Shedding Light on Maternal Education and Child Health in Developing Countries

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Abstract

This paper investigates the intergenerational effects of maternal education on child health in 68 developing countries across five continents over nearly three decades. Exploiting the between-sisters variation in the educational attainment of the mothers, we find that mother's education is positively associated with child health measured by the three most commonly used indices, namely height-for-age, weight-for-height, and weight-for-age. Our mechanism analyses further show that these favorable effects could be, at least in part, attributed to fertility behavior, assortative matching, health care utilization, access to information, health knowledge, and labor market outcome. Given the long-lasting impacts of early-life health over the life cycle, our findings underline the importance of maternal education in improving economic and social conditions in developing countries.

JEL codes: I10, I26, O15
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1 Introduction

Among under-five children worldwide in 2018, the proportion of stunted children (those too short for their age) was 22% while the fraction suffering from wasting (children too thin for their height) was 7% (Unicef, World Health Organization, and World Bank, 2019). These statistics indicate a widespread presence of undernutrition which accounts for approximately half of all deaths among children under five (Unicef, 2019). Besides, poor early-life health, in the form of childhood undernutrition, has a long-lasting effect over the life cycle such as cognitive impairment, lower educational attainment, higher vulnerability to chronic diseases, and declining productivity as well as earnings (Martorell, 1999; Alderman et al., 2006; Briend and Berkley, 2016). Given these detrimental private and social costs, considerable attention has been drawn to the improvement of child health where maternal education is regarded as one of the key solutions.

According to Grossman (1972, 2006), not only are the more educated mothers capable of "*producing*" better child health with a given set of health inputs (i.e. productive efficiency), but they are also able to allocate health inputs more efficiently compared to women who are less educated (i.e. allocative efficiency). Nevertheless, there is conflicting empirical evidence on the relationship between maternal education and child health (e.g., Currie and Moretti, 2003; Lindeboom et al., 2009; Chou et al., 2010; McCrary and Royer, 2011; Keats, 2018; among others). In addition, as pointed out in Grossman (2006, 2015), the establishment of the causal relationship between maternal education and child health is plagued with the problem of endogeneity. Specifically, the existence of "*third omitted*" variables which jointly determine maternal education and child quality, such as genetics and family endowments, complicates the identification of the causal impacts. Multiple studies address this endogeneity problem by relying on the exogenous changes in education induced by multiple government programs within the instrumental-variable framework (Breierova and Duflo, 2004; Chou et al., 2010; Aslam and Kingdon, 2012; Grepin and Bharadwaj, 2015; Keats, 2018), or by the age-at-school-entry policies using the regression discontinuity design approach (McCrary and Royer, 2011). However, these studies tend to quantify the effects of interest for a subgroup of population within a context of one individual country.

In exploring the relationship between the intergenerational transmission of education and child health, the contribution of our study is three folds. First, instead of focusing on just one country, our sample covers 68 developing countries across five continents over nearly three decades. This wide coverage across time and space makes it possible to interpret our results as externally valid. Second, to ensure the internal validity of our estimates, we exploit the between-sisters variation in educational attainment among the mothers in a sister fixed effects framework. In other words, our identification comes from the comparison of health outcomes among children born to mothers who are biological sisters. Finally, we contribute to the literature by exploring a variety of pathways through which mother's education improves child health. Policywise, understanding the underlying mechanisms can be helpful in designing targeted programs to magnify the beneficial effects of maternal education.

We utilize the Demographic and Health Surveys which provide rich information on demographics, health, and nutrition among women and children. Child health is captured by the three most commonly used anthropometric measures, namely, height-for-age, weight-for-height, and weight-for-age z-scores. In addition, we also examine three child nutrition indicators derived from these z-scores: stunting (a low height-for-age), wasting (a low weight-for-height), and underweight (a low weight-for-age). Under-nutrition, which includes stunting, wasting, and underweight, strongly precipitates mortality among children under five years old (WHO and Unicef, 2009).

Exploiting the between-sisters variation in the educational attainment of the mothers, our paper reaches the following findings. First, we uncover favorable effects of maternal education on child health. Specifically, a one-year increase in mother's education raises child's weight-for-height z-score by 0.02 standard deviations, and increases child's height-for-age as well as weight-for-age z-scores by 0.04 standard deviations. Furthermore, an additional year of education accumulated by the mother decreases the probability of the child being wasted by 0.2 percentage points, and reduces the incidence of stunting as well as underweight by 1 percentage point. Second, we analyze multiple channels through which maternal education affects child health. We find that these favorable intergenerational impacts could be, at least in part, attributed to five main groups of mechanisms: (i) mother's fertility behavior (proxied by the number of children and mother's age at first birth), (ii) assortative matching (proxied by husband's education), (iii) mother's health care utilization (proxied by the number of prenatal visits, and whether mother sought prenatal care from formal sources, delivered the birth at a health facility, as well as received delivery assistance from professionals), (iv) access to information and health knowledge (proxied by whether mother watches television, reads newspapers, knows about ovulation cycle, utilizes contraception), and (v) labor market outcome (proxied by different measures of her labor force participation status and labor earnings). Particularly, the more educated mothers are more liable to reduce the number of births, increase the age at first birth, and marry higher-educated husbands. Moreover, there is a tendency among the more educated women to increase the number of prenatal care visits, to obtain prenatal care from formal sources, to deliver the birth at a formal medical institution, as well as to receive delivery assistance from health professionals. Education further induces mothers to acquire information through television and newspapers, to have knowledge of the ovulation cycle, to adopt contraceptive methods, as well as to be engaged in and earn more from market work. Finally, we detect heterogeneity in the impacts of mother's education on child health by continent and income group. The effects tend to be larger in magnitude for Latin American and middle-income countries.

Previous literature documents that poor childhood health diminishes health outcomes, reduces educational attainment, and potential earnings in adulthood (Martorell, 1999; Almond et al., 2005; Currie, 2009; Dewey and Begum, 2011). Furthermore, the cumulative consequences of poor health in early life could potentially be more adverse and long-lasting for children in developing countries than those in developed countries (Currie and Vogl, 2013). Therefore, our findings underline the importance of maternal education in enhancing economic and social conditions in developing countries. Our results also suggest that improving access to education for women could help achieve the Millennium Development Goals 4 (reduce child mortality) and 5 (improve maternal health).

The paper proceeds as follows. Section 2 presents a review of related literature. Section 3 describes the data. Section 4 outlines the empirical strategy. Section 5 discusses our estimating results, robustness checks, potential mechanisms, and heterogeneity analyses. Section 6 concludes the paper.

2 Literature Review

Our study can be related to the literature that evaluates the intergenerational impacts of parental education on infant and child health. Among developed countries, Currie and Moretti (2003), Grytten et al. (2014), and Lundborg et al. (2014) find that children born to better-educated mothers tend to be healthier. In the context of the U.S., using the availability of colleges in the woman's county at age 17 as an instrument for education, Currie and Moretti (2003) document that more educated mothers have more favorable birth outcomes indicated by higher birth weight and longer gestational age. The authors attribute this relationship to the increased likelihood of mothers being married and the utilization of prenatal care, as well as the reduction in smoking. Also employing the instrumental variable (IV) method, Grytten et al. (2014) and Lundborg et al. (2014) present evidence that mother's education generates positive impacts on infant-child health in Norway and Sweden, respectively. Lundborg et al. (2014) further show that assortative matching, the reduction in fertility, and the increase in income contribute to the observed effects in Sweden. However, several studies show no evidence on the relationship of interest. For instance, within the regression discontinuity design (RDD) framework, McCrary and Royer (2011) show that women born just after the school entry date accumulate fewer educational years than those born just before the school entry dates. By comparing children born to women from both sides of the cutoff dates, the authors find virtually no difference in birth weight and gestational age. Lindeboom et al. (2009) also reach a similar conclusion when exploiting the increase in the minimum school-leaving age in the UK as a quasi-experiment.

Within the context of developing countries, numerous attempts have been made to establish the causal link between parental education and child health. These studies rely on the exogenous variation in educational attainment induced by the exposure to certain government programs (e.g. school construction, the elimination of primary school fees, or compulsory schooling law) within an IV regression framework. Specifically, by exploiting the school construction program in Indonesia, Breierova and Duflo (2004) uncover the reduction in mortality rate among children born to higher educated parents. Grepin and Bharadwaj (2015) come to a similar conclusion as they instrument female education with exposure to the secondary school expansion in Zimbabwe. Employing the elimination of primary school fees in Uganda, Keats (2018) shows an increase in child health investment and a decline in child malnutrition as returns to increased maternal education. Chou et al. (2010) document the reduction in the incidence of low birth weight and mortality among infants born to parents who accumulated more education induced by the extended compulsory education in Taiwan. Utilizing the compulsory schooling reform in Turkey as an IV for education, Gunes (2015) detects favorable health outcomes among children born to higher educated mothers while Dincer et al. (2014) only uncover weak evidence on child mortality. A few studies attempt to explore the pathways for the effects of maternal education on child health. In particular, Grepin and Bharadwaj (2015) and Gunes (2015) regard the increased age at first birth and decreased demand for children as important mechanisms behind the favorable impact of maternal education in Zimbabwe and Turkey, respectively. Keats (2018) attributes the impacts of maternal education to increased contraception use and employment opportunities.

Outside the economics literature, a variety of development studies seek to explore and explain the link between parental schooling and child nutrition. For example, in a cross-sectional study, Semba et al. (2008) show that maternal education is a strong determinant of child stunting in Indonesia and Bangladesh. Aslam and Kingdon (2012), employing an IV framework, find that maternal schooling improves child health measured by anthropometric measures, in the context of Pakistan. Alderman and Headey (2017) point out the child health returns to parental education are larger for mothers than for fathers in 56 developing countries.

The above-mentioned studies, however, only consider individual countries separately. Moreover, as discussed in Grossman (2006, 2015), there exist two important issues. The first issue is the conflicting findings in empirical studies. While several studies detect the positive impacts of maternal education on child health (e.g., Currie and Moretti, 2003; Chou et al., 2010; Keats, 2018; among others), others point to the nonexistence of such relationship (e.g., Lindeboom et al., 2009; McCrary and Royer, 2011; among others). The second issue is the problem of endogeneity, which refers to unobservable factors that jointly determine maternal education and child quality, such as genetics and family endowments. These "*third omitted*" variables make it challenging to identify the causal impacts of interest. Therefore, Grossman (2006; 2015) suggests that there should be more research on the link between mother's education and child health.

Our paper aims to address these concerns and contribute to the literature in three aspects. First, instead of focusing on just one country, our sample covers 68 developing countries across five continents from 1990 to 2018. This wide coverage across time and space lends support to the external validity of our estimates, i.e. our results could be generalized to out-of-sample countries.[1] Second, we explore the link between maternal education and child health using a different empirical approach compared to the studies mentioned previously. In particular, we exploit the between-sisters variation in the number of educational years accumulated by the mothers while prior studies adopt either the IV or the RDD method as the identification strategy. The richness of our data allows us to match mothers with

[1] In this respect, the closest work to ours is Desai and Alva (1998) who also examine the impacts of maternal education on child health in a context of 22 developing countries. Not only does our paper cover a broader context (68 developing countries), but we also attempt to address the problem of endogeneity.

their biological sisters who also have children. Therefore, our identification comes from the comparison of health outcomes among children born to mothers who are biological sisters.[2] Finally, we contribute to the literature by exploring a variety of channels through which mother's education improves child health.

3 Data

To uncover the effects of maternal education on child health, we employ the data from the Demographic and Health Surveys (DHS). Conducted by the Inner City Fund (ICF) International, the DHS program is jointly funded by the United States Agency for International Development (USAID) and other parties, such as the United Nations Children's Fund (UNICEF), the United Nations Population Fund (UNFPA), the World Health Organization (WHO), and the Joint United Nations Program on HIV and AIDS (UNAIDS).

The DHS are administered in over 90 developing countries across five continents and cover a wide range of topics including population, health, and nutrition. There are four types of questionnaires in the DHS: Household, Woman, Man, and Biomarker. The Household Questionnaire is intended to gather general demographic information on all household members (for example, age, sex, education, etc.), the relationship with household head, characteristics of the residence such as the ownership of various assets and utility usage, among others. From the Household Questionnaire, eligible members are selected for individual interviews which are based on Woman's or Man's Questionnaire. The Man's Questionnaire gathers background information, reproduction, and health knowledge among eligible men. The Woman's Questionnaire targets women in reproductive age (15-49) and collects information on woman's background characteristics, health knowledge and health behaviors, fertility patterns, child's health/nutrition status, as well as husband's background. Finally, the Biomarker Questionnaire provides details on child's anthropometry (height and weight), hemoglobin level in the blood, along with HIV test results.[3]

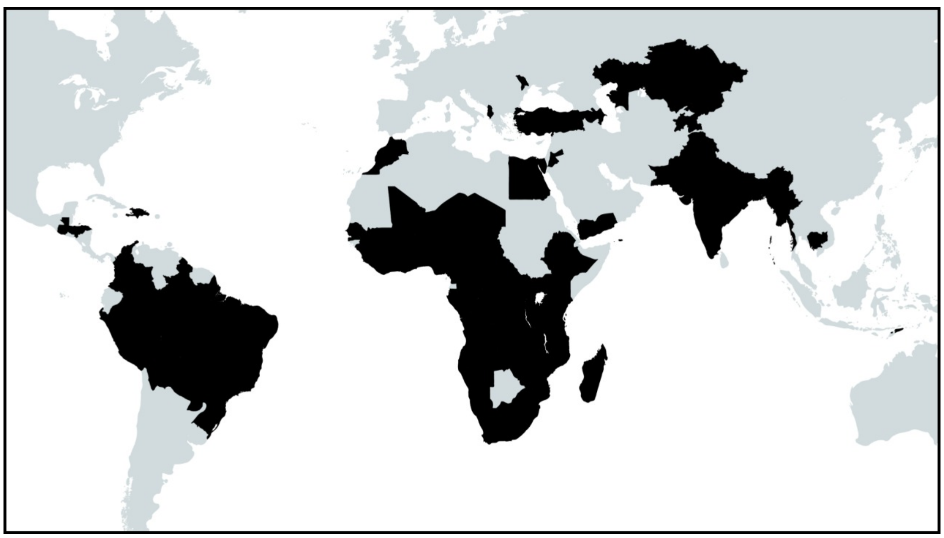
The DHS child file contains detailed information, both demographic and anthropometric, on children aged zero to four. We concentrate on women aged 18 and older since this is

[2] In terms of identification strategy, the closest work to ours is Wolfe and Behrman (1987). The authors use the between-siblings comparison in the context of Nicaragua and find that mother's schooling does not seem to affect the health outcome of their children. The sibling fixed effects method is also utilized in various studies for different research objectives (see, for example, Altonji and Dunn, 1996a; Altonji and Dunn, 1996b; Aaronson, 1997; Currie and Stabile, 2006; Fletcher and Wolfe, 2008; Fletcher, 2010).

[3] See https://dhsprogram.com for more details.

the age threshold for adulthood recognized in most countries. The focus on women aged 18 and older enables us to isolate the impacts of education at completed schooling (McCrary and Royer, 2011). Since our identification strategy hinges upon the between-sisters variation in completed years of education (details are provided in Section 4), we need to construct a sample made up of sister groups. Groups of sisters are identified as follows. First, the mothers who are biological daughters of the household head form a group of sisters. Second, the mothers who are biological sisters of the household head (and the head herself if she's also a mother in our sample) are considered a group of sisters as well. Hence, our sample consists of children under five born to women who are at least 18 years old and can be matched to their biological sisters.[4]

Figure 1: Geographic Coverage



NOTE: The black regions illustrate the geographic coverage of our sample.

We use data from 1990 and onward because the information on the relationship with the head of the household is not available in the DHS data prior to 1990. Since we measure child health with child's anthropometric indices, we can only make use of countries and data waves which contain details on child's anthropometry. These restrictions leave us with 23,958 children across 68 countries in Africa, Latin America, and Eurasia with data covering from 1990 to 2018.[5] The list of countries along with the information on geographic area and income

[4] Biological sisters also include half sisters. However, the data does not allow us to distinguish half siblings from full siblings.

[5] In our sample, there are four countries that can be classified as European countries, namely, Albania, Armenia, Azerbaijan, and Moldova. We group these countries with other 14 Asian countries and refer to this set of countries as Eurasia. Besides, there are four North American and six South American nations. They are also grouped together and referred to as Latin America.

group classification is provided in Table B1 in the Appendix. In addition, the black regions in Figure 1 illustrate the geographic coverage of our sample.

3.1 Mother Characteristics

The DHS Women file provides us with a wide variety of mother characteristics. The main explanatory variable is mother's education, which is the total number of educational years completed by the mother. The age and birth order of the mother are also available. Our main empirical model controls for mother's education, age differentials between the mother and her sister, and mother's birth order (summary statistics in Table 1). As we explore mechanisms behind our estimated effects, we draw on the information about mother's fertility behavior, husband characteristics, utilization of health care service, access to information, health knowledge, and engagement in market work. Descriptive statistics of these variables are provided in Table A1.

Table 1: Summary Statistics

	(1)	(2)	(3)	(4)
	All	Africa	Eurasia	Latin America
	Mean (SD)			
Panel A: Mother Characteristics				
Mother's Education	6.110	5.339	6.841	7.283
	(4.463)	(4.197)	(4.951)	(4.341)
Mother's Age	26.016	26.118	25.961	25.833
	(5.777)	(6.106)	(4.782)	(5.642)
Mother's Age Differentials	5.120	5.599	4.265	4.656
	(3.995)	(4.321)	(3.145)	(3.602)
Mother's Birth Order	3.014	3.041	2.423	2.988
	(2.436)	(2.435)	(2.109)	(2.478)
Panel B: Child Health Outcomes				
Height-for-age z-score	-1.167	-1.214	-1.287	-0.984
	(1.503)	(1.557)	(1.568)	(1.314)
Weight-for-height z-score	-0.321	-0.342	-0.792	0.038
	(1.201)	(1.192)	(1.201)	(1.099)
Weight-for-age z-score	-0.986	-1.027	-1.422	-0.604
	(1.321)	(0.292)	(1.303)	(1.244)
Stunting	0.270	0.292	0.305	0.199
	(0.444)	(0.455)	(0.460)	(0.399)
Wasting	0.070	0.072	0.132	0.024
	(0.255)	(0.258)	(0.338)	(0.153)
Underweight	0.217	0.225	0.341	0.117
	(0.413)	(0.418)	(0.474)	(0.321)
Observations	23,958	13,507	4,178	6,273

Panel A of Table 1 reports the mean value of maternal education for women in the full sample and in each continent. The average years of education completed by all women are approximately 6.11 years. On average, women in Latin America attain the highest number of educational years (7.28 years), followed by women in Eurasia (6.84 years), and African women (5.34 years). The mean age of mothers is roughly 26.12 in the Africa sample, 25.96 in the Eurasia sample, and 25.83 in the Latin America sample.

3.2 Child Health

We measure child health with child's anthropometry, including height-for-age, weight-for-height, and weight-for-age. Anthropometric measures are calculated for children under five by their age and sex, based on the Centers for Disease Control and Prevention (CDC) Standard Deviation-derived Growth Reference Curves which are derived from the National Center for Health Statistics (NCHS)/CDC Reference Population. Measuring child health based on the international reference population is justified since the height and weight of well-fed healthy children follow a similar growth path across countries (Martorell and Habicht, 1986; Grantham-McGregor et al., 2007).

Child's anthropometric measures reflect the nutrition and growth status of children in both the long run and the short run. Given gender, height-for-age reflects long-run health status and weight-for-height indicates current health status (Thomas et al., 1991; WHO, 2008). Particularly, a low height-for-age (stunting) is perceived as the prolonged lack of nutrients that support normal growth or repeated illness suffering. A low weight-for-height (wasting), on the other hand, is caused by recent adverse circumstances such as a significant decrease in food consumption or serious illness. In addition, weight-for-age is an indicator of body mass relative to age and is influenced by both height-for-age and weight-for-height. In the DHS data, height-for-age, weight-for-height, and weight-for-age are expressed by the z-score classification system. In other words, these anthropometric measures are described as the number of standard deviations below or above the median of the international reference population. Z-score, as pointed out in WHO (1997), is the best system for analysis and demonstration of anthropometric data.

We further measure child health with different nutritional statuses. Specifically, Stunting, Wasting, and Underweight are three indicators constructed based on height-for-age, weight-for-height, and weight-for-age z-scores, respectively (WHO, 1997). Stunting is a dummy variable that takes the value of one if height-for-age z-score is below -2, and zero otherwise. Wasting is a dichotomous variable which takes the value of one if weight-for-height z-score is lower than -2, and zero otherwise. Similarly, Underweight is an indicator taking the value of one if weight-for-age z-score is less than -2, and zero otherwise. The threshold value of -2 is established by WHO (1997).

Panel B of Table 1 provides the descriptive statistics of anthropometric measures of all children aged 0-4 in our sample, disaggregated by continent. Overall, the average of child health in our sample is below the world average which also includes children from developed countries. The raw means of all three anthropometric measures are the highest in Latin America and lowest in Eurasia. On average, child's height-for-age z-score lies at -1.17 standard deviations. The mean values of height-for-age z-score in Africa, Eurasia, and Latin America are -1.21, -1.29, and -0.98 standard deviations, respectively. Moving to weight-for-height z-score, the mean of this measure is the highest in Latin America (0.04 standard deviations), then in Africa (-0.34 standard deviations), and lowest in Eurasia (-0.79 standard deviations). The mean weight-for-age z-score is -0.99 standard deviations for the full sample, -1.03 standard deviations for the Africa sample, -1.42 standard deviations for the Eurasia sample, and -0.60 standard deviations for the Latin America sample. The fractions of children categorized as stunted, wasted, and underweight are provided in the lower half of Panel B of Table 1.

3.3 Sample Representativeness

Since our identification of the effects of maternal education on child health hinges upon the between-sisters variation in educational attainment (more details in Section 4), our sample consists of children of sisters who live together. There could be a concern that this living arrangement might engender a selected sample, despite the wide coverage across time and space of our sample (68 countries, over three decades).

To shed some light on this potential issue, we proceed to test if the mothers in our estimating sample (who live with their sisters) are different from those outside of our sample (who do not live with their sisters). To do so, we separately regress each of the mother characteristics on the dummy Sister Group, conditional on statistical area-by-wave-by-birth year fixed effects. Sister Group is a categorical variable which takes the value of one if the mother can be matched with her sisters and zero otherwise. Coefficients on Sister Group are reported in

Table 2.[6] Mother characteristics include mother's education, age, birth order, an indicator for whether mother belongs to the major religious group in her country, husband education, and current place of residence (indicator for rural area). The estimating results in Table 2 are statistically and economically insignificant. Therefore, women in our estimating sample are mostly similar to those in the remaining DHS sample, lending suggestive evidence for the external validity of our estimates.

Table 2: Suggestive Evidence on External Validity

	(1)	(2)	(3)
	Mother Education	Mother Age	Mother Birth Order
Sister Group	0.077	0.038	-0.006
	(0.193)	(0.039)	(0.016)
Observations	123,932	123,990	123,990
	Major Religion	Husband Education	Rural Area
Sister Group	0.006	0.012	-0.006
	(0.023)	(0.020)	(0.004)
Observations	101,412	91,476	119,897

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on the Sister Group dummy where each of the mother characteristics is regressed on Sister Group and statistical area-by-wave-by-birth year fixed effects. Sister Group is a categorical variable which takes the value of one if the mother can be matched with her sister and zero otherwise.

4 Empirical Strategy

We first estimate the relationship between maternal education and child health with an ordinary least square (OLS) model given by,

$$H_{jict} = \beta_0 + \beta_1 Education_{jict} + X'_{jict}\Omega + \epsilon_{jict} \quad (1)$$

where the subscript j, i, c, and t refer to child, mother, country, and survey year, respectively. The dependent variable H_{jict} stands for child health which is captured by height-for-age, weight-for-height, and weight-for-age z-scores, as well as three indicators for stunting, wasting, and underweight.

We proceed to describe the independent variables. First, our main explanatory, $Education_{jict}$, represents the total number of educational years completed by the mother. Next, the vector X'_{jict} includes the birth order of the mother, the age difference between the mother and her

[6] Sample size is large because all DHS women who have children with anthropometric z-scores are included.

sister, the birth order of the child, whether the child is a plural birth, subnational region fixed effects and survey year fixed effects. We do not control for the age and sex of the child because the anthropometric outcomes already take into account these factors. In other words, height-for-age, weight-for-height, and weight-for-age are calculated for a given age and sex. To account for differential trends in child health and educational attainment in different subnational regions, we add region-specific mother's birth cohort trend to X'_{jict}. Finally, we denote by ϵ_{jict} the error term. Standard errors are clustered at the country level to account for serial correlation at the country level.[7]

In the OLS model, we make a simple cross-sectional comparison of health measures of children born to random women with different numbers of educational years. Given that unobserved family endowment affects mother's educational attainment and could influence child health, the OLS estimates are likely to be biased. We attempt to control for unobserved heterogeneity in family background by comparing the health outcomes of children born to biological sisters in a sister fixed effects model as follows,

$$H_{jisct} = \beta_0 + \beta_1 Education_{jisct} + \lambda_s + X'_{jisct}\Omega + \epsilon_{jisct} \quad (2)$$

Here, the subscript s refers to set of biological sisters. In other words, a mother and her biological sisters together form a unique set s. The inclusion of sister fixed effects, λ_s, eliminates confounding unobserved endowments common to biological sisters. In other words, the between-sisters comparison alleviates the contamination due to common unobserved factors (for example, genes and unmeasured family endowments) which are correlated with both mother's education and child health. The inclusion of sister fixed effects absorbs the subnational region and survey year fixed effects as well. Our coefficient of interest, β_1, corresponds to the weighted average of the differences in health outcomes of children born to biological sisters where one sister achieves one more year of education than the other.

While being able to capture across family differences, the sister fixed effects cannot control for the heterogeneity within family that could be correlated with both mother education and child health. First, siblings' differences in innate ability could lead one sister to attain more education than the other and, at the same time, make one sister more capable of caring for their children. Although ability differences might be attributed to the random differences

[7] 68 countries in our sample correspond to 68 clusters. Changing the cluster level to the subnational region or statistical area further strengthens the significance level of our estimates.

in genetic endowment, the role of genetics on cognitive ability has fallen under suspicion as parenting has been shown to be a key factor (Petrill et al., 2006; Chen and Li, 2009; Anger and Heineck, 2010). Therefore, the nurturing effect of parents is likely to be the second contaminator. Specifically, parental investment might favor the first-born child (Conley and Glauber, 2006; Price, 2008; Lehmann et al., 2016). It could also be the case that parents learn how to care for their children over time, which puts the later-born kids into an advantage (Aaronson, 1997). Lastly, sisters who were born years apart may experience changes in family environments, for instance, neighborhood condition or marital status of the parents, which in turn, brings about the differences in educational attainment.

We attempt to address the above confounders as follows. First, we control for the birth order of the mother since it could capture parental investment heterogeneity. Next, we control for the age differences between sisters to account for potential changes in family environments.[8] Our identifying assumption is that after controlling for both across and within family confounders suggested by the literature which could simultaneously affect mother's education and child health, the educational differences between sisters are as good as random.

Although there is no formal test for the internal validity of our assumption, we conduct several informal tests to provide suggestive evidence supporting our identifying assumption. To see whether the differences in educational accumulation between sisters are uncorrelated with other observable factors, we conduct a left-hand-side balancing test (Pei et al., 2019). Particularly, we regress each of the mother's characteristics prior to first birth on mother's educational attainment, conditional on sister fixed effects and statistical area-by-wave-by-birth year fixed effects. Mother's characteristics prior to first birth include whether mother is a plural birth, mother's childhood place of residence (indicator for a city), and the time interval from marriage to first birth (in months). These characteristics could be good proxies for sisters' early-life experiences.[9]

The results are reported in Table 3. Coefficients on Mother's Education are all statistically and economically insignificant. Although the estimate in Column 3 is larger in absolute value than those in the remaining columns, it indicates that one year of education is associated with

[8] In this respect, we try estimating the effects of interest for a sample of sisters who are close in age in various robustness checks. See Section 5.2 for more details.

[9] The focus of the DHS data is women's behaviors after conception, thus leaving us with only these characteristics reflecting sisters' early-life experiences.

the decrease in the interval between marriage and first birth by approximately 0.4 months (12 days), which is economically very small. This informal test lends some suggestive evidence for the internal validity of our sister fixed effects estimates. In other words, after controlling for sister fixed effects which account for family heterogeneity, and factors suggested by prior literature (birth order and age differences) which could potentially affect mother's education and child health at the same time, the educational differences between sisters are as good as random. We carefully note that, like any other identification method, it is impossible to directly test for internal validity. The presenting results are only suggestive and informative for our identifying assumption.[10,11]

Table 3: Suggestive Evidence on Internal Validity

	(1)	(2)	(3)
	Mother is Plural Birth	Mother Childhood Place of Residence	Marriage to First Birth Interval (months)
Mother's Education	-0.009	0.005	-0.403
	(0.009)	(0.005)	(0.414)
Observations	19,599	19,599	14,958

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on Mother's Education where each of the mother's characteristics prior to first birth is regressed on mother's educational attainment, sister fixed effects, and statistical area-by-wave-by-birth year fixed effects.

Besides, another complication is the measurement errors which may be related to the sibling-

[10] As an additional check for internal validity, we follow the test outlined in Altonji and Dunn (1996a) who also employ the sibling fixed effects methodology to investigate the impact of education quality on wage. Specifically, the dependent variable is the deviation from (sister) group mean of mother's completed years of education. The main explanatory variables are the deviations from (sister) group mean of mother's characteristics prior to first birth: whether mother is a plural birth, mother's childhood place of residence, and the time interval from marriage to first birth (in months). All regressions control for statistical area-by-wave-by-birth year fixed effects. Evident from Table A2, coefficients on the deviations of mother's characteristics are all statistically indistinguishable from zero. While there is no statistical evidence for these relationships, we carefully note the results here do not mean there is no relationship at all. The magnitude of the estimate on childhood place of residence suggests it could be correlated with mother's education. However, this effect is partially captured by the age differences between sisters which account for potential changes in family environments and are already controlled for in our regressions.
In another test, we regress each of the mother's characteristics prior to first birth on an Educational Difference dummy, which takes the value of one if sisters attain different numbers of educational years and zero otherwise, conditional on statistical area-by-wave-by-birth year fixed effects. As shown in Table A3, coefficients on the Educational Difference dummy are all statistically and economically insignificant. Again, this informal test lends suggestive evidence in favor of the internal validity of our identification strategy.

[11] Besides, we also estimate the effects of interest for a sample of sisters who are close in age in various robustness checks (Section 5.2) because our identifying assumption tends to hold for sisters born close together. The results in Table 5 lend further support to our empirical model.

fixed effect (Smith, 2009). A simple comparison between the OLS with the fixed effects estimates does not help to identify the problem, since the effects of measurement error and confounding factors might move in opposite directions and partially cancel each other out. In the particular case when measurement errors in the self-reported educational attainment are classical, the estimated effects could be attenuated toward zero (Ashenfelter and Zimmerman, 1997). Therefore, if measurement errors are classical, our estimates could be lower bounds of the true effects.

In addition to estimating the effects of maternal education on child health, we further explore underlying pathways within the sister fixed effects model. To do so, we estimate the following equation,

$$M_{jisct} = \delta_0 + \delta_1 Education_{jisct} + \lambda_s + X'_{jisct}\Gamma + \upsilon_{jisct} \tag{3}$$

where the outcome M_{jisct} denotes various potential mechanisms through which maternal education could affect child health. All the variables on the right-hand side are defined as above. The magnitude and the statistical significance of δ_1 provide suggestive evidence on potential channels that explain the relationship between maternal education and child health. We consider multiple dimensions which are suggested to be associated with child quality: (i) mother's fertility behavior (Becker, 1973; Li et al., 2008; Paranjothy et al., 2009), (ii) husband characteristics (Behrman and Rosenzweig, 2002; Chou et al., 2010), (iii) mother's utilization of health care service (Currie and Moretti, 2003; Liu et al., 2017), (iv) mother's access to information and health knowledge (Thomas et al., 1991; Aguero and Bharadwaj, 2014; Dincer et al., 2014), and (v) mother's labor market outcome (Zaslow et al., 1998; Secret and Peck-Heath, 2004).

For the first group of channels, we capture mother's fertility behavior by the number of children she ever gives birth to and mother's age at first birth. For the second group, husband characteristics include husband's educational attainment and whether the husband currently lives with the family. In the third group, mother's utilization of health care service is proxied by the number of prenatal visits, whether mother sought prenatal care from formal sources (defined as care provided by trained health professionals), whether the mother delivered the birth at a formal health facility (either public or private medical institution), and whether birth delivery was assisted by medical professionals. In the fourth group, access to information is proxied by whether mother acquires information from television or newspapers. We capture health knowledge by whether mother knows about the ovulation cycle and whether mother utilizes any contraceptive method. In the final group, we look at different dimensions of mother's labor market outcome, namely, whether the woman is currently working, whether she worked in the past 12 months, whether she has a paid job (i.e. does market work, as opposed to unpaid job), and her earnings from work.

5 Results

5.1 Main Results

We present the estimates of the effects of maternal education on child health in Table 4. The structure is as follows. Results on height-for-age, weight-for-height, and weight-for-age measures are reported in Panel A, B, and C, respectively. Column 1 through 4 provide the estimates using the z-score system, and Column 5 through 8 show the impacts on health indicators derived from the corresponding z-scores.[12]

For every panel in Table 4, Column 1 and 5 are our most parsimonious specifications conditioning on only maternal education. In Column 2 and 6, we proceed to add a set of controls including mother's birth order, the age difference between mother and her sister, child's birth order, whether the child is a plural birth, dummies for subnational regions, survey year fixed effects, and region-specific mother's birth cohort trend.[13] In Column 3 and 7, we introduce sister fixed effects to our first and most parsimonious specifications, i.e. Column 1 and 5. Finally, Column 4 and 8 are our most extensive specifications where we incorporate a full set of controls as described in Column 2 and 6. Note that the inclusion of sister fixed effects absorbs subnational region and survey year fixed effects.

Height-for-age – Starting with child's height-for-age z-score and stunting status (defined as height-for-age z-score less than -2), in Column 1 and 5 of Panel A, we provide the results conditioning on only mother's education. An additional year of maternal education is associated with an increase in child's height-for-age z-score by almost 0.07 standard deviations, and a decrease in child's incidence of stunting by 1.8 percentage points. Nevertheless, these specifications are not appropriate because we omit important controls that determine child health. Therefore, in Column 2 and 6, we introduce a set of covariates as mentioned previously.

[12] We present the estimates using the percentile system in Table A4. Height-for-age, weight-for-height, and weight-for-age percentiles indicate the ranking of the child's anthropometric measures among the reference population.

[13] We do not control for mother's age because it is potentially endogenous (Chou et al., 2010). The inclusion of mother's age, however, leaves our estimates intact.

With the inclusion of these controls, maternal education still has positive effects on child's height-for-age z-score and negative effects on the child's probability of being stunted. The magnitude of these estimates is comparable to those in Column 1 and 5.

Table 4: Impacts of Maternal Education on Child's Anthropometric Measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A	Height-for-age z-score				Stunting			
Mother's Education	0.065***	0.060***	0.033***	0.036***	-0.018***	-0.017***	-0.011***	-0.011***
	(0.005)	(0.005)	(0.006)	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	23,958	23,958	23,958	23,958	23,958	23,958	23,958	23,958
Panel B	Weight-for-height z-score				Wasting			
Mother's Education	0.040***	0.039***	0.021***	0.020***	-0.005***	-0.004***	-0.003**	-0.002**
	(0.007)	(0.006)	(0.004)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	23,958	23,958	23,958	23,958	23,958	23,958	23,958	23,958
Panel C	Weight-for-age z-score				Underweight			
Mother's Education	0.069***	0.065***	0.033***	0.037***	-0.017***	-0.016***	-0.010***	-0.010***
	(0.007)	(0.005)	(0.005)	(0.005)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	23,958	23,958	23,958	23,958	23,958	23,958	23,958	23,958
Controls	.	✓	.	✓	.	✓	.	✓
Sibling Fe	.	.	✓	✓	.	.	✓	✓
Region-specific linear trend	.	✓	.	✓	.	✓	.	✓

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on Mother's Education where each child health outcome is regressed on the educational attainment of the mother along with other covariates indicated in the lower rows of the table. Controls include birth order of the mother, the age difference between the mother and her sister, birth order of the child, whether the child is a plural birth, subnational region fixed effect, and survey year fixed effects. In Column 4 and 8, sister fixed effects absorb the subnational region and survey year fixed effects.

We introduce sister fixed effects into our model in Column 3-4 and Column 7-8. Our sister fixed effects models point to the positive relationship between maternal education and child's height-for-age, regardless of the presence of control variables. Specifically, our most extensive specifications (Column 4 and 8) show that an additional year of mother's education increases child's height-for-age z-score by 0.04 standard deviations, and reduces the incidence of stunting by 1.1 percentage points. Compared to the OLS, the magnitude of the sister fixed effects estimates drops substantially, suggesting that failure to account for family background can inflate the effects of interest. Overall, our estimating results indicate that improvements in maternal education could generate favorable gains in child nutrition measured by height-for-age.

Weight-for-height − In Panel B, we present the estimated impacts of maternal education on child's weight-for-height z-score and the wasting status (defined as weight-for-height z-score less than -2). We first quantify the effects of interest without any other regressors. The estimates in Column 1 and 5 suggest that there is a positive association between mother's education and child's weight-for-height z-score and a negative relationship between maternal education and child's incidence of wasting. Particularly, an additional year of maternal education raises child's weight-for-height z-score by 0.04 standard deviations and decreases child's probability of being wasted by 0.5 percentage points.

According to our most extensive specifications (Column 4 and 8), the between-sisters estimates point to a 0.02 standard deviation increase in child's weight-for-height z-score and 0.2 percentage point decline in child's probability of being wasted, in response to an additional year of mother's education. Based on these estimates, we conclude that maternal education can improve child's weight-for-height z-score as well as reduce the incidence of wasting for the child.

Weight-for-age − We are also interested in weight-for-age because this measure can capture both height-for-age and weight-for-height (WHO, 1997). Both the OLS and the sister fixed effects estimates show that maternal education is linked with higher child's weight-for-age z-score and lower probability of being underweight (defined as weight-for-age z-score less than -2). Our most extensive specifications indicate that an additional year of education accumulated by the mother leads to an increase of 0.04 standard deviations in child's weight-for-age z-score and a reduction of 1 percentage point in underweight incidence.

Besides using child health outcomes expressed by standardized measures (z-scores and the indicators derived from the z-scores), we also examine the effects on child weight in kilograms and child height in centimeters.[14] As shown in Column 1 and 2 of Table A5, our most extensive specifications (sister fixed effects with full controls) suggest that an additional year of maternal education raises child weight and height by 0.03 kilograms and 0.06 centimeters, respectively. So far we have detected positive impacts of maternal education on both child weight and height. Although an improvement in height is desirable, an increase in weight entails a complexity as obesity is also a problem in developing countries (Kelishadi, 2007; Muthuri et al., 2014). To shed some light on the impacts of maternal education on child

[14] Unlike the z-scores, child weight in kilograms and height in centimeters do not account for child's age and sex. Therefore, we control for the age and sex of the child in these regressions.

obesity, we construct two indicators, each of which takes the value of one if weight-for-height and weight-for-age z-scores are greater than 2, respectively.[15] Results are reported in Column 3 and 4 of Table A5. We do not find enough evidence that maternal education increases the incidence of the child being overweight.

Taken together, we present strong evidence on the positive association between mother's education and child health measured by height-for-age, weight-for-height, and weight-for-age. In our most extensive specifications, we find that an additional year of maternal education raises child's weight-for-height z-score by 0.02 standard deviations, and increases child's height-for-age as well as weight-for-age z-scores by 0.04 standard deviations. We also detect reductions in the incidence of stunting, wasting, and underweight.

In our empirical model, the inclusion of sister fixed effects takes into account the unobserved heterogeneity in family background. Besides, we further control for suggested factors varying within family that leads to different educational levels between sisters and child outcomes simultaneously. As suggested by the literature, those factors include (i) birth order which proxies for parental investment, and (ii) age differences between sisters which could capture potential changes in family environments over time. Despite our attempt to account for both across and within family confounders suggested by the literature, there could possibly exist unexplored individual characteristics which are jointly correlated with both sisters' educational differences and child health. If such factors exist, our identifying assumption could be violated. We acknowledge this is the weakness of our empirical model, as there is no formal test for internal validity. Nevertheless, we do provide some informal and suggestive evidence to show that the confounding issues are unlikely (Table 3, Table 5, Table A2, and Table A3). At the very least, our results can, in any case, provide suggestively meaningful evidence for the relationship between maternal education and child health.

Our estimated child health returns to maternal education are comparable in magnitude with those in Desai and Alva (1998) and Alderman and Headey (2017) who study the relationship of interest in a context of many developing countries. Specifically, Desai and Alva (1998) show that children born to mothers with secondary education (usually from grade 6 to 12) have higher height-for-age z-score by approximately 0.23 standard deviations than those born to women without secondary education. Similarly, Alderman and Headey (2017) find that

[15] The threshold is established by WHO (1997).

children born to mothers with tertiary education (13+ educational years) are almost 0.5 standard deviations taller for their age than children of mothers without education.

Our estimated impacts are smaller in magnitude than those in studies investigating individual countries. Particularly, Turkish mothers who finished primary school have children with higher height-for-age and weight-for-age z-scores by 1.1 and 1.0 standard deviations, respectively (Gunes, 2015). The return to one year of education among Ugandan women is the increase in child's height-for-age z-score by 0.43 standard deviations (Keats, 2018). However, our results stand in contrast with Lindeboom et al. (2009) and McCrary and Royer (2011) who do not find evidence on the impact of maternal education on child health.[16] In brief, employing a different empirical strategy and reaching consistent findings (with those in a majority of studies) for a large sample of 68 countries, our paper calls for more investment in improving women's education given the positive externalities it could generate for the second generation.

5.2 Robustness Checks

Recall that our identification strategy relies on the assumption that the education differences between sisters could only be explained by random shocks. As discussed in Section 4, siblings born many years apart are likely to experience changes in family environment, leading to differences in educational attainment. Thus, the identifying assumption tends to hold for close sisters in terms of age, as they are more likely to grow up in similar environments. In the following robustness exercises, we restrict our sample to sisters who were born up to ten, five, two, and zero (twins) years apart. The estimating results are presented in Table 5. Reported coefficients come from our most extensive specification (sister fixed effects model with a full set of controls).

In Panel A, focusing on the sample of sisters who were born up to ten years apart, we uncover the favorable relationship between maternal education and child nutrition. Particularly, an additional year of mother's education is associated with an increase in child's height-for-age, weight-for-height, and weight-for-age z-scores by 0.03, 0.02, and 0.03 standard deviations, respectively. Moreover, a one-year increase in mother's education reduces the incidence of stunting, wasting, and underweight by 1, 0.3, and 1 percentage points, respectively. Furthermore, we find similar results when we instead concentrate on the sample of sisters

[16] The difference could result from the fact that Lindeboom et al. (2009) and McCrary and Royer (2011) adopt different empirical strategy (IV and RDD, respectively) and look at birth outcomes rather than child health outcomes.

born up to five years apart (Panel B). These estimates are comparable in magnitude and significance level to those found in the main results.

Next, we gradually narrow the age window between sisters. The smaller the age differential, the more similar the early environments between sisters. Specifically, in Panel C, we focus on sisters who are at most two years apart. Doing so leaves our estimated effects on child health intact. Particularly, an additional year of mother's education raises child's height-for-age, weight-for-height, and weight-for-age z-scores by 0.03, 0.02, and 0.03 standard deviations, respectively. Maternal education, at the same time, decreases the incidence of stunting, wasting, and underweight.

Table 5: Robustness Checks

	(1)	(2)	(3)	(4)	(5)	(6)
	Height-for-age z-score	Weight-for-height z-score	Weight-for-age z-score	Stunting	Wasting	Underweight
Panel A: Age Difference ≤ 10 years						
Mother's Education	0.037***	0.022***	0.037***	-0.010***	-0.003***	-0.010***
	(0.006)	(0.005)	(0.006)	(0.002)	(0.001)	(0.001)
Observations	21,428	21,428	21,428	21,428	21,428	21,428
Panel B: Age Difference ≤ 5 years						
Mother's Education	0.037***	0.017***	0.033***	-0.011***	-0.003**	-0.011***
	(0.007)	(0.005)	(0.007)	(0.002)	(0.001)	(0.002)
Observations	15,387	15,387	15,387	15,387	15,387	15,387
Panel C: Age Difference ≤ 2 years						
Mother's Education	0.033***	0.021**	0.034***	-0.007*	-0.004*	-0.011**
	(0.011)	(0.009)	(0.011)	(0.004)	(0.002)	(0.004)
Observations	6,954	6,954	6,954	6,954	6,954	6,954
Panel D: Twin						
Mother's Education	0.049	0.019	0.041	-0.031**	-0.000	-0.032**
	(0.050)	(0.022)	(0.032)	(0.015)	(0.007)	(0.013)
Observations	736	736	736	736	736	736

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on Mother's Education where each child health outcome is regressed on the educational attainment of the mother, sister fixed effects, and other controls. Controls include the birth order of the mother, the age difference between the mother and her sister, birth order of the child, whether the child is a plural birth, and region-specific mother's birth cohort trend.

Finally, we restrict our sample to children born to twin sisters (their mothers are twins) in Panel D. It is worth noting that the identifying assumption is most likely to hold for twins as they share not only the same environment but also the same genes. Maternal education has positive impacts on all anthropometric z-scores. The magnitude of the estimates are slightly larger than the estimates in other panels and in the main results. Although there is not enough statistical power, it does not indicate the absence of an actual effect (Amrheim et al., 2019). Mother's education also reduces the probability of the child being stunted and underweight. Collectively, these robustness checks further strengthen our main results reported in Table 4.

5.3 Potential Mechanisms

In this section, we explore potential channels through which maternal education improves child health using the sister fixed effects model. As discussed in Section 4, we divide potential channels into five main groups: (i) fertility behavior, (ii) husband characteristics, (iii) utilization of health care service, (iv) access to information as well as health knowledge, and (v) labor market outcome. The estimating results are provided in Table 6.

Fertility Behavior – First, the increase in educational accumulation may lead to declining fertility (Osili and Long, 2008; Dincer et al., 2014; Lavy and Zablotsky, 2015; Keats, 2018). The decrease in the number ("*quantity*") of children enables mothers to allocate more resources to their existing kids, leading to an increase in child "*quality*" (Becker and Lewis, 1973; Hanushek, 1992; Li et al., 2008). This is the classical quantity-quality trade-off of children (Becker, 1960). Second, prior studies suggest that women tend to delay childbearing as they attain more educational years (Frost et al., 2005; Dincer et al., 2014; Grepin and Bharadwaj, 2015; Neels et al., 2017) and mother's age at birth tends to affect child's health outcomes (Francesconi, 2008; Paranjothy et al., 2009).

We capture mother's fertility behavior by the number of children she ever gives birth to (Number of Children), and mother's age at first birth (Age at First Birth). As evident from Column 1, Panel A of Table 6, a one-year increase in mother's education is associated with a decrease of approximately 0.02 births. As reported in Column 2 of Panel A, an additional year of maternal education increases mother's age at first birth by 0.11 years. It is likely that the reduction in fertility and increased age at first birth contribute to the improvement in child health.

Husband Characteristics – Better-educated women tend to marry better-educated men, a pattern known as assortative matching (Becker, 1973; Siow, 2015). Therefore, two parents with a high level of education could generate substantial improvement in child health compared to less educated couples (Breierova and Duflo, 2004; Lindeboom et al., 2009; Chou et al., 2010). In other words, high-quality husband, as the return to female education in the marriage market, could be one pathway to the effects of maternal education on child health.

We measure husband characteristics with the total number of educational years completed by the husband (Husband's Education), and whether the husband currently lives with the family (Husband Presence at Home). As shown in Column 3 of Panel A, an additional year of mother's education is associated with an increase in husband's educational attainment by 0.42 years, suggesting that assortative matching contributes to the favorable impacts of maternal education on child health.[17] However, mother's education does not affect the probability of the husband being present in the family (Column 4, Panel A).

Health Care Service Utilization – Prenatal care is reported to positively influence child health (Makate and Makate, 2016; Liu et al., 2017). Hence, it could potentially be an important pathway if higher educated women are more liable to increase the use of prenatal care (Currie and Moretti, 2003).

To shed light on whether mother's utilization of health care service during pregnancy could explain the impact of mother's education on child health, we analyze the number of prenatal visits by the mother (Number of Prenatal Visits), and three dummy variables respectively indicating whether mother sought prenatal care from formal sources, defined as health care provided by trained medical personnel such as doctors, nurses, and midwives (Prenatal Care from Formal Sources), whether mother delivered the birth at a formal health facility (Delivery at Health Facility), and whether she received delivery assistance from medical professionals (Delivery Assistance from Professionals).

The estimating results are reported in Panel B. Specifically, an additional year of education increases the number of prenatal visits by 0.07 visits, raises the likelihood of women obtaining high-quality prenatal care (service from formal sources) by 1.5 percentage points. Furthermore, improvements in maternal education are also associated with the increase in the probability of delivery at a formal health institution and receipt of delivery assistance from medical professionals by 1.0 and 0.9 percentage points, respectively. The results are consonant with

[17] It is interesting to know the effects of paternal education on child nutrition. We control for father's education in the most extensive sister fixed effects model. Evident from Table A6, the impacts of maternal education remain unchanged although the magnitude is slightly smaller than that in the main results. Paternal education also generates favorable effects on child nutrition but the magnitude is smaller than that of the effects of mother's. The results suggest that paternal education explains part, but not all, of the effects of maternal education.

those reported in Dincer et al. (2014) and Gunes (2015). These findings suggest that mother's increased utilization of high-quality health care service during pregnancy is an important channel transmitting the positive impacts of mother's education on child health.

Table 6: Potential Mechanisms

	(1)	(2)	(3)	(4)
Panel A: Fertility Behavior and Husband Characteristics				
	Number of Children	Age at First Birth	Husband Education	Husband Presence at Home
Mother's Education	-0.018***	0.113***	0.419***	0.005***
	(0.002)	(0.015)	(0.031)	(0.002)
Observations	23,958	23,958	16,235	13,406
Panel B: Health Care Service Utilization				
	Number of Prenatal Visits	Prenatal Care from Formal Sources	Delivery at Health Facility	Delivery Assistance from Professionals
Mother's Education	0.074***	0.015***	0.010***	0.009***
	(0.018)	(0.002)	(0.002)	(0.002)
Observations	20,082	23,958	23,958	23,958
Panel C: Access to Information and Health Knowledge				
	Watch Television	Read Newspaper	Knowledge of Ovulation	Contraception Utilization
Mother's Education	0.013***	0.018***	0.015***	0.009***
	(0.002)	(0.003)	(0.002)	(0.002)
Observations	20,077	19,899	23,943	23,958
Panel D: Labor Market Outcome				
	Currently Working	Worked in the Last 12 Months	Market Work	Mother Earnings
Mother's Education	0.005*	0.006*	0.005*	0.015*
	(0.003)	(0.003)	(0.002)	(0.007)
Observations	22,516	9,438	3,411	1,133

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on Mother's Education where each mechanism variable is regressed on the educational attainment of the mother, sister fixed effects, and other controls. Controls include the birth order of the mother, the age difference between the mother and her sister, birth order of the child, whether the child is a plural birth, and region-specific mother's birth cohort trend.

Access to Information & Health Knowledge – We proceed to investigate whether mother's increased access to information and health knowledge are potential pathways for the effects on child health. First, education enables women to efficiently process information, particularly, to learn and adopt new methods of childcare. Therefore, the effects of maternal education on child health tend to work through the extent to which women access information (Thomas et al., 1991). Second, more educated women are more likely to have better health knowledge (Aslam and Kingdon, 2012; Aguero and Bharadwaj, 2014; Andalon et al. 2014; Dincer et al., 2014), enabling them to "*produce*" healthier children.

To proxy for information access, we generate two dummy variables: (i) the first takes the value of one if mother obtains information from television and zero otherwise (Watch Television), and (ii) the second takes the value of one if mother relies on newspapers as a source of information and zero otherwise (Read Newspaper). We measure health knowledge by dummy variables indicating whether mother knows about ovulation and whether mother utilizes any contraceptive method. Knowledge of Ovulation is coded as one if the mother knows about the ovulation cycle and zero otherwise. Contraception Utilization is also a dichotomous variable taking the value of one if the mother adopts any birth control method and zero otherwise. Mother's utilization of contraception could proxy for wanted pregnancy which positively influences birth outcomes and child health (Eggleston et al., 2001; Gipson et al., 2008).

Evident from Column 1 and 2 of Panel C, an additional year of education increases the likelihood of mothers watching television and reading newspapers by 1.3 and 1.8 percentage points, respectively. From Column 3 and 4, a one-year increase in mother's education is associated with the increase in knowledge of ovulation cycle and contraception utilization by 1.5 and 0.9 percentage points, respectively. These results imply that the access to, and probably the processing of information, along with better health knowledge are crucial in transmitting the positive effects of education.

Labor Market Outcome – Finally, we attempt to see if mother's labor market outcome could explain the impacts of maternal education on child health. Higher educational attainment induces women to be engaged in market work (Evans and Saraiva, 1993; Klasen et al., 2019). Moreover, children born to working mothers tend to be healthier than those born to stay-at-home mothers (Zaslow et al., 1998; Secret and Peck-Heath, 2004). Compared to their non-working counterparts, working women enjoy higher earnings, which allows them to allocate more resources to their children's well-being. Therefore, female engagement in market work along with earnings from work could be one potential pathway to the effects of maternal education on child health.

Mother's labor market outcome is captured by three indicators: Currently Working (takes the value of one if the woman is employed at present and zero otherwise), Worked in the Last 12 Months (takes the value of one if the woman ever has some employment in the past

12 months and zero otherwise), Market Work (takes the value of one if the woman earns cash for work and zero otherwise), and Mother Earnings (the log of mother's annual earnings from work). As evident from Panel D, education increases the likelihood of women currently working and working in the last 12 months. Moreover, education raises not only the likelihood of women getting engaged in market work but also her earnings from work. These estimates suggest that positive effects on child health could be partially explained by the improvements in mother's labor market outcome.

Collectively, we provide evidence that the favorable impacts of maternal education on child health could be, at least in part, attributed to five main groups of mechanisms: (i) mother's fertility behavior (proxied by the number of children and mother's age at first birth), (ii) assortative matching (proxied by husband's education), (iii) mother's health care utilization (proxied by the number of prenatal visits, whether mother sought prenatal care from formal sources, delivered the birth at a health facility, received delivery assistance from professionals), (iv) access to information and health knowledge (proxied by whether the mother watches television, reads newspapers, whether she knows about the ovulation cycle, utilizes contraception), and (v) labor market outcome (proxied by different measures of her labor force participation status and labor earnings). Particularly, the more educated mothers are more liable to reduce the number of births, increase the age at first birth, and marry higher-educated husbands. Moreover, there is a tendency among the more educated women to increase the number of prenatal care visits, to obtain prenatal care from formal sources, to deliver the birth at a formal medical institution, as well as to receive delivery assistance from health professionals. Education further induces mothers to acquire information through television and newspapers, to have knowledge of the ovulation cycle, to adopt contraceptive methods, as well as to be engaged in and earn more from market work.

5.4 Heterogeneity Analyses

In this section, we present the sister fixed effects estimates of the heterogeneous impacts of maternal education on height-for-age, weight-for-height, and weight-for-age measures by continent and income group. The estimating results are reported in Table 7.[18]

[18] For these regressions, we provide robust standard errors. We do not cluster standard errors at the country level because disaggregation by continent and income group would reduce the number of clusters to below 50, which could potentially lead to the problem of downwards-biased cluster-robust variance matrix estimate and over-rejection of the null hypothesis (Cameron and Miller, 2015). We also try clustering at the subnational region level, which results in a large number of clusters. Doing so does not change the

Table 7: Heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)
	Height-for-age z-score	Weight-for-Height z-score	Weight-for-age z-score	Stunting	Wasting	Underweight
Panel A: Africa						
Mother's Education	0.034***	0.021***	0.035***	-0.011***	-0.003**	-0.009***
	(0.008)	(0.007)	(0.007)	(0.003)	(0.002)	(0.002)
Observations	13,507	13,507	13,507	13,507	13,507	13507
Panel B: Eurasia						
Mother's Education	0.020	0.008	0.016	-0.007	-0.003	-0.008*
	(0.014)	(0.010)	(0.011)	(0.005)	(0.003)	(0.005)
Observations	4,178	4,178	4,178	4,178	4,178	4,178
Panel C: Latin America						
Mother's Education	0.044***	0.026***	0.046***	-0.011***	0.000	-0.009***
	(0.010)	(0.008)	(0.009)	(0.003)	(0.001)	(0.003)
Observations	6,273	6,273	6,273	6,273	6,273	6,273
Panel D: Low-income						
Mother's Education	0.032***	0.019***	0.032***	-0.010***	-0.003**	-0.011***
	(0.007)	(0.004)	(0.006)	(0.002)	(0.001)	(0.002)
Observations	17,063	17,063	17,063	17,063	17,063	17,063
Panel E: Middle-income						
Mother's Education	0.045***	0.025***	0.047***	-0.012***	-0.000	-0.006**
	(0.010)	(0.009)	(0.010)	(0.003)	(0.001)	(0.003)
Observations	6,895	6,895	6,895	6,895	6,895	6,895

NOTE: Robust standard errors are provided in the parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on Mother's Education where each child health outcome is regressed on the educational attainment of the mother, sister fixed effects, and other controls. Controls include the birth order of the mother, the age difference between the mother and her sister, birth order of the child, whether the child is a plural birth, and region-specific mother's birth cohort trend.

Disaggregating by continent, the estimated child health return to mother's education in Africa, Eurasia, and Latin America is provided in Panel A, B, and C, respectively. We detect heterogeneity in the impacts of maternal education on child health across continents. For example, an additional year of maternal education raises child's height-for-age z-score by approximately 0.03 standard deviations in Africa, by 0.02 standard deviations in Eurasia, and by 0.05 standard deviations in Latin America (Column 1, Panel A, B, and C). With respect to weight-for-age z-score, the magnitude of the effects is 0.02 standard deviations in Africa, 0.01 standard deviations in Eurasia, and 0.03 standard deviations in Latin America (Column 2, Panel A, B, and C). The pattern is the same for weight-for-age z-score.

significance level of our results reported in Table 7.

The remaining child nutrition indicators (stunting, wasting, and underweight) give us the same picture (Column 4, 5, 6 of Panel A, B, C). Overall, the estimated child health return to maternal education is the highest in Latin America and lowest in Eurasia. We urge a level of caution in comparing these estimates across continents because there are only 10 Latin America countries and 18 Eurasian countries compared to 40 African countries in our sample (see Table B1).

Instead of classifying by continent, we also look at the heterogeneous impacts by income group. Based on the World Bank's classification in 1995, we divide countries in our sample into low-income group (49 countries) and middle-income group (19 countries). The list of countries is provided in Table B1. We report the impacts for low-income and middle-income countries in Panel D and E, respectively. Overall, a higher level of maternal education reduces the incidence of stunting, wasting, and underweight in both groups. The magnitude of the effects on all three anthropometric z-scores is larger for the middle-income group than the low-income group. Specifically, an additional year of maternal education raises child's height-for-age z-score by 0.03 and 0.05 standard deviations in low-income and middle-income countries, respectively. While in the low-income group, a one-year increase in mother's education is associated with a 0.02 standard deviation increase in child's weight-for-height z-score, the estimated impact is 0.03 standard deviations in the middle income sample. We observe the same pattern for child's weight-for-age z-score.

Our findings are in line with those in prior studies which report a larger return to maternal education in higher-income countries compared to lower-income countries. For example, an additional year of mother's education reduces the incidence of low birth weight by 10% and 20% in the US and in Norway, respectively (Currie and Moretti, 2003; Grytten et al., 2014). The corresponding effect is only 5.5% in Taiwan (Chou et al., 2010).

Finally, we conduct a heterogeneity analysis along the line of time. Specifically, we attempt to examine how the relationship between maternal education and child health evolves over time. In our most extensive sister fixed effects model, we include the interaction between mother's education and indicators for survey waves. The coefficient on this interaction captures the differential effects of mother's educational attainment on child anthropometric measures by time. We report the results in Table A7. There is weak evidence this relationship diminishes over time as suggested in Karlsson et al. (2019).

6 Conclusion

By studying a broad context across time and space (68 countries over almost three decades), we investigate the intergenerational effects of maternal education on child health. Our identification strategy compares the average health outcomes of children born to women who are biological sisters and attain different levels of education. We uncover positive impacts of mother's education on child health measured by the three most commonly used indices, namely, height-for-age, weight-for-height, and weight-for-age. Specifically, an additional year of maternal education raises child's weight-for-height z-score by 0.02 standard deviations, and increases child's height-for-age as well as weight-for-age z-scores by 0.04 standard deviations. Mother's education also reduces the probability of the child being stunted, wasted, and underweight. Intuitively, investment in female education could engender beneficial gains for their offspring, in terms of supporting child's normal growth, and cushioning the negative health shocks, thus facilitating a healthy development in child's early life.

We further examine multiple pathways for the effects on child health. We show that mother's education improves child health through fertility behavior, assortative matching, health care utilization, access to information, health knowledge, labor force participation, and labor earnings. Specifically, education enables women to reduce fertility, increase the age at first birth, and marry a well-educated husband. We provide strong evidence that higher educated mothers are more likely to increase both the quantity and quality of health care utilization, which ultimately affects child health. Particularly, women are more liable to increase the number of prenatal care visits, to obtain prenatal care from formal sources, to deliver the birth at a formal medical institution, as well as to receive delivery assistance from health professionals, as she accumulates more education. Moreover, education also enables mothers to acquire information through television and newspapers, to have knowledge of the ovulation cycle, as well as to adopt contraceptive methods. Finally, our results suggest that the increased tendency to participate in the labor market and higher earnings from work could partially explain the link between maternal education and child health.

In addition, we present heterogeneous effects of mother's education by continent and income group. We detect the largest returns to mother education in Latin America and the lowest in Eurasia. However, this finding should be interpreted with caution due to the unbalanced number of countries across the continent. In addition, our estimating results indicate that the impacts of maternal education are larger in magnitude in middle-income countries than in low-income countries.

Given the persistent effects of childhood health over the life-cycle (Martorell, 1999; Almond et al., 2005; Currie, 2009; Dewey and Begum, 2011), our estimating results highlight the importance of maternal education in enhancing economic and social conditions in developing countries. Therefore, government programs which aim to improve access to education for young women could potentially improve child health in the short run, as well as generate aggregate economic benefits in the long run since healthy children will eventually become educated and productive adults themselves. Our findings also suggest that improving access to education for women could help achieve the Millennium Development Goals 4 (reduce child mortality) and 5 (improve maternal health).

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Appendix A

Table A1: Summary Statistics of Additional Variables

	Mean	SD
Fertility Behavior		
Number of Children	2.592	1.814
Age at First Birth	19.867	3.805
Husband's Characteristics		
Husband's Education	6.876	4.962
Husband Presence at Home	0.484	0.499
Health Care Service Utilization		
Number of Prenatal Visits	4.671	3.971
Prenatal Care from Formal Sources	0.647	0.478
Delivery Assistance from Professionals	0.620	0.485
Delivery at Health Facility	0.554	0.497
Access to Information		
Television	0.308	0.462
Newspaper	0.183	0.386
Health Knowledge		
Knowledge of Ovulation	0.819	0.384
Contraception Utilization	0.309	0.462
Labor Market Outcome		
Currently Working	0.486	0.499
Worked in the Last 12 Months	0.168	0.374
Market Work	0.847	0.360

Table A2: Suggestive Evidence on Internal Validity 2

	(1)	(2)	(3)
	Deviation of Mother Education from Group Mean		
Mother is Plural Birth	-0.017		
	(0.389)		
City as Childhood Place of Residence		0.497	
		(0.623)	
Marriage to First Birth Interval (months)			-0.007
			(0.005)
Observations	19,599	19,599	14,958

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on the main explanatory variables from different regressions. Dependent variable is the deviation from (sister) group mean of mother's completed years of education. The main explanatory variables are the deviations from (sister) group mean of mother's characteristics: whether mother is a plural birth, mother's childhood place of residence, and the time interval between marriage to first birth (in months). All regressions control for statistical area-by-wave-by-birth year fixed effects.

Table A3: Suggestive Evidence on Internal Validity 3

	(1)	(2)	(3)
	Mother is Plural Birth	Mother Childhood Place of Residence	Marriage to First Birth Interval (months)
Educational Difference	0.002	0.007	-0.686
	(0.038)	(0.016)	(2.577)
Observations	19,599	19,599	14,958

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on the Educational Difference dummy where each of the mother's characteristics prior to first birth is regressed on Educational Difference and statistical area-by-wave-by-birth year fixed effects. Educational Difference is an indicator that takes the value of one if sisters attain different numbers of educational years and zero otherwise.

Table A4: Impacts of Maternal Education on Child's Anthropometric Measures 2

	(1)	(2)	(3)
	Height-for-age Percentile	Weight-for-height Percentile	Height-for-age Percentile
Mother's Education	0.557***	0.507***	0.741***
	(0.110)	(0.093)	(0.135)
Observations	23,958	23,958	23,958

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on Mother's Education where each child health outcome is regressed on the educational attainment of the mother, sister fixed effects, and other controls. Controls include the birth order of the mother, the age difference between the mother and her sister, birth order of the child, whether the child is a plural birth, age and sex of the child, and region-specific mother's birth cohort trend.

Table A5: Impacts of Maternal Education on Child's Anthropometric Measures 3

	(1)	(2)	(3)	(4)
	Weight (kg)	Height (cm)	Overweight (WHZ)	Overweight (WAZ)
Mother's Education	0.031***	0.059***	0.001	0.000
	(0.006)	(0.021)	(0.001)	(0.001)
Observations	23,958	23,958	23,958	23,958

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Each estimate represents the coefficient on Mother's Education where each child health outcome is regressed on the educational attainment of the mother, sister fixed effects, and other controls. Controls include the birth order of the mother, the age difference between the mother and her sister, birth order of the child, whether the child is a plural birth, and region-specific mother's birth cohort trend. Regressions in Column 1 and 2 also control for the age and sex of the child.

Table A6: Father Education

	(1)	(2)	(3)	(4)	(5)	(6)
	Height-for-age z-score	Weight-for-height z-score	Weight-for-age z-score	Stunting	Wasting	Underweight
Mother's Education	0.030***	0.019***	0.032***	-0.009***	-0.002*	-0.008***
	(0.006)	(0.006)	(0.007)	(0.002)	(0.001)	(0.002)
Father's Education	0.025***	0.001	0.016**	-0.005***	0.000	-0.003**
	(0.006)	(0.005)	(0.006)	(0.001)	(0.001)	(0.002)
Observations	16,235	16,235	16,235	16,235	16,235	16,235

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The reported estimates represent the coefficients on Mother's Education and Father's Education where each child health outcome is regressed on the educational attainment of the mother, educational attainment of the father, sister fixed effects, and other controls. Controls include the birth order of the mother, the age difference between the mother and her sister, birth order of the child, whether the child is a plural birth, and region-specific mother's birth cohort trend.

Table A7: Impacts of Maternal Education Over Time

	(1) Height-for-age z-score	(2) Weight-for-height z-score	(3) Weight-for-age z-score	(4) Stunting	(5) Wasting	(6) Underweight
Mother's Education	-0.006**	-0.002	-0.005*	0.001	-0.000	0.000
× survey wave	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)
Mother's Education	0.063***	0.030**	0.061***	-0.016***	-0.001	-0.011**
	(0.014)	(0.011)	(0.014)	(0.005)	(0.003)	(0.004)
Observations	23,958	23,958	23,958	23,958	23,958	23,958

NOTE: Robust standard errors are clustered at country level. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. The reported estimates represent the coefficients on the interaction between Mother's Education and survey wave as well as Mother's Education in sister fixed effects regressions. Controls include the birth order of the mother, the age difference between the mother and her sister, birth order of the child, whether the child is a plural birth, and region-specific mother's birth cohort trend.

Appendix B

Table B1: List of Countries

	(1)	(2)	(3)
Country	Continent	Income Group	Proportion (%)
Albania	Eurasia	Low	1.28
Armenia	Eurasia	Low	0.92
Angola	Africa	Low	8.40
Azerbaijan	Eurasia	Low	1.55
Bangladesh	Eurasia	Low	13.84
Burkina Faso	Africa	Low	9.31
Benin	Africa	Low	6.91
Bolivia	Latin America	Middle	5.81
Brazil	Latin America	Middle	3.83
Burundi	Africa	Low	1.89
Congo Democratic Republic	Africa	Low	10.36
Central African Republic	Africa	Low	25.72
Congo	Africa	Low	24.35
Cote d'Ivoire	Africa	Low	32.23
Cameroon	Africa	Low	43.14
Colombia	Latin America	Middle	10.99
Dominican Republic	Latin America	Middle	10.65
Egypt	Africa	Middle	8.13
Ethiopia	Africa	Low	4.03
Gabon	Africa	Middle	26.63
Ghana	Africa	Low	2.86
Gambia	Africa	Low	11.72
Guinea	Africa	Low	18.52
Guatemala	Latin America	Middle	6.85
Guyana	Latin America	Low	5.76
Honduras	Latin America	Low	12.75
Haiti	Latin America	Low	19.04
India	Eurasia	Low	7.14
Jordan	Eurasia	Middle	16.45
Kenya	Africa	Low	5.35
Cambodia	Eurasia	Low	11.10
Kazakhstan	Eurasia	Middle	4.62
Comoros	Africa	Low	5.68
Kyrgyz Republic	Eurasia	Low	3.07
Liberia	Africa	Low	13.60
Lesotho	Africa	Middle	8.21
Morocco	Africa	Middle	0.24
Moldova	Eurasia	Middle	1.36
Madagascar	Africa	Low	19.77
Mali	Africa	Low	13.96
Myanmar	Eurasia	Low	9.19
Maldives	Eurasia	Middle	23.43
Malawi	Africa	Low	7.28
Mozambique	Africa	Low	6.71

Nicaragua	Africa	Low	15.86
Nigeria	Africa	Low	7.80
Niger	Africa	Low	11.39
Namibia	Africa	Middle	17.51
Nepal	Eurasia	Low	2.86
Peru	Latin America	Middle	13.55
Pakistan	Eurasia	Low	8.24
Paraguay	Latin America	Middle	22.89
Rwanda	Africa	Low	8.72
Sierra Leone	Africa	Low	11.31
Senegal	Africa	Low	15.15
Sao Tome and Principe	Africa	Low	6.51
Swaziland	Africa	Middle	12.62
Chad	Africa	Low	32.55
Togo	Africa	Low	3.31
Tajikistan	Eurasia	Low	3.77
Timor-Leste	Eurasia	Low	18.40
Turkey	Eurasia	Middle	7.48
Tanzania	Africa	Low	17.10
Uganda	Africa	Low	4.30
Yemen	Eurasia	Low	1.72
South Africa	Africa	Middle	17.38
Zambia	Africa	Low	15.34
Zimbabwe	Africa	Low	3.94

NOTE: Proportion refers to the fraction of observations in our estimating sample (i.e. children with anthropometric z-scores and born to mothers who can be matched with sisters) out of the total observations (i.e. children with anthropometric z-scores and born to mothers who can and cannot be matched with their sisters) in each country. Overall, our sample is approximately 10% of the total observations. The proportion is 12.89%, 7.58%, and 11.21% in Africa, Eurasia, and Latin America, respectively. The proportions in middle-income and low-income countries are 11.51% and 11.14%, respectively.