunting	Underweight	Wasting	Diarrhoea	Moderate Anaemia
Age Band 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	1.507	1.351	1.027	1.365	1.315
	(1.478 - 1.962)	(1.416 - 1.603)	(1.236 - 1.477)	(0.870 - 1.211)	(1.216 - 1.533)	(1.131 - 1.528)
15-17	1.307	1.341	1.218	1.040	1.326	1.357
	(1.160 - 1.474)	(1.274 - 1.412)	(1.131 - 1.313)	(0.923 - 1.170)	(1.224 - 1.436)	(1.222 - 1.507)
18-20	1.083	1.272	1.122	1.007	1.244	1.327
	(0.963 - 1.219)	(1.210 - 1.338)	(1.043 - 1.207)	(0.899 - 1.129)	(1.151 - 1.343)	(1.200 - 1.468)
21-23	1.018	1.191	1.052	1.018	1.227	1.349
	(0.903 - 1.148)	(1.132 - 1.254)	(0.976 - 1.132)	(0.908 - 1.141)	(1.135 - 1.326)	(1.219 - 1.493)
24-26	1.079	1.087	0.989	1.004	1.108	1.239
	(0.948 - 1.228)	(1.028 - 1.148)	(0.912 - 1.071)	(0.889 - 1.135)	(1.019 - 1.203)	(1.114 - 1.378)
30-32	1.191	0.925	0.824	0.915	0.979	1.117
	(0.981 - 1.445)	(0.845 - 1.013)	(0.717 - 0.947)	(0.749 - 1.119)	(0.860 - 1.115)	(0.947 - 1.317)
33-35	1.340	1.025	0.872	0.976	0.831	1.079
	(1.041 - 1.725)	(0.908 - 1.156)	(0.715 - 1.062)	(0.733 - 1.299)	(0.687 - 1.006)	(0.854 - 1.362)
Sex of Child						
Male (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Female	0.787	0.900	0.915	0.854	0.927	0.956
	(0.759 - 0.815)	(0.888 - 0.913)	(0.895 - 0.935)	(0.821 - 0.889)	(0.903 - 0.951)	(0.927 - 0.985)
Type of Birth						
Singleton (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Twin	4.998	1.302	1.627	1.264	0.918	1.135
	(4.609 - 5.421)	(1.207 - 1.404)	(1.459 - 1.814)	(1.018 - 1.570)	(0.782 - 1.077)	(0.963 - 1.337)
Age of Child in Months						
48-59 months (Reference)		1.00	1.00	1.00	1.00	1.00
36-47 months		1.146	1.023	0.986	1.392	1.219
		(1.119 - 1.174)	(0.986 - 1.062)	(0.916 - 1.060)	(1.311 - 1.477)	(1.147 - 1.296)
24-35 months		1.246	1.123	1.145	2.446	1.609
		(1.217 - 1.275)	(1.083 - 1.164)	(1.066 - 1.229)	(2.316 - 2.582)	(1.513 - 1.711)
12-23 months		1.169	1.114	1.572	3.818	2.240
		(1.141 - 1.198)	(1.073 - 1.156)	(1.466 - 1.686)	(3.625 - 4.021)	(2.102 - 2.386)
Education 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	1.286	1.282	1.022	1.143	1.079
	(1.160 - 1.382)	(1.243 - 1.329)	(1.214 - 1.354)	(0.945 - 1.105)	(1.092 - 1.196)	(1.009 - 1.154)
No education or incomplete primary	1.626	1.482	1.586	1.243	1.192	1.159
	(1.480 - 1.786)	(1.429 - 1.536)	(1.495 - 1.681)	(1.141 - 1.355)	(1.131 - 1.256)	(1.075 - 1.248)
Mother has a Partner						
Yes (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
No	0.977	1.148	1.237	1.232	1.105	1.110
	(0.881 - 1.084)	(1.106 - 1.193)	(1.158 - 1.322)	(1.101 - 1.379)	(1.043 - 1.170)	(1.022 - 1.206)
Education 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	1.068	1.097	1.037	1.059	1.053
	(1.027 - 1.176)	(1.040 - 1.097)	(1.052 - 1.144)	(0.969 - 1.109)	(1.015 - 1.104)	(0.993 - 1.117)
No education or incomplete primary	1.232	1.131	1.233	1.151	1.068	1.098
	(1.147 - 1.324)	(1.099 - 1.163)	(1.180 - 1.288)	(1.070 - 1.238)	(1.019 - 1.120)	(1.029 - 1.172)
Age Band of the Mother's Partner at the Birth of the Mother's First Birth						
24-29 (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
12-17	1.410	1.148	1.125	1.008	1.049	1.090
	(1.237 - 1.606)	(1.081 - 1.219)	(1.017 - 1.245)	(0.801 - 1.269)	(0.932 - 1.181)	(0.937 - 1.269)
18-23	1.077	1.054	1.026	0.979	1.032	1.050
	(1.026 - 1.130)	(1.035 - 1.073)	(0.997 - 1.056)	(0.927 - 1.034)	(0.997 - 1.068)	(1.010 - 1.092)
30-35	0.942	0.964	0.953	0.941	0.958	0.997
	(0.884 - 1.005)	(0.939 - 0.990)	(0.918 - 0.990)	(0.882 - 1.004)	(0.915 - 1.002)	(0.949 - 1.046)
36-41	0.996	0.986	0.932	0.929	1.032	1.069
	(0.904 - 1.097)	(0.945 - 1.028)	(0.875 - 0.992)	(0.835 - 1.034)	(0.960 - 1.108)	(0.994 - 1.149)
42-59	1.046	1.036	1.030	0.977	1.101	0.962
	(0.932 - 1.173)	(0.983 - 1.093)	(0.954 - 1.111)	(0.855 - 1.118)	(1.004 - 1.207)	(0.874 - 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	1.182	1.272	1.110	1.171	1.157
	(1.063 - 1.219)	(1.148 - 1.216)	(1.216 - 1.331)	(1.032 - 1.194)	(1.117 - 1.227)	(1.093 - 1.224)
Middle	1.223	1.257	1.416	1.276	1.209	1.246
	(1.136 - 1.316)	(1.218 - 1.297)	(1.348 - 1.486)	(1.176 - 1.384)	(1.149 - 1.272)	(1.170 - 1.326)
Poorer	1.268	1.332	1.524	1.344	1.244	1.287
	(1.173 - 1.371)	(1.289 - 1.376)	(1.448 - 1.604)	(1.233 - 1.466)	(1.177 - 1.314)	(1.203 - 1.378)
Poorest	1.289	1.445	1.671	1.458	1.289	1.338
	(1.187 - 1.399)	(1.397 - 1.496)	(1.585 - 1.762)	(1.331 - 1.598)	(1.213 - 1.369)	(1.245 - 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	1.082	1.029	0.943	0.939	0.981
	(0.991 - 1.099)	(1.059 - 1.106)	(0.996 - 1.064)	(0.891 - 0.998)	(0.905 - 0.974)	(0.937 - 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	0.956	1.031	1.034	1.002	0.988
	(1.047 - 1.156)	(0.938 - 0.975)	(1.000 - 1.063)	(0.980 - 1.092)	(0.969 - 1.037)	(0.950 - 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	1.224	1.137	1.045	1.041	1.035
	(1.062 - 1.217)	(1.191 - 1.259)	(1.091 - 1.184)	(0.978 - 1.116)	(0.997 - 1.087)	(0.982 - 1.090)
Child Measles Vaccination						
Vaccinated (Reference)	1.00	1.00	1.00	1.00	1.00	1.00
Not vaccinated	1.108	1.070	1.164	1.195	1.072	1.109
	(1.038 - 1.183)	(1.042 - 1.100)	(1.120 - 1.209)	(1.113 - 1.284)	(1.020 - 1.127)	(1.051 - 1.170)
Observations	176,583	119,018	122,680	120,246	135,121	31,520

The effect of young age of mother at first birth on poor child health outcomesreflects 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 socio-economic status. That is, if all women are of the same socio-economic status, then any age gradient reflects the biological mechanism. This hypothesis is explored by stratifying low and high socio-economic status.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). Incontrast 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 socio-economic status 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 in low SES households than in the high SES households (Table 5). However, when considering the relative risk ratios across the age groups for outcomes of stunting, underweight and diarrhoea, the relative risk 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 relative risk of age on these child health outcomes across the two groups indicates that early childbearing is not just a risk factorin lower socio-economic groups, and that the biological mechanism of young mothers plays a role in determining child health outcomes.

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Table 5: Adjusted Relative Risk Ratios in High SES and Low SES Households

	Infant Mortality		Stunting		Underweight		Wasting		Diarrhea		Moderate Anemia	
	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 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	1.747	1.899	1.244	1.750	1.167	0.875	1.062	1.792	1.342	0.388	1.438
	(1.015 - 3.040)	(1.338 - 2.283)	(1.473 - 2.449)	(1.118 - 1.385)	(1.169 - 2.619)	(1.004 - 1.355)	(0.358 - 2.140)	(0.776 - 1.452)	(1.229 - 2.612)	(1.057 - 1.702)	(0.108 - 1.400)	(1.047 - 1.974)
15-17	1.297	1.315	1.474	1.143	1.377	1.066	1.234	0.968	1.377	1.181	1.234	1.504
	(0.984 - 1.710)	(1.029 - 1.681)	(1.313 - 1.655)	(1.040 - 1.257)	(1.147 - 1.654)	(0.935 - 1.215)	(0.950 - 1.602)	(0.744 - 1.258)	(1.172 - 1.618)	(0.964 - 1.446)	(1.001 - 1.521)	(1.144 - 1.978)
18-20	1.087	1.104	1.308	1.085	1.260	0.984	1.181	0.964	1.395	1.107	1.154	1.433
	(0.846 - 1.398)	(0.865 - 1.409)	(1.179 - 1.452)	(0.987 - 1.192)	(1.071 - 1.482)	(0.863 - 1.121)	(0.951 - 1.467)	(0.743 - 1.250)	(1.214 - 1.603)	(0.905 - 1.354)	(0.964 - 1.381)	(1.092 - 1.880)
21-23	1.020	1.016	1.221	1.065	1.156	0.948	1.198	0.990	1.318	1.126	1.203	1.500
	(0.800 - 1.300)	(0.790 - 1.307)	(1.102 - 1.352)	(0.968 - 1.171)	(0.985 - 1.357)	(0.830 - 1.084)	(0.976 - 1.472)	(0.759 - 1.292)	(1.152 - 1.508)	(0.917 - 1.382)	(1.008 - 1.437)	(1.141 - 1.972)
24-26	1.015	1.116	1.083	0.989	1.028	0.941	1.207	1.076	1.206	1.139	1.105	1.424
	(0.783 - 1.315)	(0.848 - 1.470)	(0.972 - 1.208)	(0.890 - 1.100)	(0.871 - 1.215)	(0.811 - 1.091)	(0.979 - 1.489)	(0.811 - 1.428)	(1.048 - 1.388)	(0.911 - 1.425)	(0.925 - 1.320)	(1.066 - 1.901)
30-32	1.647	0.710	0.918	0.911	0.875	0.827	0.971	0.832	0.940	1.111	1.151	1.270
	(1.183 - 2.291)	(0.414 - 1.216)	(0.771 - 1.093)	(0.760 - 1.093)	(0.666 - 1.150)	(0.624 - 1.097)	(0.697 - 1.351)	(0.488 - 1.418)	(0.757 - 1.167)	(0.777 - 1.590)	(0.886 - 1.496)	(0.820 - 1.966)
33-35	1.407	0.956	1.049	1.222	0.743	0.860	1.128	0.650	0.769	0.821	1.036	1.438
	(0.846 - 2.341)	(0.525 - 1.740)	(0.822 - 1.338)	(1.013 - 1.473)	(0.471 - 1.170)	(0.594 - 1.245)	(0.713 - 1.785)	(0.287 - 1.473)	(0.555 - 1.065)	(0.488 - 1.379)	(0.686 - 1.565)	(0.826 - 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	0.829	0.850	0.929	0.911	0.921	0.886	0.843	0.913	0.959	0.942	0.963
	(0.627 - 0.782)	(0.781 - 0.881)	(0.814 - 0.888)	(0.908 - 0.951)	(0.850 - 0.977)	(0.890 - 0.954)	(0.802 - 0.979)	(0.786 - 0.905)	(0.859 - 0.969)	(0.910 - 1.011)	(0.868 - 1.021)	(0.910 - 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	4.557	1.212	1.271	1.704	1.448	1.365	1.392	0.768	1.015	1.061	1.183
	(4.278 - 6.916)	(3.932 - 5.281)	(0.991 - 1.482)	(1.111 - 1.454)	(1.290 - 2.251)	(1.179 - 1.778)	(0.898 - 2.074)	(0.917 - 2.112)	(0.533 - 1.106)	(0.716 - 1.437)	(0.733 - 1.534)	(0.860 - 1.627)
Age of Child in Months												
Age 48-59 months (reference)			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
36-47 months			1.239	1.118	1.037	1.037	0.877	0.994	1.410	1.453	1.258	1.219
			(1.145 - 1.341)	(1.076 - 1.162)	(0.919 - 1.170)	(0.976 - 1.102)	(0.741 - 1.039)	(0.868 - 1.138)	(1.229 - 1.617)	(1.289 - 1.638)	(1.064 - 1.487)	(1.095 - 1.357)

24-35 months			1.415	1.172	1.182	1.142	0.956	1.236	2.466	2.507	1.763	1.469
			(1.310 - 1.528)	(1.129 - 1.216)	(1.049 - 1.331)	(1.077 - 1.211)	(0.806 - 1.133)	(1.086 - 1.408)	(2.174 - 2.796)	(2.246 - 2.799)	(1.493 - 2.081)	(1.319 - 1.637)
12-23 months			1.392	1.081	1.107	1.151	1.156	1.853	3.891	3.720	2.585	1.927
			(1.287 - 1.506)	(1.040 - 1.124)	(0.977 - 1.254)	(1.084 - 1.222)	(0.974 - 1.371)	(1.632 - 2.104)	(3.449 - 4.389)	(3.347 - 4.135)	(2.163 - 3.090)	(1.727 - 2.149)
Education 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		1.266		1.208		1.103		1.177		1.099	
	(1.049 - 1.420)		(1.191 - 1.346)		(1.101 - 1.325)		(0.969 - 1.255)		(1.085 - 1.277)		(0.987 - 1.223)	
Mother has a Partner												
Omitted Category: Yes												
No	1.012	0.960	1.215	1.038	1.333	1.180	1.249	1.608	1.038	1.223	1.100	1.063
	(0.811 - 1.263)	(0.739 - 1.246)	(1.108 - 1.332)	(0.949 - 1.135)	(1.127 - 1.577)	(1.012 - 1.377)	(0.985 - 1.583)	(1.179 - 2.193)	(0.926 - 1.163)	(1.030 - 1.451)	(0.930 - 1.301)	(0.814 - 1.388)
Education 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	1.100	1.115	0.997	1.137	1.056	0.910	1.266	1.071	0.989	1.087	0.987
	(0.911 - 1.201)	(0.902 - 1.341)	(1.052 - 1.182)	(0.926 - 1.074)	(1.041 - 1.242)	(0.940 - 1.187)	(0.807 - 1.027)	(0.994 - 1.613)	(0.989 - 1.159)	(0.852 - 1.148)	(0.979 - 1.208)	(0.782 - 1.246)
No education or incomplete primary	1.303	1.277	1.206	1.039	1.381	1.224	1.180	1.452	1.209	1.002	1.221	0.974
	(1.059 - 1.602)	(1.059 - 1.540)	(1.109 - 1.312)	(0.968 - 1.116)	(1.218 - 1.566)	(1.094 - 1.370)	(0.981 - 1.420)	(1.149 - 1.834)	(1.069 - 1.368)	(0.869 - 1.156)	(1.043 - 1.428)	(0.777 - 1.222)
Age Band of the Mother's Partner at the Birth of 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
12-17	1.284	1.528	1.010	1.087	1.106	1.085	0.551	0.959	1.206	1.091	1.124	1.005
	(0.668 - 2.470)	(1.261 - 1.851)	(0.697 - 1.466)	(0.996 - 1.186)	(0.627 - 1.952)	(0.937 - 1.256)	(0.141 - 2.147)	(0.672 - 1.368)	(0.847 - 1.715)	(0.883 - 1.349)	(0.664 - 1.901)	(0.785 - 1.285)
18-23	1.122	1.090	1.141	1.036	1.072	1.015	1.028	0.977	0.967	1.076	1.069	1.061
	(0.948 - 1.327)	(1.008 - 1.178)	(1.070 - 1.217)	(1.006 - 1.068)	(0.970 - 1.186)	(0.970 - 1.063)	(0.872 - 1.211)	(0.889 - 1.073)	(0.881 - 1.061)	(1.006 - 1.149)	(0.954 - 1.198)	(0.989 - 1.138)
30-35	0.907	0.970	0.937	0.964	0.917	0.960	1.012	0.878	0.911	0.990	0.892	1.122
	(0.770 - 1.069)	(0.863 - 1.090)	(0.875 - 1.004)	(0.919 - 1.012)	(0.825 - 1.019)	(0.898 - 1.026)	(0.880 - 1.163)	(0.767 - 1.004)	(0.831 - 1.000)	(0.895 - 1.094)	(0.795 - 1.000)	(1.027 - 1.226)
36-41	0.784	0.950	0.962	1.030	0.760	0.970	1.070	0.851	0.994	0.993	0.876	1.180
	(0.587 - 1.048)	(0.797 - 1.132)	(0.852 - 1.086)	(0.963 - 1.101)	(0.614 - 0.940)	(0.880 - 1.069)	(0.842 - 1.360)	(0.701 - 1.034)	(0.851 - 1.160)	(0.855 - 1.152)	(0.715 - 1.074)	(1.044 - 1.334)
42-59	0.698	1.100	1.106	1.054	1.119	0.960	1.388	0.885	0.949	1.078	0.910	1.012
	(0.413 - 1.178)	(0.912 - 1.327)	(0.907 - 1.349)	(0.973 - 1.141)	(0.807 - 1.550)	(0.854 - 1.079)	(0.940 - 2.052)	(0.711 - 1.103)	(0.731 - 1.233)	(0.909 - 1.280)	(0.656 - 1.263)	(0.869 - 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		1.223		1.288		1.045		1.143		1.121	
	(1.111 - 1.445)		(1.161 - 1.290)		(1.187 - 1.398)		(0.926 - 1.180)		(1.065 - 1.226)		(1.023 - 1.228)	
Middle												
Poorer		0.996		0.936		0.923		0.937		0.957		0.977
		(0.938 - 1.057)		(0.913 - 0.959)		(0.891 - 0.956)		(0.870 - 1.008)		(0.905 - 1.012)		(0.922 - 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	1.138	0.936	0.964	1.001	1.066	0.991	1.163	0.966	1.065	0.976	1.028
	(0.924 - 1.229)	(1.017 - 1.273)	(0.883 - 0.993)	(0.925 - 1.004)	(0.919 - 1.089)	(0.995 - 1.142)	(0.874 - 1.123)	(1.015 - 1.333)	(0.884 - 1.055)	(0.979 - 1.159)	(0.886 - 1.076)	(0.933 - 1.133)
Flush Toilet at Child's House												
Flush toilet at house (reference)												
No flush toilet at house	0.948	1.369	1.158	1.173	1.082	1.239	1.011	0.996	1.088	1.057	0.984	0.982
	(0.818 - 1.098)	(1.075 - 1.745)	(1.089 - 1.232)	(1.064 - 1.294)	(0.988 - 1.185)	(1.037 - 1.481)	(0.879 - 1.164)	(0.753 - 1.318)	(0.994 - 1.191)	(0.889 - 1.257)	(0.872 - 1.110)	(0.797 - 1.209)
Child Measles Vaccination												
Not vaccinated	1.653	1.000	1.190	1.066	1.211	1.200	1.229	1.185	1.045	1.030	1.299	1.127
	(1.309 - 2.088)	(0.905 - 1.106)	(1.072 - 1.320)	(1.022 - 1.111)	(1.037 - 1.414)	(1.130 - 1.275)	(0.969 - 1.559)	(1.050 - 1.337)	(0.907 - 1.204)	(0.940 - 1.129)	(1.101 - 1.531)	(1.035 - 1.228)
Observations	40,299	38,612	28,797	23,657	29,345	24,846	28,783	24,251	32,809	27,435	8,027	6,026

Note: 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.

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Results: Sensitivity Analysis

Recent work by Subramanian *et al*[2] and Ozaltin*et al*[34] 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 Demographic and Health Surveys 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 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 (Table A5). Controlling for height, which is an additional biological covariate, and religion, which is an additional social covariate, the general relationship between the age of mother at first birth and child health outcomes persists (Table A5).

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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 mother at first birth rises up to ages 27-29. This is a much higher age than has been previously reported, where teen pregnancy is emphasized as a risk factor. In the adjusted model, we show that there is an elevated risk in infant mortality in first borns to mother's below ages 27-29, though 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 mothers below ages 27-29 have elevated and statistically significant risks for stunting, diarrhoea, and anaemia outcomes.

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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 United States has seen a steady rise in the average age at first birth from 21 in 1970 to 25 in 2000.[38] Age at first birth is increasing in some of our sample countries, but is still lagging behind the level seen in United States. For example, in the 1993 Bangladesh DHS the mean age for first births in the last five years was 18.2, but in 2007 had risen to 18.5. In

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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.[39] The results in this paper indicate that there are benefits to reducing infant mortality and improving child health by delaying the age at first birth even for women in their early twenties.

Taken together, 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 presents 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 minimized. Moreover, We find evidence of a paternal age gradient, although it is weaker than the maternal age gradient. This indicates that social mechanisms play a role in part, but the biological maturity of the mother also plays a role in determining child health outcomes. This finding was also supported by the stratification by low and high socio-economic status, where we found that the age gradient was not solely reflecting socio-economic 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 twenties has a positive impact on child survival. While from the 2005-6 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 young 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 can stem from the inclusion of a greater number of countries, and also from a wider time horizon. As the 2005-6 India National Family Health Survey-3 is one of the 118 surveys within our current study, the comparison between our study and the Raj *et al*[13] study highlights that generalizing across countries does not always reflect each country's experience. Thus we include the country specific examples in the appendix (Table A3). Even so, for the case of India in our sample we include three National Family Health Surveys (1992, 1998, 2005-6). Thus, even the country

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specific results maydiffer 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 that of Subramanian *et al.* [40]which teases out the biological from the socio-economic predictors of child health outcomes.If being a young mother is associated with low socio-economic status in ways we have not controlled for, maternal age at first birth may simply be a proxy for socio-economic status. However if this were true, we would expect the effect of young fathers to be similar to that of mothers (Subramanian *et al.* [40] 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 tothe benefits of delaying first birth to age 27-29to child health, there are certain limitations that should be considered when interpreting the results. The primary variable of interest, age of 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 a 0-11 and 12-60 month age range. 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 their 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 World Health Organization guidelines and include the 60 month olds 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 minimized for this group of interest.

A further limitation of the model is that the socio-economic measures of male and female education, along with the wealth index, may not fully capture the socio-economic status 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.

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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 age of 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, andsecular 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 suffer from 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 mother is differentially (or similarly) related to various outcomes. However,an investigation of the vulnerability of 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 Demographic and Health Surveys.

Conclusions and implications

The current study documents that the first born child of a woman aged less than 27-29 in low- to middle-income countries, is at a higher risk of infant mortality, stunting, underweight, diarrhoea, and moderate to severeanaemia, but notwasting. 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 minimized. The risk of underweight decreases significantly as a woman delays her first birth and is minimized by age 21. These results offer support to the evidence of the benefits of delaying first birthto 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

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potentially omit a group of women in their early twenties who are also at risk of having children with poor health outcomes. Development of programs targeting women in general, and not just targeting teen mothers, should provide women and families with tools to make informed decisions over the timing of their first birth and the benefits of delaying the birth. Highlighting the benefits of delaying first birth to the child's health, not only allowing women to mature biologically, but also to provide a mechanism for young female family members improve knowledge and skills in childcare, family planning and empower female autonomy in decision-making within the household.

Our results indicated that while the absolute risk of poor child health outcomes is lower when the mother is in a high socio-economics household, there remains a high relative risk of poor child health outcomes for young mothers even in high socio-economics households. The persistence of the age gradient across the SES groups highlights that child and maternal health issues associated with age of the mother cut across socio-economiclines and the children of young-rich women are not shielded from the relative risk 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.

Encouraging women to delay their first birth, and encouraging families to permit the delay when the woman is not granted autonomy over her reproductive health decisions, come through providing women with viable and valuable alternatives. Education programs aimed atencouraging women to stay in school, take on meaningful employment opportunities, and provide service to the community, relieves the immediacy of the need or desire for child bearing. It also provides empowerment to women in illustrating to herself and her family that her contribution to society need not only be defined by her reproductive life. By delaying a few years and engaging in other activities she contributes to society as well as broadening her skills and knowledge to go on to be a more informed and more highly educated mother. These benefits to the women, then trickle through the generations and benefit her offspring. In this paper, we show that those benefits are in terms of health, but future studies may highlight the educational and social benefits for a child if a woman delays her first birth.

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References

1. United Nations. We Can End Poverty 2015: Millennium Development Goals, 2011.
2. Subramanian SV, Ackerson LK, Davey Smith G, John NA. Association of Maternal Height With Child Mortality, Anthropometric Failure, and Anemia in India. *JAMA* 2009;301(16):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(15):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 D.C.: Center for Global Development, 2009.
5. Kembo J, Van Ginneken JK. Determinants of Infant and Child Mortality in Zimbabwe: Results of Multivariate Hazard Analysis. *Demographic Research* 2009;21(13):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. *American Journal of Public Health* 1984;74(10):1098-106.
7. Manda SOM. Birth intervals, breastfeeding and determinants of childhood mortality in Malawi. *Social Science & Medicine* 1999;48(3):301-12.
8. Reynolds HW, Wong EL, Tucker H. Adolescents' Use of Maternal and Child Health Services In Developing Countries. *International Family Planning Perspectives* 2006;32(1):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. *American Journal of Obstetrics and Gynecology* 1982;143(7):793-98.
10. Vitolo MR, Gama CM, Bortolini GA, Campagnolo PD, Drachler ML. Some risk factors associated with overweight, stunting and wasting among children under 5 years old. *J Pediatr (Rio J)* 2008;84(3):251-57.
11. Wang SC, Lee SH, Lee MC, Wang L. The effects of age and aboriginality on the incidence of low birth weight in mountain townships of Taiwan. *Journal of Public Health* 2009;31(3):406-12.
12. Hobcraft J. Fertility patterns and child survival: a comparative analysis. *Population Bullitin of the United Nations* 1992;33:1-31.
13. Raj A, Saggurti N, Winter M, Labonte A, Decker MR, Balaiah D, 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. *Br Med J (Clin Res Ed)* 2010;340.
14. Trussell J, Hammerslough C. A hazards-model analysis of the covariates of infant and child mortality in Sri Lanka. *Demography* 1983;20(1):1-26.
15. ICF Macro. DHS Final Reports. In: DHS M, editor. Calverton, 2011.
16. Cooper LG, Leeland NL, Alexander G. Effect of maternal age on birth outcomes among young adolescents. *Social Biology* 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(17):1113-18.
18. Geronimus AT. On Teenage Childbearing and Neonatal Mortality in the United States. *Population and Development Review* 1987;13(2):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. *Population and Development Review* 1994;20(3):585-609.
20. Horon IL, Strobino DM, MacDonald HM. Birth weights among infants born to adolescent and young adult women. *American Journal of Obstetrics and Gynecology* 1983;146:444-9.
21. Trussell J. Teenage pregnancy in the United States. *Family Planning Perspectives* 1988;20:262-72.
22. Ventura SJ, Mathews TJ, Hamilton BE. Births to teenagers in the United States, 1940-2000. *National Vital Statistics Report* 2001;49(10).
23. Alam N. Teenage motherhood and infant mortality in Bangladesh: Maternal age-dependent effect of parity one. *Journal of biosocial science* 2000;32(2):229-36.

24. DHS. Demographic and Health Surveys. Calverton, MD: MEASURE DHS, 2009.
25. Rutstein SO, Rojas G. Guide to DHS Statistics. Calverton, Maryland: ORC Macro, MEASURE DHS+, 2003.
26. Wirth ME, Wirth E, Delamonica E, Sacks D, Balk A, Minujin A. 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, editor. *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, Maryland, USA: Macro International Inc, 2008.
29. ICF Macro. Demographic and Health Survey Interviewer's Manual. In: Macro International, editor. Calverton, Maryland, U.S.A.: ICF Macro, 2006.
30. ICF Macro. Description of the Demographic and Health Surveys Individual Recode Data File. In: Measure DHS, editor, 2008.
31. Demographic and Health Survey. Sampling Manual. DHS-III. Calverton, Maryland: Macro International, 1996.
32. ICF Macro. Measure DHS Biomarkers Inventory. In: DHS M, editor, 2011.
33. Borghi E, de Onis M, Garza C, Van den Broeck J, Frongillo E, Grummer-Strawn L, et al. Construction of the World Health Organization child growth standards: selection of methods for attained growth curves. *Statistics in Medicine* 2006;25(2):247-65.
34. 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(15):1507-16.
35. Filmer D, Pritchett LH. Estimating wealth effects without expenditure data--or tears: an application to educational enrollments in states of India. *Demography* 2001;38(1):115-32.
36. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol* 2004;159(7):702-06.
37. Deaton A. *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*. Baltimore: World Bank, 1997.
38. Mathews TJ, Hamilton BE. Mean age of mother, 1970-2000. *National Vital Statistics Report* 2002;51(1).
39. Bongaarts J. Does Family Planning Reduce Infant Mortality Rates? *Population and Development Review* 1987;13(2):323-34.
40. Subramanian SV, Ackerson LK, Smith GD. Parental BMI and Childhood Undernutrition in India: An Assessment of Intrauterine Influence. *Pediatrics* 2010;126(3):663-71.

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Competing Interests: None declared

Ethical Review

The DHS data collection procedures were approved by the ICF Macro International (Calverton, Maryland) 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 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.

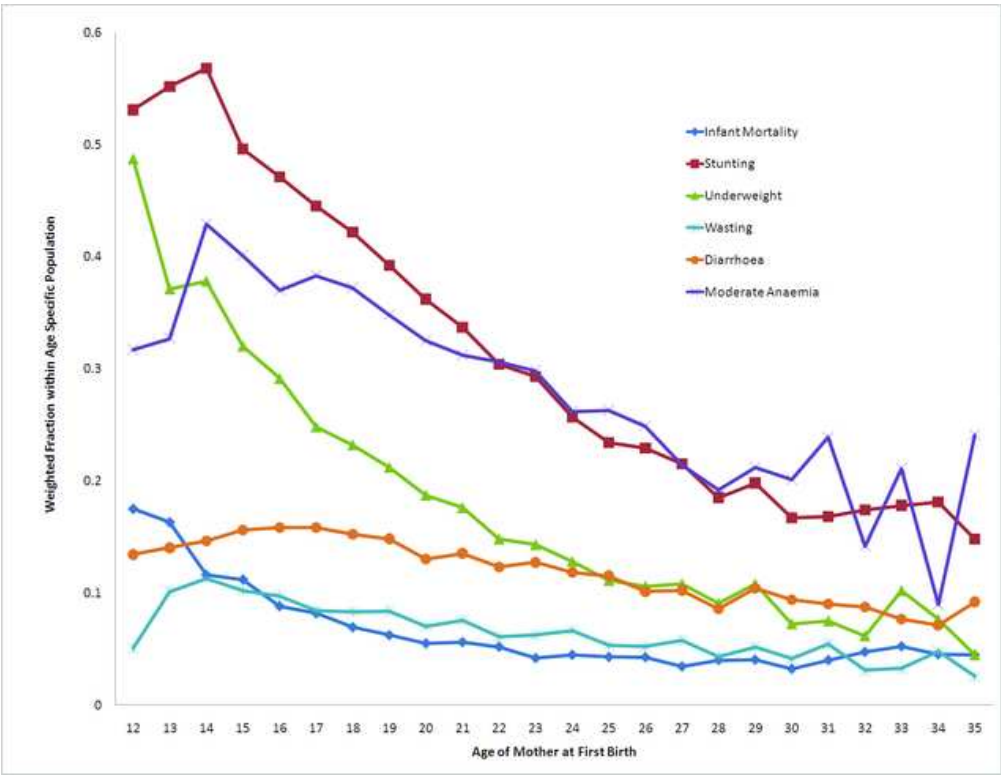

Figure 1: Child Health Indicator Weighted Prevalence by Age of Mother at First Birth
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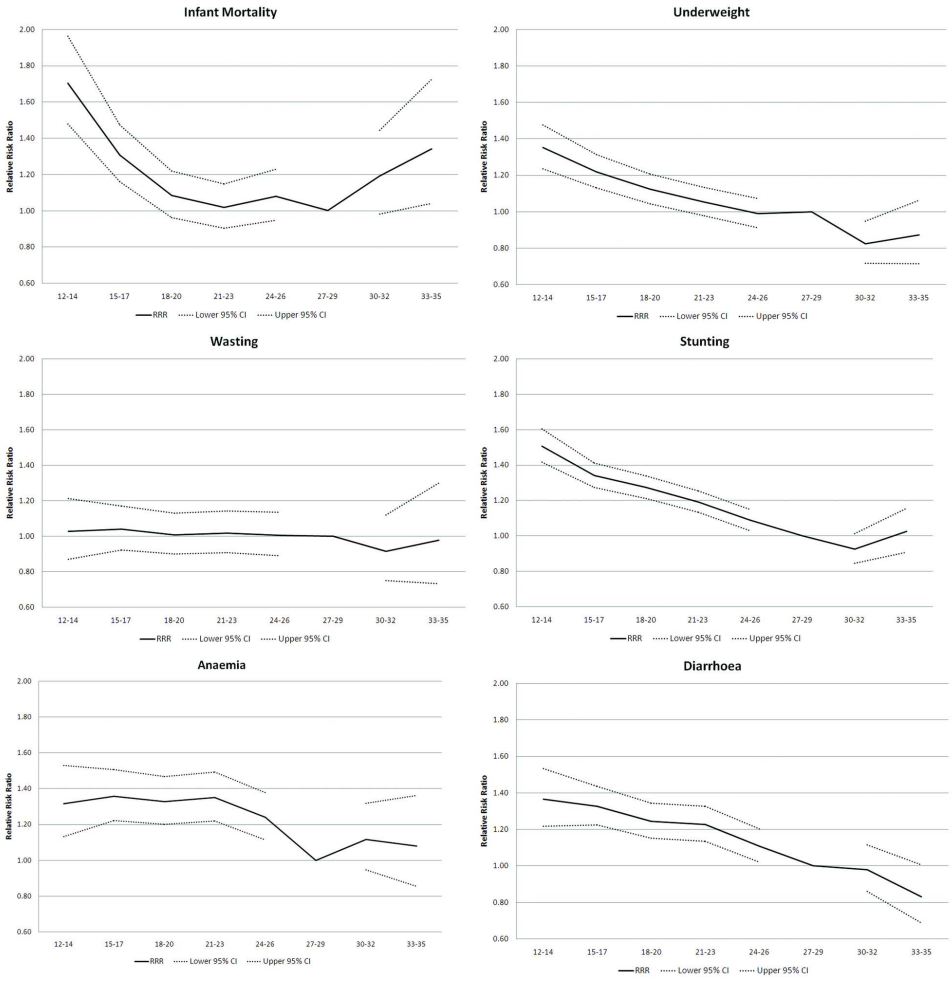

Figure 2: Plot of Adjusted Relative Risk Ratios and 95% Confidence Intervals as per the results tabulated in Table 4
174x176mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

All items below are included in the study entitled: Association of Maternal Age with Infant Mortality, Child Anthropometric Failure, Diarrhoea, and Anaemia for First Births in Low- and Middle-Income Countries

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized

		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.