Maternal Education Reduces Sex-Differentials in Under-Five Mortality in Southern Asia and Sub-Saharan Africa

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Abstract

Background: The sex-differential in infant and child mortality varies considerably across and within societies. Maternal education has been linked to lower sex-differentials, but the evidence is mixed. We assessed the role of maternal education for the sex-differential at both individual and context level for two of the highest mortality regions of the world.

Methods: We analyse recent Demographic and Health Surveys from 31 Sub-Saharan African and 4 Southern Asia countries. We observe almost 50,000 deaths before age 5 in over half a million children. We assess the variation in Male:Female mortality ratios by education of the mother and the average female educational level of the context in which the children live while controlling for household characteristics.

Findings: In Southern Asia girls are more likely to die than boys, whereas in Africa mortality among boys is higher. Both regions show a clear pattern of gender bias by maternal education. In Sub-Saharan Africa, the M:F ratio for under-five mortality is 1·07 (95%CI 1·03-1·10) among non-educated women, 1·11 (1·07-1·16) among women with some primary education and 1·21 (1·14-1·29) among women with some secondary or more education. For Southern Asia the ratio are 0·84 (0·79-0·89), 1·03 (0·92-1·15) and 1·06 (0·96-1·17) respectively. The M:F ratio for child mortality is significantly more biased against girls among non-educated mothers. Context level female education is not associated with the sex-differential.

Interpretation: Even in regions with excess male mortality, mortality chances are positively biased in favour of boys. This gender bias is overt in Southern Asia and more hidden in Sub-Saharan Africa. It is most clearly visible among children with an uneducated mother. In absolute and relative terms girls are significantly better off when their mother has some education.

Introduction

In most populations, girls are more likely to survive the first years of life than boys. Especially in the first months of life, this sex-differential in mortality is pronounced[1-3]. The advantage of girls is thought to be driven by biological and epidemiological factors as well as social factors and medical technology[1, 3]. Whereas in most countries there is excess mortality of boys in young children, there are some regions where girls' mortality rate is higher than that of boys [4-6].

A major cause of this excess female mortality can be found in external circumstances, which, in some regions, are so detrimental to girls that their biological advantage is completely overridden and mortality among girls is higher than among boys.
Most studies on the sex-differential in infant and child mortality have focused on regions where excess female mortality suggest such a strong gender bias: India, Pakistan and Bangladesh in particular [5-10]. Relatively little attention has been paid to regions where a pattern of male excess mortality is observed. It is often assumed that in these regions no gender bias exists. For instance, Sen in his famous work[11] on missing women assumes that sex-ratios in Sub-Saharan Africa are not affected by a gender bias and therefore uses them in his comparison to Southern Asia. However, it is very well possible that also in regions with male excess mortality gender biases exist that lead to disadvantages for girls, because the 'natural' gender-neutral ratio is actually substantially higher than 1.[1-3, 12]

Data from the Human Mortality Database show that the M:F ratio in Western Europe was in the range of 1·15 to 1·30 for infant mortality (q_0^M/q_0^F) at the time that under-five mortality was at a similar level as currently in the poorest parts of our world (5·0-12·5%).[1] Hence, in countries where the M:F rate is below this level, there is suspicion of gender discrimination.

In this study, we compare the sex-differential in the two regions of the world with highest levels of under-five mortality: Southern Asia and sub-Saharan Africa. We examine to what extent the sex-differential in these regions approaches the 'gender neutral' range (defined in this case as approximately 1·15-1·30), and we study to what extent the sex-differential varies by maternal education and by the average educational level of women in the community.

The focus on maternal education is important, because it is known to be the most powerful social determinant of overall infant and child mortality.[13-19] Maternal education has been associated with lower sex-differentials, because it may indicate increased health knowledge in mothers, more power vis-à-vis males in the household, and more equal gender values.[4, 15, 20] Female education at the community level may influence the sex-differential independent of the individual mother's education, because it is an indicator of the position of women in general. This position of women in society ultimately translates to the power of a woman vis-à-vis her husband and other males in the household and local community. As a better economic position of women at the context level increases the returns to investments in girls, mothers are expected to invest more in their daughters if they live in a community with more educated females.

The empirical evidence regarding effects of mother's education is not clear. The most elaborate study to date examined mortality of children 6-60 months old in 27 countries separately. It was based on the first round of Demographic and Health Survey (DHS) program from the 1980s and 1990s.[15] Given the relatively low numbers of cases in the initial rounds of DHS, the study differentiated only between two levels of education (none or any). The usual positive association between maternal education and child survival was found, but there was no evidence for lower sex-differentials among mothers with education compared to mothers without education. A study in Matlab, Pakistan[7], found no support for an effect of maternal education on the sex-differential in mortality and neither did a study of a small sample born in Central Java. [21] At least three other studies, on the other hand, did suggest that education at the household level decreases the sex-differential.[8, 9, 22] Regarding female education at the community level, there are indications that this factor indeed influences child mortality independent of the mother's educational level.[18] Whether it also affects the sex-differential in child mortality is still unknown.

This study aims to extend our understanding of the role of female education in determining sex-differentials in child mortality in three ways. First, it updates and substantially extends empirical evidence by analysing the interaction between child's sex and female education in Southern Asia and Sub-Saharan Africa using a newly constructed database with recent information on over 500,000 children born in 35 countries. Second, we explicitly include regions where there is excess male mortality, because, even where boys are more likely to die than girls, there could still be a substantial gender bias to the disadvantage of girls. Third, we examine the effect of female education at two levels, the individual mother level and the community level, in order to gain insight into the independent effect of female education at each level on the sex-differential in child mortality.

Methods

Data

The data are derived from the Demographic and Health Surveys (DHS). We use recent surveys for 31 Sub-Saharan African countries (Benin, Burkina Faso, Cameroon, Chad, Congo Brazzaville, Congo DR, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Kenya, Liberia, Lesotho, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe) and 4 Southern Asian countries (Bangladesh, India, Nepal, and Pakistan). The DHS are cluster surveys. This means that first a number of small areas (called clusters) within the countries are selected, typically consisting of one or a few villages or neighbourhoods. Next within each clusters about 30 households are randomly selected to be interviewed. Response rates are generally very high, in the order of 90 to 99 percent.

We include explanatory variables at the household, cluster, subnational regional (henceforth called 'district') and national level. Within Southern Asia, 49 districts and 440 clusters can be distinguished; within Sub-Saharan Africa these numbers are 339 and 1,767 respectively. The Southern Asian subsample contains information on 144,997 children born in the five years before the survey, of which 9,691 had died by the time of interview. In the Sub-Saharan African subsample, these numbers were 376,544 births and 39,935 deaths respectively.

The following information on the child is included: sex, age, birth order, whether it was delivered at home or in a hospital, and twin status. For the mother we include educational level, age at birth, age at birth^2 and household wealth at the time of the interview. Maternal education was measured in three levels: no education, incomplete or complete primary education and more than primary education. Household wealth was measured by an index constructed on the basis of household assets (such as TVs, cars, phones), the possession of land, and housing characteristics (such as floor material, roofing, toilet facilities, source of drinking water). Using a method developed by Filmer & Pritchett[23], all households within a country are ranked on the basis of the available characteristics and divided into wealth index deciles.

Community level female education was measured by average number of years of schooling among all women aged 30-45 in the cluster of households that the children's mother lived at the time of interview. As indicator of the level of health care facilities at the district level we use the percentage of children who received a polio vaccination in the last 5 years. GDP per capita at the national level[24] is also taken into account.

Statistical techniques

We employ multilevel logistic regression models to take into account the nested structure of the data. We differentiate four levels: mothers and children – level 1; cluster level (about 30 households) – level 2; district level – level 3; and country level – level 4. Random intercepts at all levels are modelled. When interacting child's sex with cluster level education we add random slopes for the child's sex to the model at the cluster level. Case weights provided by DHS are applied. Models are estimated in MlwiN 2.23.[25] Note that with the large number of cases and low incidence rates the odds ratios from the logistic model start to converge to rate ratios. Because different causes of death prevail at different ages and there are sex differences in susceptibility, we separately analyse (1) total mortality (0-60 months), (2) neonatal mortality (in the first month), (3) infant mortality (1-12 months), and (4) child mortality (13-60 months).

Results

Tables 1 and 2 present descriptive statistics for infant and child mortality in Sub-Saharan Africa and Southern Asia respectively. Sub-Saharan Africa has the highest under-five mortality rates in the world. Mortality among boys (11·2%) is clearly higher than among girls (10·0%). In Southern Asia, the overall under-five mortality is substantially lower than in Sub-Saharan Africa (6·7%) but here boys and girls have an almost similar mortality rate.

Mortality rates in the first month after birth are clearly higher among boys. In Southern Asia boys have a 17% higher odds of neonatal mortality than girls and in Sub-Saharan Africa boys even have a 33% higher odds. After the first month, boys in Africa still have a somewhat higher odds of dying than girls, whereas in Southern Asia boys do clearly better than girls. For Southern Asian boys, the odds of experiencing infant mortality (dying in months 2-12) is 14% lower than for Southern Asian girls. The odds of experiencing child mortality (dying in months 13-60) is even 35% lower for Southern Asian boys compared to Southern Asian girls. In one respect, however, the pattern is similar in Southern Asia and Sub-Saharan Africa: in both contexts the M:F ratio is highest for neonatal mortality and lower for infant and child mortality.

For household wealth and mother's education, findings are as expected. Although the mortality rates and the male-female ratio's differ between Sub-Saharan Africa and Southern Asia, we observe in both settings that mortality decreases as wealth and maternal education increase. In a bivariate analysis, household wealth shows the same pattern as maternal education. If education and wealth are analyzed simultaneously, however, the effect of wealth is no longer significant, suggesting that maternal education trumps wealth and that the initial wealth effect actually runs through maternal education (see similar findings in Caldwell's seminal study[26] and, more recently, Fuchs et al[27]).

In both contexts, mortality is higher among children of the youngest (15-19) and oldest (40-49) mothers. However, in Africa the M:F ratio under these circumstances is favourable for girls, whereas in Southern Asia this is only the case for children of young mothers. Among children of the oldest women in Southern Asia, mortality among boys is somewhat lower than among girls.

The M:F ratio decreases with the birth order. This is particularly the case in Southern Asia where is decreases from 1·17 among first children to 0·85 among fourth and later children. Mortality among girls is substantially increased when they are the fourth or later child. The M:F ratio also decreases when there is a living male sibling. This suggests that competition with male siblings is negative for girls[7]. Finally, we observe a strong increase in mortality among twins.

Table 3 shows the M:F ratio for total under-five mortality, neonatal mortality, infant mortality and child mortality by maternal education for both continents. The models presented control for various household characteristics as well as the average level of female education in the social context and development indicators at the regional level. For total under-five mortality, infant mortality, and child mortality the patterns in both contexts are clear: as mother's educational level increases so does the M:F ratio, and among the highest educated group it comes closer to the gender-neutral range of 1·15-1·30. Figure 1 shows this pattern for total under-five mortality. In Sub-Saharan Africa, the main difference seems to lie between mothers with more than primary education on the one hand and mothers with primary or less education on the other hand. The M:F ratio of 1·21 (1·14-1·29) among women with more than primary education is significantly higher than the M:F ratio's in both lower educated groups. In Southern Asia, the difference in the M:F ratio for under-five mortality is particularly pronounced when comparing non-educated women to women with at least some education.

Neonatal mortality clearly stands out in two ways in Table 3. First, we observe M:F ratio's significantly higher than 1 for five of the six educational groups: all three groups in Sub-Saharan Africa, and the two educated groups in Southern Asia. Note that for neonatal mortality the gender-neutral rate mentioned earlier is probably too conservative (i.e. too low), as boys are known to be more vulnerable in this period due to biological differences[3]. Among non-educated women in Southern Asia the M:F ratio for neonatal mortality is still only 1·05 and not significantly different from 1. Although there is absolute excess mortality of boys among these mothers, this level of excess mortality is much lower than expected (compared for example to the 1·32 for this group in Sub-Saharan Africa). Second and more importantly, the M:F ratio's for neonatal mortality do not show the pattern by maternal education that can be observed for total under-five, infant and child mortality In Southern Asia the M:F ratio of 1·05 (0·97-1·14) among uneducated women is not significantly different from the M:F of 1·18 among women with more than primary education. Also in Sub-Saharan Africa, the neonatal M:F ratio does not differ systematically with maternal education.

For infant mortality after the first month, the M:F ratios show the expected trend by maternal education in Sub-Saharan Africa; the ratio increases with educational level. However, the three M: F ratios are not significantly different from each other. In Southern Asia the M:F ratio appears to be higher among women with more than primary education, but also here the difference is not statistically significant.

Child mortality - dying between 13 and 60 months - is about three times as high in Sub-Saharan Africa (2·5%) as compared to Southern Asia (0·8%). For the analysis of child mortality by maternal education we merged the two highest educational categories to observe sufficient numbers of deaths by educational group. In both contexts, the M:F ratio is significantly higher in the educated group compared to the uneducated group. This difference is particularly striking in Southern Asia.

The association between mother's education and the M:F ratio's is not affected by controlling for the average educational attainment of women aged 30-45 in the direct proximity of the mothers and children. There is a significant and negative relationship between cluster level female education and the mortality rates for boys and girls independently of the mother's education in Sub-Saharan Africa but not in Southern Asia (not shown in Table 3). For instance, for total under-five mortality the association between cluster level female education and mortality is OR=0·97 (0·96-0·98). There is no evidence for an association between cluster level female education and M:F ratios.

Discussion

The relative advantage of girls regarding under-five mortality is larger among higher educated mothers in Southern Asia and Sub-Saharan Africa. In Sub-Saharan Africa this means that girl's absolute advantage is larger, in Southern Asia it means that their excess mortality (compared to boys) is lower if mothers have more education. The effect of maternal education on the sex-differential seems to be located at the level of the individual mother; we found no evidence for a sex difference in the contextual effect of average female education at the cluster or regional level.

Our primary interest is in how the M:F ratio varies with maternal education. As it is clear that a ratio of 1 does not reflect the gender-neutral situation, we compared to observed M:F ratio's to a gender-neutral range of 1.15-1.30. Although this range is based on high quality Western European data, it has to be stressed that this range is not a golden standard. Moreover, this range can vary by mortality type and mortality level. Our own calculations on data from the Human Mortality Database suggest the range used here is appropriate for under-five mortality it is unclear whether it is appropriate for neonatal mortality, especially at the high levels of neonatal mortality in Sub-Saharan Africa. We therefore stress caution in interpreting the absolute M:F ratio's and prefer to emphasize the variation by maternal education.

We pooled data for several countries. This has limitations as well as advantages. We pooled the data for three reasons. First, we are looking for general patterns instead of country -specific patterns. Second, we wanted to control for risk factors for child mortality at the level of the context in which the children live. Without adequate control for context factors, it cannot be precluded that effects observed for household-level factors (e.g. mother's education) are in fact driven by context factors (e.g. community female education). Because context factors may work both at the level of the local community and at the level of the larger district and national context, ideally, control factors at different context levels should be included. This is only possible if data are used with sufficient variation and cases at those levels. By combing DHS datasets for 35 countries and distinguishing both districts and clusters within those countries, this study provides better controls for confounding context factors than any earlier study. Third, we want to investigate different types of under-five mortality, in particular child mortality (13-60 months). Again, to obtain sufficient statistical power to test the hypothesis that there are differences by maternal education, we need a large number of cases. We performed a number of sensitivity check to make sure our results are not biased by pooling the data. In the African sub-sample the analysis are not dominated by any single country. The results do not change when leaving any single country out of the analysis. The sample size of India is – like its real population –much larger than those of Pakistan, Bangladesh and Nepal. However, if we weight the Indian cases down the conclusions are affected. If we pool only the other three Southern Asian countries, we have less statistical power, but we still find a substantial and significant difference by maternal education in the M:F ratio for child mortality: Among lower uneducated women the M:F ratio is 0·58 (0·39-0·85) and this is significantly lower (p=0·015) than the M:F ratio of 1.20 (0·71-2·02) found among educated mothers.

In additional robustness checks, we ran models with the mean years of education among men aged 30 and older as an indicator of regional economic development. This did not lead to different findings from the ones presented here. We also tried a different measurement of female education at the context level by using the percentage of women with at least some education. This gave similar result to using the average number of years of schooling. We also tested for an interaction between M:F ratio and district level education, but found no significant relationship. Finally, we controlled for father's years of education (if a father was present). Father's education increases survival chances in addition to the effect of maternal education, although it is less strong. However, father's schooling did not affect the M:F ratio and taking father's education into account does not change the significant variation of the M:F ratio by maternal education. This indicates not only that the findings for maternal education are robust, it also suggests that factors related to the educational level of the individual mother are more important for the M:F ratio than characteristics related to the father.

Various mechanisms may underlie the observed sex-differentials. Conscious gender-bias in favour of boys with regard to nutrition and care are only one possible mechanism. There is substantial evidence for the existence of such bias in Southern Asia[5, 10, 28], but this is much less the case for Sub-Saharan Africa. More detailed analyses into the cause of the sex-differential in Sub-Saharan Africa is needed before strong conclusions can be drawn about the reasons for the relative disadvantage girls experience there, especially if their mothers have no education. As we were able to control for household wealth, cluster level female education and regional development, we content that our findings suggest that the relevant mechanisms that explain the observed gender difference in both Sub-Saharan Africa and Southern Asia most likely have a direct and possibly a causal link to individual mothers' education. At least at this level of development, maternal education seems beneficial for overall under-five mortality as well as gender equality for young children.

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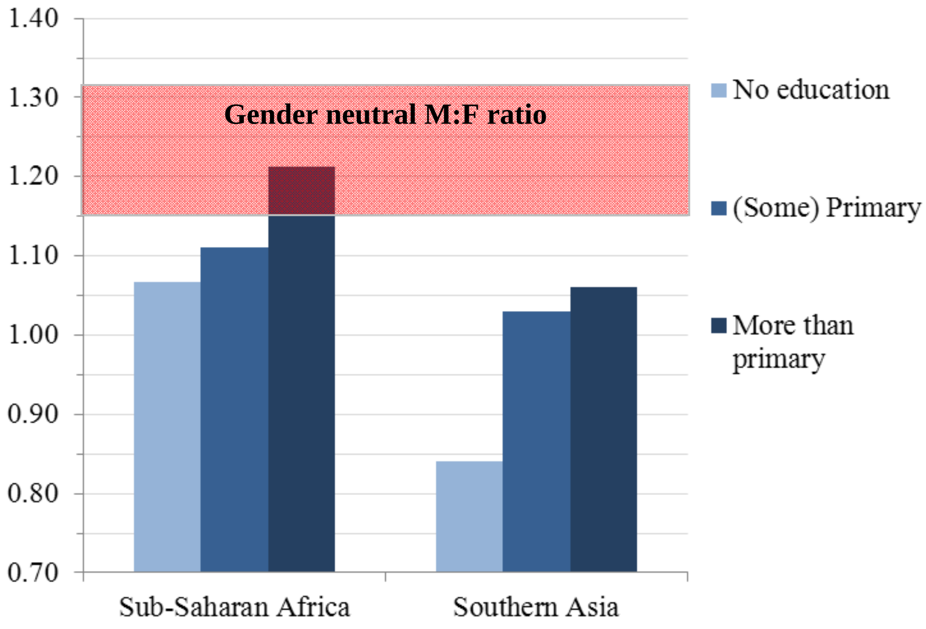

Figure 1.
M:F ratio for under-five mortality by mother's education in Sub-Saharan Africa and Southern Asia.

Table 1.
Descriptives statistics of infant and child mortality by independent variables and sex in Sub-Saharan Africa (unadjusted Male:Female odds ratios).

	Males			Female			M:F
Mortality (months)	n	n died	%died	n	n died	%died	odds ratio
Under-five (0-60)	190 434	21 234	11·2%	186 110	18 701	10·0%	1·12
Neonatal (0)	190 434	7 654	4·0%	186 110	5 666	3·0%	1·33
Infant (1-12)	182 780	9 078	5·0%	180 444	8 726	4·8%	1·03
Child (13-60)	173 702	4 502	2·6%	171 718	4 309	2·5%	1·03
Mother's education							
No education	92 168	11 570	12·6%	89 739	10 458	11·7%	1·09
(Some) Primary	65 451	7 214	11·0%	64 636	6 310	9·8%	1·15
More than primary	32 815	2 450	7·5%	31 735	1 933	6·1%	1·24
Mother's age							
15-19	12 205	1 557	12·8%	11 828	1 277	10·8%	1·21
20-29	96 530	10 724	11·1%	94 591	9 295	9·8%	1·15
30-39	64 126	6 665	10·4%	62 286	6 116	9·8%	1·07
40-49	17 573	2 288	13·0%	17 405	2 013	11·6%	1·14
Birth order							
1	56 067	6 541	11·7%	54 222	5 330	9·8%	1·21
2-3	56 641	5 777	10·2%	55 519	5 144	9·3%	1·11
4+	77 726	8 916	11·5%	76 369	8 227	10·8%	1·07
Living male sibling							
no	79 934	9 708	12·1%	77 655	8 228	10·6%	1·17
yes	110 495	11 526	10·4%	108 451	10 472	9·7%	1·09
Twin							
no	184 052	19 378	10·5%	179 766	17 018	9·5%	1·13
yes	6 382	1 856	29·1%	6 344	1 683	26·5%	1·14
Household wealth							
lowest 30%	68 765	8 362	12·2%	67 697	7 468	11·0%	1·12
middle 40%	80 369	9 301	11·6%	78 387	8 249	10·5%	1·11
top 30%	41 300	3 571	8·6%	40 032	2 984	7·5%	1·18

Table 2.
Descriptives statistics of infant and child mortality by independent variables and sex in Southern Asia (unadjusted Male:Female odds ratios).

	Males			Female			M:F
Mortality (months)	n	n died	% died	n	n died	% died	odds ratio
Under-five (0-60)	75 007	4 989	6·7%	69 990	4 702	6·7%	0·99
Neonatal (0)	75 007	3 055	4·1%	69 990	2 448	3·5%	1·17
Infant (1-12)	71 952	1 498	2·1%	67 542	1 633	2·4%	0·86
Child (13-60)	70 454	436	0·6%	65 909	621	0·9%	0·65
Mother's education							
No education	36 399	3 054	8·4%	34 571	3,098	9·0%	0·93
(Some) Primary	12 436	844	6·8%	11 812	740	6·3%	1·09
More than primary	26 172	1 091	4·2%	23 607	864	3·7%	1·15
Mother's age							
15-19	5 017	500	10·0%	4 806	393	8·2%	1·24
20-29	48 638	3 124	6·4%	45 393	2 902	6·4%	1·00
30-39	18 938	1 161	6·1%	17 602	1 216	6·9%	0·88
40-49	2 414	204	8·5%	2 189	191	8·7%	0·97
Birth order							
1	30 496	2 113	6·9%	28 658	1 715	6·0%	1·17
2-3	26 303	1 486	5·6%	24 181	1 460	6·0%	0·93
4+	18 208	1 390	7·6%	17 151	1 527	8·9%	0·85
Living male sibling							
no	40 422	2 750	6·8%	37 183	2 457	6·6%	1·03
yes	34 585	2 239	6·5%	32 807	2 245	6·8%	0·94
Twin							
no	73 907	4 679	6·3%	68 854	4 396	6·4%	0·99
yes	1 100	310	28·2%	1 136	306	26·9%	1·06
Household wealth							
lowest 30%	28 384	2 483	8·7%	27 169	2 464	9·1%	0·96
middle 40%	29 872	1 844	6·2%	27 823	1 713	6·2%	1·00
top 30%	16 751	662	4·0%	14 998	525	3·5%	1·13

Table 3.
Male:Female odds ratio for four types of under-5 mortality by maternal education and contextual female education in Sub-Saharan Africa and Southern Asia (multivariate models).

	Sub-Saharan Africa					Southern Asia				
Total mortality (0-59 months)	OR	95% CI				OR	95% CI			
No education	1·07	1·03	-	1·10		0·84	0·79	-	0·89	
(Some) Primary	1·11	1·07	-	1·16		1·03	0·92	-	1·15	a
Secondary or more	1·21	1·14	-	1·29	a,b	1·06	0·96	-	1·17	a
Cluster level female education (in years)	1·00	0·99	-	1·01		0·99	0·97	-	1·02	
Neonatal mortality (1st month)										
No education	1·32	1·24	-	1·40		1·05	0·97	-	1·14	
(Some) Primary	1·27	1·19	-	1·36		1·25	1·09	-	1·44	a
Secondary or more	1·45	1·31	-	1·61	b	1·18	1·05	-	1·33	
Cluster level female education (in years)	0·99	0·97	-	1·01		1·00	0·97	-	1·03	
Infant mortality (1-12 months)										
No education	0·98	0·94	-	1·03		0·77	0·70	-	0·85	
(Some) Primary	1·03	0·97	-	1·10		0·75	0·62	-	0·90	
Secondary or more	1·08	0·98	-	1·19		0·93	0·77	-	1·13	
Cluster level female education (in years)	1·01	0·99	-	1·02		0·99	0·95	-	1·03	
Child mortality (13-59 months)										
No education	0·98	0·92	-	1·05		0·48	0·41	-	0·57	
(Some) primary or more	1·09	1·02	-	1·18	a	0·85	0·66	-	1·11	a
Cluster level female education (in years)	1·00	0·98	-	1·02		0·97	0·90	-	1·04	

a= significantly different from "No education", b= significantly different from "(Some) Primary".

All models include: mother's age at birth, mother's age at birth squared, birth order, birth order squared, twin, male living siblings, household wealth decline, household wealth decline squared, district polio vaccination level, country level GDP per capita. Random intercepts are included for the cluster, district and country level. Random slopes for child sex are modelled when child's sex is interacted with female education at the cluster level.