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PIER Working Paper

21-010

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March 5, 2021

https://ssrn.com/abstract=3798572

Title:

Adolescent Cognitive Gender Gaps Reflect Differential Dynamic Associations with Undernutrition and Poverty in Preschool and Preadolescent Ages

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Short title:

Gender gaps in cognitive achievements

JEL Codes:

I14 'Health and equality'; I24 'Education and Inequality'; N36, N36, and N37 Asia, Latin America and Africa; O15 'Human Resources • Human Development • Income Distribution • Migration'.

Abstract

We look beyond the traditional focus on the gender gap in schooling attainment by investigating how gender differences in cognitive achievement in mid-childhood and adolescence are associated with trajectories of deprivation, measured by undernutrition and poverty. This study uses longitudinal data that include math, reading, and receptive vocabulary test scores at ages eight and 15 years for children in four low- and middle-income countries.

We find associations between nutrition status in preschool years and cognitive achievements more substantial for eight-year-old girls than their male counterparts. Between ages eight and 15, however, the cognitive development of girls is less responsive than for boys to their growth and poverty (proxied by wealth at age 12 years). We find significant associations of the test scores in math and reading at age 15 with nutritional status at age 12 and with preadolescence wealth at age 12 for boys in India and Peru, as well as all boys in the pooled sample. Consequently, considerable gender gaps are observed unfavorable to girls in cognitive achievement at age 15 for India and Peru. This study adds another rationale for governments in countries with significant stunting prevalence and gender gaps favoring males to invest more in preschool children.

Keywords: Gender differences, undernutrition, poverty, cognitive development, low- and middle-income countries

1. Introduction

The developing world witnessed impressive progress in education as measured by schooling attainment over the last fifty years, particularly for females with the previous gender gap greatly favoring males being reduced as a result.[1] The overall schooling increase and the reduction in gender gaps are important achievements for many low- and medium-income countries (LMICs). In many LMICs, however, females' schooling still lags behind that of males, particularly for adolescents at the secondary and tertiary levels (Evan et al., 2020). The United Nations (UN) 2030 Agenda for Sustainable Development envisages 'a world of equal opportunity permitting the full realization of human potential and contributing to shared prosperity' (UN, 2015:5). This document recognizes, however, that in the world today there 'are enormous disparities of opportunity, wealth and power. Gender inequality remains a key challenge' (UN, 2015:6). The World Bank emphasizes that gender inequalities are likely to cause misallocations of human capital investments, reduce productivities and increase income and wealth inequalities (World Bank 2012).

The adolescent educational gender gap, of course, reflects possible gender differentials since birth. Very influential *Lancet* estimates are that ~250 million children under five years of age are at risk of not being able to fulfill their developmental potential due to early-life deprivations (Black, et al 2017; Lu, Black and Richter 2016). The *Lancet* estimates are based primarily on chronic undernutrition as reflected in stunting and secondarily on living in poverty as indicators of child deprivations. The previous literature has not assessed, however, to what extent adolescent gender gaps in education reflect gender differences in associations with undernutrition and poverty through mid-childhood starting at age five and into adolescence.

The purpose of this paper is to help fill this important gap in the literature by estimating the gender differences in the associations between adolescent education at age 15 and earlier deprivations as measured by nutritional status and poverty. We advance over the previous literature in a number of ways. First, to represent education we use cognitive test performance rather than schooling attainment that is used in most of the previous literature because, as is increasingly recognized, schooling attainment is a noisy measure of learning, particularly in developing countries (Pritchett 2013; Filmer, et al. 2020). Second, we consider the predictive power of earlier deprivations not only in the preschool ages that have been emphasized in much of the previous literature such as the *Lancet* series on early childhood development referred to above, but also in mid-childhood and early adolescence. Third, in contrast to most of the literature that focuses on gender differences in investments in children (Behrman and Deolalikar 1990; Cameron and Worswick 2001; Azam and Kingdon 2012), children's time use (Putnick and Bornstein 2016; Singh and Krutikova 2018; Singh and Mukherjee 2018), schooling enrollments and schooling attainment (King and Lillard 1987; King and Mason 2000; Grant and Behrman 2010; World Bank 2010), we focus explicitly on gender differences in the extent to which previous deprivations in various lifecycle stages predict cognitive achievement in adolescence and thus illuminate the mechanisms underlying adolescent educational gender gaps.[2] Fourth, we use carefully collected comparable Young Lives longitudinal data over 14 years from four very different LMICs – Ethiopia, India, Peru and Vietnam—which enhances exploring the generalizability of our results. The OECD (2014) report on Social Institutions and Gender Index categorizes the degree of son bias in these four countries to vary considerably: Peru as "very low," Ethiopia as "low" and India and Vietnam as "very high".

The children under study took tests in math, early grade reading, and receptive vocabulary at ages eight and 15 years. Longitudinal data on nutritional status and household wealth were collected at ages one, five, eight, 12, and 15. Together, these rich data allow us to eliminate the influence of many unobserved individual characteristics and separate the impacts of deprivation in early childhood up to age five from that in mid-childhood and early adolescence. Our approach starts with the null hypothesis that deprivation affects cognitive development of girls the same as boys. We then test the null hypothesis by presenting evidence on the associations of adolescent cognitive outcomes with dimensions of deprivation in different stages of child development and for different countries.

2. Background

The study countries of Ethiopia, India, Peru, and Vietnam represent four major LMIC regions and have diverse socioeconomic and political systems. One year before the children in the sample under study were born, in 2000, the per capita gross domestic product (GDP) adjusted for purchasing power parity (PPP) of Peru was $6,783. In that year, Ethiopia was among the poorest countries globally with a PPP-adjusted GDP of $612. India and Vietnam were in the middle among these four countries, with PPP-adjusted GDPs of $2,650 and $2,600, respectively. Economic conditions changed significantly in the following years in all four countries. Between 2002 and 2012, real GDP in Peru grew at an average annual rate of 6%, which led to substantial poverty reduction. Ethiopia decreased the poverty rate from 44% of the population in 2000 to under 24% in 2015-16. The Asian countries made impressive progress as well. According to OECD's Economic Surveys, about 140 million people in India were taken out of poverty in less than ten years.[3] In the first decade of the new Millennium, Vietnam maintained economic growth averaging 7 percent per year and reached lower-middle-income status in 2010.

Undernutrition in early childhood is a primary indicator of child deprivation, as noted in the introduction. It also is associated with deficits in cognition and school achievement through later childhood (Walker et al., 2007). There is a significant body of literature that used data from LMICs to identify the 1000 days from conception as a critical window during which child growth and cognitive development are particularly susceptible to undernutrition (Prentice et al., 2013). One of the key messages reported by some of these studies is that the nutritional insults in this critical window lead to irreversible damages, and that nutritional interventions after two years are unlikely to have any effects (Victora et al. 2008, 2010). If true, that undermines the motivation for initiatives such as providing school meals or deworming provided through schools. Some more recent studies suggest that, although early interventions are critical, interventions to improve the nutrition of preprimary and primary school-age children also merit serious consideration (Crookston et al., 2013; Fink and Rockers, 2014; Georgiadis et al., 2017; and Bundy et al., 2018).

Focus on early childhood might explain why gender has been reported not to make a difference in the association between nutritional status and cognitive development of children. The evidence on the matter is limited. Glewwe and Miguel (2008) reviewed the empirical literature on relationships between child health, primarily nutritional status, and school outcomes in LMICs and concluded that there is no clear evidence of gender differences in the impact of child health on education.

A second major indicator of child deprivation in the literature, as noted in the introduction, is poverty. A common conjecture is that household socioeconomic status, or wealth, affects performance on cognitive tests separately from any effect of nutritional status. In LMICs, an increase in household wealth is associated with more expenditures on educational inputs. Household wealth affects the time used for studying at home, which is an essential input into academic achievement. For instance, if households own bicycles or have access to electricity and piped water, it takes less time for children to do the washing, cooking, and cleaning in the house and to fetch water or wood for cooking.

3. Methodology

3.1 Data

The data used for the current study were collected by Young Lives, which is an international longitudinal study investigating the changing nature of childhood poverty in four LMICs over 15 years (Barnett et al., 2013). Twenty sentinel sites per study country were selected non-randomly to cover all but the richest areas, while within each sentinel site, 100 households with children of the targeted birth cohort were chosen randomly.[4] The concept of a sentinel site comes from health surveillance studies and entails a form of purposive sampling in which the site is deemed to represent a certain type of population and is expected to show typical trends affecting those people or areas. In the Young Lives data, sentinel sites in Ethiopia are based on *kebeles*, which are the lowest level of administration. For India, *mandals*, which are administrative areas containing between 20 and 40 villages, are the sentinel sites. The sentinel sites in Peru are districts. For Vietnam, a sentinel site is defined as a commune; or if a commune selected as a sentinel site had an insufficient number of one-year-old children, then neighboring communes with similar socioeconomic conditions were additionally selected to have enough children to allow a random selection of ~100 one-year-old children. Overall, the sampled households were similar to national averages, with slightly poorer-than-average households in Vietnam and slightly better-off-than-average households in India and Ethiopia (Fink and Rockers, 2014).

3.2 Study indicators

Young Lives has completed five rounds of surveys to date. The first round of data collection from primary caregivers took place in 2002 when children in the Younger Cohort[5] were approximately one year of age (plus or minus six months). At this age to represent long-run nutritional status, supine length was measured using standardized length boards. At ages five, eight, 12, and 15 years in Rounds 2, 3, 4, and 5 to represent long-run nutritional status, standing heights were measured to 1 mm with standardized stadiometers. These data are used to calculate the height-for-age z-score (HAZ) using WHO standards for well-nourished populations as reference populations (WHO 2006; De Onis et al. 2007). Child characteristics also include child sex and whether the child is the mother's eldest.

Young Lives data include measures of cognitive development at different ages. In all survey rounds from age five, children's skills in receptive vocabulary were tested using locally-adapted versions of the Peabody Picture Vocabulary Test (PPVT). Quantitative skills were assessed using paper-based mathematics tests at ages eight, 12, and 15 years. The Early Grade Reading Assessment (EGRA) was conducted at age eight, and tests for reading comprehension were administered at ages 12 and 15 years. More details on the psychometric characteristics of cognitive skills instruments used with the Young Lives children can be found in Cueto and Leon (2013).

Household characteristics include a wealth index, mother's ethnicity/caste and schooling, and father's schooling. Wealth is measured as an index that ranges from 0 to 1 and is constructed as the simple average of three indicators of standards of living: housing quality, consumer durables, and services. Housing quality uses the mean rooms per person as a continuous variable and dichotomous variables on the quality of materials used to build the roofs, walls, and floors. The consumer durables index reflects ownership of basic consumer durables, including radios, refrigerators, bicycles, motorcycles, cars, mobile phones, landline phones, fans, and televisions. Finally, the services index encompasses access to safe drinking water, electricity, sanitation facilities, and cooking fuel. More details on the wealth index can be found in Briones (2017). We use wealth as an inverse indicator of poverty, the second major factor emphasized with regard to child deprivation in the prior literature (see the introduction). For each parent's schooling, we use a dummy variable for whether the parent completed primary school.[6] Finally, we use a set of dummy variables to characterize the caste of the mother in India and the mother's ethnicity in the other three countries.

3.3 Modeling and statistical methods

We focus on equations that highlight the relations between the two deprivation indicators, nutritional status (inversely related to undernutrition) and wealth (inversely related to poverty), and cognitive skills in mid-childhood (age eight) and adolescence (age 15). Age eight is of interest because it is in mid-childhood, and is pre-puberty for most children (Rogol, Clark, and Roemmich 2000). The deprivation indicators are for different ages across the estimates, at the end of the preschool period (age five) for equation 3 in which cognitive skills at age eight are the dependent variables, and at preadolescence (age 12) for equation 4 in which cognitive skills at age 15 are the dependent variables.

3.3.1 Definitions of instrumental variables

The analysis in this study involves some right-side variables that may be endogenous, which can lead to inconsistent estimates. To deal with this possible problem, we apply a set of instrumental variables (IVs). One of these instrumental variables is the unpredicted change in nutritional status between ages one and five, defined as the residual term in the following Ordinary Least Squares (OLS) regression in the country single-sex samples:

$$H_{5y} = a_0 + a_1 H_{1y} + a_2 ctrl0 + g_{1\_5y} \quad \text{(0a)}$$

where H_{5y} is the height-for-age z-score (HAZ) at the age of five and H_{1y} is HAZ at age one. The vector $ctrl0$ includes factors such as whether the child is the mother's first-born, parental schooling, and mother's ethnicity, or caste in the case of India. g_{1_5y} is by construction uncorrelated with H_{1y} and with the underlying determinants of H_{1y}. Therefore, for example, if fixed long-run parental preferences or resources or child genetics affect H_{1y}, they are not correlated with g_{1_5y}.

Analogously, the unpredicted change g_{5_8y} in HAZ between ages five and eight is estimated using equation (0b), and the corresponding variable for the period to age 12 years is defined by equation (0c).

$$H_{8y} = b_0 + b_1 H_{5y} + ctrl0 + g_{5\_8y} \quad \text{(0b)}$$

$$H_{12y} = c_0 + c_1 H_{8y} + ctrl0 + g_{8\_12y} \quad \text{(0c).}$$

Again g_{5_8y} is uncorrelated with H_{5y} and the determinants of H_{5y} and g_{8_12y} is uncorrelated with H_{8y} and the determinants of H_{8y}. We use these instruments in Two-Stage Least Squares (2SLS) estimates of equations that contain child height-for-age on their right sides. In addition to the unpredicted changes in H, the IVs also include preschool wealth. The latter is used in 2SLS regressions of equations 4 and 6, which contain lagged cognitive outcomes among the explanatory factors.

3.3.2 Estimates of associations of cognitive skills at ages eight and 15 with earlier undernutrition and poverty

Equation 1 specifies the relations of cognitive development at age eight with (a) preschool child nutritional status at age five and (b) preschool household wealth at age five.

$$C_{8y} = \alpha_0 + \alpha_1 H_{5y} + \alpha_2 W_{5y} + ctrl0 + u \quad \text{(1)}$$

where C_{8y} are the cognitive tests scores (math, early grade reading, and receptive vocabulary) at age eight; H_{5y} is HAZ at age five years; and W_{5y} is the household wealth index at age five years. Finally, $ctrl0$ is defined the same as in equations 0a-c.

Equation 2 relates adolescent cognitive skills with preadolescent nutritional status and wealth. We use value-added models as in Singh (2015) and Aurino et al. (2019a) to estimate the associations with preadolescent nutritional status and household wealth, conditional on the cognitive outcomes in mid-childhood (age eight). As Aurino et al. (2019a) state, "The value-added models are commonly considered the most robust approach in the face of potential biases stemming from missing data on endowments and educational inputs in observational data." These studies use lagged cognitive scores, which control not only for latent abilities but also the influence of shocks in earlier life-cycle stages that might have long-run effects on child development. For cognitive outcomes at age 15, we use the following value-added model.

$$C_{15y} = \beta_0 + \beta_1 H_{12y} + \beta_2 W_{12y} + ctrl1 + \bar{u} \quad (2),$$

where C_{15y} represents one of the scores (math, reading, or receptive vocabulary) on the tests administered at age 15 years; H_{12y} is HAZ at age 12, W_{12y} is the household wealth index at age 12 years, $ctrl1$ includes all the factors in $ctrl0$ and the test score at age eight for the same test used at age 15 as the dependent variable in the value-added specification. Specifically, $ctrl1$ contains the math score at eight if C_{15y} is the outcome for math at 15 (and similarly for receptive vocabulary). We use EGRA as the lagged outcome in the case of reading. Equations 1 and 2 will be used as building blocks for equations 3, 4, 5 and 6 below.

3.3.3 Use of interaction factors to estimate gender differences in the associations of child cognition with previous nutritional status and poverty

The focus of this study is on gender differences, captured by interaction terms with the dichotomous variable *F* that equals one if the child is a girl (female). For the outcomes at age eight, we estimate the following equation:

$$C_{8y} = RHS\ (1) + F \times RHS(1) + v \quad (3)$$

where $RHS\ (1)$ is the right-hand side of equation 1. The coefficients in $RHS\ (1)$ and the corresponding ones in $F \times RHS(1)$ generally are not identical because of differential gender effects. The variables H_{5y} in $RHS\ (1)$ and $F \times H_{5y}$ in $F \times RHS(1)$ will be treated as endogenous in estimation of equation 3. We use g_{1_5y} and $F \times g_{1\_5y}$ as IVs.

Equation 4 will be used to estimate the gender differences in the relations of adolescent cognitive skills at age 15 with preadolescent nutritional status and wealth at age 12.

$$C_{15y} = RHS\ (2) + F \times RHS(2) + \bar{v} \tag{4}$$

where $RHS\ (2)$ is the right-hand side of equation 2. As in equation (3) above, the coefficients in $RHS\ (2)$ and the corresponding ones in $F \times RHS(2)$ generally are not identical. The variables H_{12y} and $F \times H_{12y}$ and the test scores at age eight and their interactions with F will be treated as endogenous. For estimation of equation 4, IVs include all the unpredicted changes g_{1_5y}, g_{5_8y}, g_{8_12y} and the household wealth index at age five, and their interactions with F.

3.3.4 Application of double interactions to study heterogeneity in the effect of deprivation across countries.

The discussions on gender difference in health outcomes often involve behavioral factors such as discrimination against girls (Deaton, 2008) and son bias (Schwekendiek and Baten, 2019) which, as noted above, may vary across countries. We therefore allow for the possibility that the effects of deprivation on cognitive achievement vary across the countries. We treat Ethiopia as the default category, and introduce dichotomous variables to present the differences between the estimates for the other three countries from those for Ethiopia. Specifically, $S_1 = 1$ if the child is from India, zero otherwise. Similarly, the dichotomous variable $S_2 = 1$ if Peru, and $S_3 = 1$ if Vietnam, zero otherwise. Formally, the equation involving interaction terms with $S_j, j = \overline{1,3}$, include interactions of higher orders as well. Note, however, $S_i \times S_j = 0$ if $i \neq j$. That allows us to ignore the interactions involving more than one of the dichotomous variables $S_j, j = \overline{1,3}$. Having dropped such high-order interactions, equations for the outcomes at age eight can be written as the following.

$$C_{8y} = (1 + S_1 + S_2 + S_3) \times RHS(3) + \varepsilon \quad (5),$$

where $RHS\ (3)$ is the right-hand side of equation 3.

The same dichotomous variables S_1, S_2, and S_3 are used in the investigation of the difference in the impact of deprivation in preadolescence on cognitive achievement in adolescence.

$$C_{15y} = (1 + S_1 + S_2 + S_3) \times RHS(4) + \bar{\varepsilon} \quad (6),$$

where $RHS\ (4)$ is the right-hand side of equation 4.

The variables on height-for-age at ages five and 12 years will be treated as endogenous, and so are their interactions with $S_j, j = \overline{1,3}$. We apply the same method to the lagged outcomes. In addition to IVs for equations 3-4, their interactions with the dichotomous variables S_1, S_2, and S_3 will be used as IVs for equations 5-6.

4. Results

Table 1 provides basic statistics about the key variables used in the analyses. It shows slightly more boys (52.5%) than girls (47.5%). As the numbers of questions differ among the tests, we rescale raw scores (in Table 1) so that all test scores have standard deviations equal to 10 to facilitate interpreting the estimates. Gender differences in test scores are all insignificant for Ethiopia, for which reason we use Ethiopia as the reference country in the pooled estimates in Appendix Tables B2 and B5. In India and Peru, however, boys scored significantly higher than girls for one test at age eight (PPVT in India, math in Peru) and for two tests at age 15 (math and PPVT in both countries). For Vietnam, on the other hand, girls outperformed boys in reading at

Table 1: Descriptive statistics of key variables

	Ethiopia			India			Peru			Vietnam		
	Girls	Boys	t	Girls	Boys	t	Girls	Boys	t	Girls	Boys	t
Math raw score at age eight	9.54	10.04	-1.28	16.75	17.04	-0.68	19.35	20.53	-3.10	26.90	26.92	-0.05
Early grade reading at age 8	14.99	14.76	0.52	15.39	14.90	1.11	22.18	22.23	-0.11	28.00	27.20	2.41
PPVT raw score at age 8	23.65	24.13	-0.69	16.17	17.98	-4.25	17.12	17.50	-1.60	27.15	27.74	-1.56
Math raw score at age 15	9.29	9.49	-0.85	9.89	10.82	-3.77	11.00	12.12	-5.01	14.77	13.90	2.78
Reading raw score at age 15	14.69	14.36	1.10	13.96	13.66	1.48	16.98	16.94	0.20	14.92	13.20	7.22
PPVT raw score at age 15	41.83	42.30	-1.13	47.10	48.22	-3.05	95.04	98.40	-4.13	59.90	59.83	0.16
HAZ at age 5 (H_{5y})	-1.32	-1.41	1.57	-1.61	-1.69	1.86	-1.53	-1.50	-0.62	-1.35	-1.34	-0.08
Stunted at age 5($H_{5y} < -2$)	0.26	0.30	-1.43	0.34	0.37	-1.52	0.33	0.31	0.75	0.23	0.27	-1.90
HAZ at age 12 (H_{12y})	-1.43	-1.41	-0.33	-1.49	-1.40	-1.78	-1.05	-0.98	-1.22	-1.07	-1.02	-0.86
HAZ Change ($H_{12y} - H_{5y}$)	-0.11	-.00	-2.32	0.12	0.29	-5.01	0.48	0.51	-0.84	0.28	0.32	-1.32
Wealth index at age 5	0.30	0.30	-0.92	0.46	0.46	0.44	0.47	0.48	-1.40	0.49	0.50	-0.79
Wealth index at age 12	0.38	0.39	-1.44	0.58	0.60	-1.81	0.60	0.60	-0.87	0.62	0.62	-0.15
First child of mother	0.25	0.23	0.88	0.41	0.37	1.35	0.38	0.37	0.41	0.46	0.47	-0.52
Mother's schooling†	0.30	0.34	-1.59	0.40	0.39	0.58	0.72	0.72	0.22	0.76	0.76	0.03
Father's schooling†	0.45	0.44	0.36	0.56	0.56	0.22	0.82	0.82	-0.03	0.80	0.78	0.95
First born	0.25	0.23	0.88	0.41	0.37	1.35	0.38	0.37	0.41	0.46	0.47	-0.52
Number of children	660	752		779	955		839	853		840	888	

Notes: †Mother's schooling is a dummy variable for completion of first cycle primary grade 4 (Ethiopia), primary school grade 5 (India), primary school grade 6 (Peru), and primary school grade 5 (Vietnam). The same definitions apply for father's schooling.

t-test for H_{5y} of girls in Ethiopia and Vietnam equal that for girls in India and Peru: 6.48 (p-val: <0.0001)

t-test for rate stunting at age five for girls in Ethiopia and Vietnam equal that for girls in India and Peru: -5.54 (p-val: <0.0001)

t-test for rate stunting at age five for boys in Ethiopia and Vietnam equal that for boys in India and Peru: -3.98 (p-val: 0.0001) both ages and in math at age 15. Thus, for three of the four countries the number of significant gender differences in test scores increased from one to two between ages eight and 15, though in India and Peru the gender differences favored boys and in Vietnam they favored girls.

At age five, the average HAZ for girls in Ethiopia was the same as that for girls in Vietnam. As noted above, in 2000 the GDP per capita of Ethiopia was below that of India and Vietnam, which in turn were below that of Peru. Nevertheless t-tests confirm that the average HAZ at age five for girls in Ethiopia and Vietnam is above that for India and Peru[7]. A similar pattern for the nutritional status at age five for boys between the two groups of countries also holds true. Between ages five and 12, the country average HAZ improves, except for Ethiopia. Finally, the statistics in Table 1 indicate that even though household characteristics differ significantly across the countries, they are about the same for boys and girls within countries.

4.1 Estimates for gender differences in the associations of cognitive skills at age eight with preschool nutritional status and household wealth

As mentioned above, nutritional status at five (H_{5y}) and the interaction $F \times H_{5y}$ are treated as endogenous. In estimations of equation 3, we use two IVs, which are the unpredicted change in nutritional status $g_{1_5y}$and interaction $F \times g_{1\_5y}$. The estimates for the instruments and the F-statistics for the first-stage regressions in Table A1 are all sufficiently strong to justify the selection of the instruments. The first four panels in Table 2 present the 2SLS estimates for equation 3 for the four countries, and the final one does so for the pooled sample. For each of the three tests there are two columns: the first one contains the estimates for boys and the second contains the estimates for the interaction terms with the dummy variable F, which is equal to one if the child is a girl. The estimates of the interaction term coefficients give the gender differences in the associations between the variable in each row and the corresponding outcome. The total effect for girls is the sum of the effect for boys in the first column and the interaction effect in the second column and is significantly different from the effect for boys if the interaction term has a significant coefficient estimate. We use the term "significant" to refer to significance at the conventional 0.05 level unless otherwise qualified.

Table 2: 2SLS regressions for equation 3 of the outcomes at age 8

	Math		Reading		PPVT	
		Inter. $\times F$		Inter. $\times F$		Inter. $\times F$
Panel A: Ethiopia						
HAZ at age 5 (H_{5y})	0.732*** (0.237)	0.239 (0.350)	0.736** (0.294)	0.083 (0.434)	1.516*** (0.428)	0.455 (0.632)
Norm. wealth at 5 (W_{5y})	3.462*** (0.325)	-0.408 (0.490)	2.777*** (0.403)	0.027 (0.608)	4.545*** (0.587)	0.996 (0.884)
Panel B: India						
HAZ at age 5 (H_{5y})	0.682** (0.338)	1.098** (0.510)	0.537 (0.379)	0.207 (0.573)	0.507 (0.351)	0.149 (0.529)
Norm. wealth at 5 (W_{5y})	0.440 (0.371)	0.620 (0.537)	-0.978** (0.417)	2.020*** (0.604)	1.008*** (0.386)	0.524 (0.558)
Panel C: Peru						
HAZ at age 5 (H_{5y})	0.689** (0.322)	0.702 (0.451)	0.766** (0.372)	0.003 (0.521)	0.573*** (0.182)	-0.095 (0.256)
Norm. wealth at 5 (W_{5y})	1.753*** (0.273)	0.077 (0.388)	1.543*** (0.315)	1.103** (0.449)	1.383*** (0.155)	0.541** (0.220)
Panel D: Vietnam						
HAZ at age 5 (H_{5y})	0.759** (0.312)	1.020** (0.517)	0.360 (0.294)	1.310*** (0.486)	0.735** (0.323)	0.713 (0.535)
Norm. wealth at 5 (W_{5y})	2.681*** (0.339)	-0.508 (0.477)	1.998*** (0.319)	-0.588 (0.449)	2.622*** (0.351)	-0.056 (0.494)
Panel E: All countries						
HAZ at age 5 (H_{5y})	0.690*** (0.152)	0.713*** (0.227)	0.589*** (0.169)	0.344 (0.253)	0.824*** (0.173)	0.276 (0.258)
Norm. wealth at 5 (W_{5y})	1.966*** (0.161)	-0.037 (0.232)	1.328*** (0.180)	0.712*** (0.259)	2.104*** (0.183)	0.309 (0.264)

Notes: Control variables include sex (***F***), first born, mother's education, father's education, caste/ethnicity, and their interactions with the dichotomous variables on sex and the countries
***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The estimates in Table 2 show that there are positive associations of nutritional status at age five with cognitive achievements for boys at age eight for all three cognitive tests in all four countries, all but three of which are statistically significant.[8] The estimates of the interaction terms are positive in 11 of the 12 cases (the exception is PPVT for Peru), significantly so in three cases (math in India, math and reading in Vietnam). Thus, the dominant pattern is for girls' test performances at age eight to be as associated or more associated with their nutritional status at age five than for boys in the individual countries and in Panel E for the pooled sample.

Table B2 in Appendix presents 2SLS estimates for equation 5, which indicate whether the estimates differ significantly for the other three countries from the default country (Ethiopia). The patterns across countries generally do not differ significantly with the exception that for Ethiopia the coefficient estimate for nutritional status at age five in the relation for PPVT is significantly larger for boys and girls than in the other countries (Table B2).

Household wealth at age five has significantly positive associations with all three test scores at age eight for boys in Ethiopia, Peru and Vietnam and for PPVT in India and an insignificant positive association for math in India, but a surprising negative significant association with reading in India. The interaction terms indicate that for eight of the nine cases in India, Ethiopia and Peru, the associations with household wealth at age five and the test scores are as large or significantly larger (for reading in India and reading and PPVT in Peru) for girls than for boys. For all three test scores in Vietnam and for math in Ethiopia, in contrast, the coefficient estimates for the interaction terms are negative, though in none of these four cases is the estimate significant even at the 0.10 level. The estimates for all countries in Panel E suggest that the associations between household wealth at age five and cognitive test scores at age eight tend to be as large or larger for girls than for boys.

Across countries, Table B2 shows that the associations are smaller (significantly so in seven of the nine cases) for the other three countries than for Ethiopia for boys, but the coefficient estimates on the interaction terms for girls are larger in math and reading for India and Peru (significantly so for reading in India) than for Ethiopia. The coefficient estimates on the interaction terms for girls tend to be smaller for Vietnam in all the tests (none significant) relative to Ethiopia.

Table C1 includes coefficient estimates for being first child of mother (five of the 12 coefficient estimates for boys are significantly positive), mother completed primary school (11 of the 12 coefficient estimates for boys are significantly positive) and father completed primary school (seven of the 12 coefficient estimates for boys are significantly positive and another three at the 0.10 level). These patterns are fairly similar to those in the previous literature. What is of primary interest for this study is the possibility of gender differences. These appear to be fairly limited, with no significant gender differences for being the first child of the mother, only one significant gender difference for mother completed primary school (smaller association for girls for PPVT in Peru), and only one significant (at the 0.10 level) gender difference for father completed primary school (smaller association for girls for PPVT in Peru).

4.2 Estimates for gender differences in the effect of preadolescence deprivation at age 12 on cognitive achievements at age 15 with value-added model including cognitive achievements at age eight

The endogenous variables in equation 4 for cognition at age 15 are HAZ at age 12 and the lagged outcomes (at age 8). The IVs include all the unpredicted growths defined in equations 0b-c, as well as their interactions with the dummy variables of F. Furthermore, IVs include household wealth indices at five, and their interactions with F . The description in the statistics in Sub-Appendix B1 and statistics in Table B1 justify the selection of the instruments.

Table 3 is organized like Table 2 but with the focus on nutritional status and wealth at age 12 instead of at age five and with the lagged outcomes at age eight among the right-side variables in the value-added model. The estimates for the lagged outcomes are positive and significant in most cases, including all the test outcomes for the pooled sample. Table B5 in the Appendix presents

2SLS estimates for equation 6, which indicate whether the estimates differ significantly for the other three countries from the default country, Ethiopia.

Table 3: 2SLS regressions for equation 4 of the outcomes at age 15

	Math		Reading		PPVT	
		Inter. × F		Inter. × F		Inter. × F
Panel A: Ethiopia						
HAZ at age 12 (H_{12y})	0.232 (0.353)	0.021 (0.473)	-0.527 (0.629)	0.900 (0.809)	-0.026 (0.168)	0.025 (0.227)
Norm. wealth at 12 (W_{12y})	-0.152 (0.629)	0.963 (0.801)	-0.793 (1.210)	2.584* (1.485)	0.288 (0.273)	0.195 (0.399)
Lagged outcomes (at 8y)	0.848*** (0.198)	-0.072 (0.262)	1.309*** (0.454)	-0.716 (0.557)	0.269*** (0.063)	-0.075 (0.081)
Panel B: India						
HAZ at age 12 (H_{12y})	1.046*** (0.352)	-1.824** (0.923)	1.162*** (0.310)	-1.243* (0.690)	0.071 (0.185)	0.063 (0.321)
Norm. wealth at 12 (W_{12y})	1.161** (0.481)	-0.722 (0.902)	1.680*** (0.390)	-0.776 (0.872)	0.016 (0.412)	0.723 (0.505)
Lagged outcomes (at 8y)	0.479 (0.343)	0.548 (0.575)	0.227 (0.262)	0.446 (0.585)	0.302 (0.288)	-0.445 (0.340)
Panel C: Peru						
HAZ at age 12 (H_{12y})	0.631** (0.310)	-0.828* (0.485)	0.538* (0.318)	-0.157 (0.441)	0.225 (0.242)	-0.029 (0.330)
Norm. wealth at 12 (W_{12y})	-0.005 (0.744)	-0.243 (0.918)	0.040 (0.742)	-0.137 (1.061)	0.558 (0.542)	1.100 (0.684)
Lagged outcomes (at 8y)	0.577* (0.322)	0.312 (0.385)	0.409 (0.341)	0.243 (0.400)	0.847*** (0.303)	-0.375 (0.350)
Panel D: Vietnam						
HAZ at age 12 (H_{12y})	0.256 (0.388)	-0.188 (0.579)	0.390 (0.341)	-0.312 (0.579)	0.215 (0.143)	0.029 (0.201)
Norm. wealth at 12 (W_{12y})	1.176 (1.075)	-0.015 (1.329)	0.258 (1.034)	1.183 (1.346)	-0.055 (0.292)	0.072 (0.415)
Lagged outcomes (at 8y)	0.946*** (0.275)	0.043 (0.355)	1.032*** (0.329)	-0.259 (0.473)	0.149 (0.092)	-0.001 (0.121)
Panel E: All countries						
HAZ at age 12 (H_{12y})	0.488*** (0.188)	-0.636** (0.296)	0.409* (0.222)	-0.287 (0.327)	0.054 (0.112)	-0.145 (0.162)
Norm. wealth at 12 (W_{12y})	0.132 (0.406)	0.066 (0.527)	0.068 (0.661)	0.414 (0.826)	0.380* (0.220)	0.482 (0.303)
Lagged outcomes (at 8y)	0.839*** (0.165)	0.075 (0.214)	0.899*** (0.325)	-0.118 (0.376)	0.401*** (0.088)	-0.111 (0.113)

Notes: HAZ at age 12, the lagged outcomes and their interactions with $\boldsymbol{F}, \boldsymbol{S_1}, \boldsymbol{S_2}, \boldsymbol{S_3}$ are treated as endogenous. Control variables include sex ($\boldsymbol{F}$), first born, mother's education, father's education, caste/ethnicity, and their interactions with the dichotomous variables on sex and the countries
***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The estimates in Table 3 indicate that there are some significant associations with the two deprivation indicators related to nutritional status and health in preadolescence at age 12 in addition to the significant associations discussed above with these two deprivation indicators at age five working through the lagged outcomes at age eight. In particular, the associations are significantly positive for boys for nutritional status at age 12 for math and reading at age 15 in India and Peru (at the 0.10 significance level for reading in Peru) and for household wealth at age 12 for math and reading at age 15 in India.

The coefficient estimates for the interaction terms indicate significantly lower associations for girls than for boys for nutritional status at age 12 with math for India and Peru (at the 0.10 level) at age 15 and significantly higher associations for girls than for boys for household wealth at age 12 with reading at age 15 in Ethiopia (at the 0.10 level).

Table B5 in Appendix indicates some significant differences by country. The associations with nutritional status at age 12 and household wealth at age 12 for reading at age 15 for boys in India are larger than the corresponding statistics for Ethiopia. Also there are significant negative estimates for interactions for girls for reading in India. None of the other statistics in Table B5 for the differences between Ethiopia and any of the other countries is statistically significant.

In addition to the significant associations with nutritional status and household wealth at age 12, there are some significant associations with the control variables, as shown in Table C2. The effect of being first child of a mother is significantly positive for reading (at 0.10 level) and for PPVT at age 15 for boys in Ethiopia. Mother completed primary school is significantly positive for reading at age 15 for boys in Ethiopia and India, and father completed primary school is significantly positive for boys in math and reading (at the 0.10 level) in India and in reading and PPVT (at the 0.10 level) in Vietnam. Most of interactions for the control variables are not significant, but there are a few exceptions: if first child of mother is significantly positive for PPVT for girls in Vietnam, mother completed primary schooling is significantly negative for math for girls in Peru, and father completed primary schooling is significantly positive for PPVT at age 15 for girls in Ethiopia and India (at the 0.10 level). The estimates for the pooled sample suggest that the effect of being first child of mother is significantly positive in PPVT at age 15 for boys and girls. If father completed primary school is significantly positive for boys and girls in math and reading. Like that for the period before age eight (Table C1), the very limited significance of the interactions for parental schooling are inconsistent with some previous studies that report stronger links within gender than across genders in intergenerational associations for schooling attainment (King and Lillard 1987; King and Mason 2000).

5. Summary and concluding remarks

We have contributed to the literature by (a) utilizing comparable longitudinal data over a decade from the end of the preschool ages to adolescence for four very different LMICs (b) to explore gender gaps in the impacts of two critical deprivation indicators that previously have been emphasized for the birth through the preschool period but not for middle childhood and adolescence – HAZ related to undernutrition and household wealth related to poverty – (c) on learning as measured by cognitive tests (not inputs into learning such as schooling attainment), (d) from end of the preschool ages to mid childhood and from childhood to adolescence, (e) using 2SLS to arguably identify causal relations. Our empirical exploration yielded five groups of important insights.

First, there are significant gender gaps in learning as measured by cognitive tests that vary by age range and vary by countries in three of the four countries examined, but not in Ethiopia. For India and Peru these gaps favored boys, but for Vietnam they favored girls. For all three of these countries the number of significant gender gaps in cognitive tests doubled between eight years of age and 15 years of age.

Second, preschool (age five) nutritional status and household wealth in most cases predicted positive cognitive test performance in mid-childhood (age eight) in all four countries for boys and girls, but with significantly larger impacts for girls in three cases for wealth and two cases for nutritional status. That the cohorts under investigation experienced reduced undernutrition and declining poverty in the first eight years of their lives means that boys and girls performed better on cognitive tests at age eight, but even more so girls. These significant gender differences in the impacts of the reduced poverty/increased wealth meant that the gender gaps in cognitive skills favoring boys was less at age eight in India and Peru than they would have been had the associations of such skills with wealth been gender neutral or favored boys. The significant gender differences in the impacts of nutritional status in preschool period favoring girls in Vietnam, in contrast, contributed to the gender gap favoring girls in that country.

Third, the factors noted in point two, including the gender differences in impacts of nutritional status and wealth at age 5, work through the cognitive test scores at age eight to affect cognitive skills at age 15 in the value-added model estimated. In addition, nutritional status at age 12 had significant positive impacts on two of the three cognitive tests at age 15 for boys in India and Peru, and in the pooled sample as well, but with significantly smaller effects for girls in four of these cases, including in the pooled sample. In India household wealth at age 12 also had significantly positive effects for boys on two cognitive tests at age 15, but without significant differences for girls. The gender differences in impacts of nutritional status favoring boys in this life-cycle period in India and Peru helped increase the gender gaps in cognitive skills at age 15 favoring boys, particularly in light of the ongoing improvements in nutrition in these economies. The only gender interaction that is significant for Ethiopia, in contrast, is for household wealth at age 12 and favored girls, thereby probably contributing to the relative gender equality in learning in that country.

Fourth, we provide new evidence that the relations determining cognitive test scores are similar across countries, but there are significant differences in the coefficient estimates across countries, including in the gender coefficient estimates (Tables B2 & B5). This suggests an important caveat about generalizing more broadly about results from one context, even though that practice is widespread.

Fifth, we provide new estimates that not only is early-life nutritional status important, but also the subsequent nutritional status that is not predicted by the early-life nutritional status is important. Evidence in this study rejects the hypothesis that the change in cognitive ability after the age of eight is not associated with growth in middle childhood and household wealth in preadolescence. For gender equality among the adolescents, however, nutritional status by the end of the preschool period is critical.

Acknowledgements

This research is funded by the Vietnam National Foundation for Science and Technology Development (NAFOSTED) under grant number 502.01-2018.08 for Le Thuc Duc.

The data used in this study come from Young Lives, an international study of childhood poverty, following the lives of 12,000 children in four countries -- Ethiopia, India, Peru and Vietnam -- over 15 years. Young Lives is core-funded by UK aid from the Department for International Development (DFID) and co-funded from 2010 to 2014 by the Netherlands Ministry of Foreign Affairs, and by Irish Aid from 2014 to 2015.

References

Acharya, Y., Luke, N., Haro, M.F, Rose, W., Russell, P.S.S., Oommen, A.M., Minz, S. 2019. Nutritional status, cognitive achievement, and educational attainment of children aged 8-11 in rural South India. *PLoS ONE* 14(10): e0223001.

Aurino, E., Fledderjohann, J., Vellakkal, S. 2019a. Inequalities in adolescent learning: Does the timing and persistence of food insecurity at home matter? *Economics of Education Review*, 70, 94-108.

Aurino, E., Schott, W., Behrman, J.R., Penny, M. 2019b. Nutritional Status from 1 to 15 Years and Adolescent Learning for Boys and Girls in Ethiopia, India, Peru, and Vietnam. *Population Research and Policy Review* 38(6): 899-931.

Azam, M., Kingdon, G.G. 2013. Are Girls the Fairer Sex in India? Revisiting Intra-Household Allocation of Education Expenditure. *World Development* 42: 143-164.

Barnett, I., Ariana, P., Petrou, S., Penny, M. E., Duc, L. T., Galab, S., Woldehanna, T., Escobal, J. A., Plugge, E., & Boyden, J. 2012. Cohort profile: The Young Lives study. *International Journal of Epidemiology*, 42(3), 701–708.

Behrman, J. R. 2020. Social Mobility and Human Capital in Low- and Middle-Income Countries. *Social Mobility in Developing Countries: Concepts, Methods, and Determinants*. A. K. Vegard Iversen, and Kunal Sen, eds. Oxford, UK, Oxford University Press.

Behrman, J. R., Deolalikar, A. B. 1990. "The Intrahousehold Demand for Nutrients in Rural South India: Individual Estimates, Fixed Effects and Permanent Income." *Journal of Human Resources* 25:4: 665-696.

Behrman, J., Schott, W., Mani, M., Crookston, B., Dearden, K., Le Thuc Duc, Fernald, L., Stein, A. 2017. Intergenerational Transmission of Poverty: Parental Resources and Schooling

Attainment and children's Human Capital in Ethiopia, India, Peru, and Vietnam. *Economic Development and Cultural Change*. 65(4), 656-697.

Bharadwaj, P., De Giorgi, G., Hansen, D., Neilson, C. 2016. The Gender Gap in Mathematics: Evidence from Chile, *Economic Development and Cultural Change*, 65(1), 141-166.

Briones, K. 2017. *How many rooms are there in your house? Measuring household socioeconomic status using the Young Lives Wealth Index,* Technical Note 43, Oxford: Young Lives.

Black, M. M., Walker, S.P., Fernald, L., Andersen, C.T., DiGirolamo, A.M., Lu, C., McCoy, D.C., Fink, G. Shawar, Y. R., Shiffman, J. 2017. Early childhood development coming of age: Science through the life course. *Lancet* 389: 77-90.

Bundy, D. A. P., de Silva, N., Horton, S., Patton, G.C., Schultz, L., et al. 2018. Investment in child and adolescent health and development: key messages from Disease Control Priorities, 3rd Edition. *Lancet* 391:687 − 99.

Cameron, L.A., Worswick, C. 2001. Education Expenditure Responses to Crop Loss in Indonesia: A Gender Bias. *Economic Development and Cultural Change*, 49(2): 351–63.

Crookston, B.T., Schott, W., Cueto, S., Dearden, K.A., Engle, P., Georgiadis, A., Lundeen, E.A. Penny, M.E., Stein, A.D., Behrman, J.R. 2013. Postinfancy Growth, Schooling, and Cognitive Achievement: Young Lives. *American Journal of Clinical Nutrition* 98(6), 1555-63.

Cueto, S., Leon, J. 2013. Psychometric characteristics of cognitive development and achievement instruments in round 3 of Young Lives. *Young Lives Technical Note* 25. Young Lives, University of Oxford.

de Onis, M., Onyango, A.W., Borghi, E., Siyam, A., Siekmann, J. 2007. Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization* 85.

Deaton, A. 2008. Height, health, and inequality: the distribution of adult heights in India. *American Economic Review*, 98(2): 468–474.

Engle, P.L., Black, M.M., Behrman, J.R., et al. 2007 Strategies to avoid the loss of developmental potential in more than 200 million children in the developing world. *Lancet* 369:229-42.

Evans, D.K., Akmal, M., Jakiela, P. 2020. Gender Gaps in Education: The Long View. *Working Papers 523,* Center for Global Development, Washington, DC.

Filmer, D., Rogers, H., Angrist, N., Sabarwal, S. 2020. Learning-adjusted years of schooling (LAYS): Defining a new macro measure of education. *Economics of Education Review*: 101971.

Fink, G., Rockers, P. C. 2014. Childhood growth, schooling, and cognitive development: Further evidence from the Young Lives study. *American Journal of Clinical Nutrition,* **100** (1), 182–188.

Fryer, R.G., Levitt, S.D. 2010. An Empirical Analysis of the Gender Gap in Mathematics. *American Economic Journal: Applied Economics* 2:210–40.

Georgiadis, A., Benny, L., Crookston, B.T., Le Thuc Duc, Hermida, P., Mani, S., Behrman, J.R. 2016. Growth trajectories from conception through middle childhood and cognitive achievement at age eight years: evidence from four low- and middle-income countries. *SSM - Population Health* 2, 43-54.

Georgiadis, A., Benny, L., Le Thuc Duc, Galab, S., Reddy, P., & Woldehanna, T. 2017. Growth recovery and faltering through early adolescence in low- and middle-income countries: Determinants and implications for cognitive development. *Social Science & Medicine* 179, 81–90.

Glewwe, P., Miguel, E. A. 2008. The Impact of Child Health and Nutrition on Education in Less Developed Countries, in: T. Paul Schultz & John A. Strauss (eds.), *Handbook of Development Economics*, edition 1, volume 4, chapter 56, pages 3561-3606, Elsevier.

Grant, M. J., Behrman, J.R. 2010. Gender Gaps in Educational Attainment in Less Developed Countries. *Population and Development Review* **36**(1): 71-89.

Himaz, R. 2018. Stunting later in childhood and outcomes as a young adult: Evidence from India, *World Development*, 104, 344-357.

King, E. M., Lillard, L. A. 1987. Education Policy and Schooling Attainment in Malaysia and the Philippines. *Economics of Education Review* 6:2, 167-181.

King, E. M., Mason, A. 2000. *Engendering Development: Through Gender Equality in Rights, Resources, and Voice.* New York, Oxford University Press for the World Bank.

Leroy, J. L., Ruel, M., Habicht, J. P. & Frongillo, E. A. 2014. Linear growth deficit continues to accumulate beyond the first 1000 days in low- and middle-income countries: global evidence from 51 national surveys. *Journal of Nutrition* 144, 1460–6.

Leroy, J. L., Ruel, M., Habicht, J. P., & Frongillo, E. A. 2015. Using height-for-age differences (HAD) instead of height-for-age z-scores (HAZ) for the meaningful measurement of population-level catch-up in linear growth in children less than 5 years of age. *BMC Paediatrics*, 15(1), 145.

Lu, C., Black, M., Richter, L.M. 2016. Risk of poor development in young children in low-income and middle-income countries: an estimation and analysis at the global, regional, and country level. *The Lancet Global Health.*

Nandi, A. Behrman, J. R, Laxminarayan, R. 2020. The Impact of a National Early Childhood Development Program on Future Schooling Attainment: Evidence from Integrated Child

Development Services in India. *Economic Development and Cultural Change*, University of Chicago Press, vol. 69(1), 291-316.

OECD Development Centre 2014. *Social Institutions and Gender Index Synthesis Report*, OECD, Paris.

OECD. 2017. *OECD Economic Surveys: India Overview,* February 2017. https://www.oecd.org/eco/surveys/INDIA-2017-OECD-economic-survey-overview.pdf

Prentice, A.M., Ward, K.A., Goldberg, G.R., Jarjou, L.M., Moore, S.E., Fulford, A.J., Prentice, A. 2013. Critical windows for nutritional interventions against stunting. *Am. J. Clin. Nutr.* 97 (5), 911–918.

Pritchett, L. 2013. *The Rebirth of Education: Schooling Ain't Learning*. Washington, DC, Center for Global Development.

Putnick, D.L., Bornstein, M.H. 2016. Girls' and boys' labor and household chores in low- and middle-income countries. *Monographs of the Society for Research in Child Development* 81(1), 104–122.

Rogol, A.D, Clark, P.A., Roemmich, J.N. 2000. Growth and pubertal development in children and adolescents: effects of diet and physical activity. *Am. J. Clin. Nutr.*, 72 (2), pp. 521s-528s.

Schott, W., Aurino, E., Penny M.E., Behrman, J.R. 2019. The double burden of malnutrition among youth: Trajectories and inequalities in four emerging economies, *Economics & Human Biology*, 34, 80-91.

Schott, W. B., Crookston, B. T., Lundeen, E. A., Stein, A. D., Behrman, J. R. 2013. Periods of child growth up to age eight years in Ethiopia, India, Peru and Vietnam: Key distal household and community factors. *Social Science & Medicine*, 97, 278–287.

Schwekendiek, D., Baten, J. 2019. Height development of men and women from China, South Korea, and Taiwan during the rapid economic transformation period of the 1960s to 1980s. *Economics & Human Biology*, 34(C), 169-180.

Singh, A. 2015. Private school effects in urban and rural India: Panel estimates at primary and secondary school ages. *Journal of Development Economics*, 113, 16-32.

Singh, A., Krutikova, S. 2017. Starting Together, Growing Apart: Gender Gaps in Learning from Preschool to Adulthood in Four Developing Countries, *Working Paper* No. 174, Oxford: Young Lives.

Singh, R., Mukherjee, P. 2018. 'Whatever she may study, she can't escape from washing dishes': gender inequity in secondary education – evidence from a longitudinal study in India, *Compare: A Journal of Comparative and International Education*, 48 (2), 262-280.

United Nations 2015. *Transforming Our World, the 2030 Agenda for Sustainable Development*.

Victora, C.G., Adair, L., Fall, C., Hallal, P.C., Martorell, R., Richter, L., Sachdev, H.S. 2008. Maternal and Child Undernutrition: Consequences for Adult Health and Human Capital. *Lancet* 371(9609), 340-57.

Victora, C. G.,. de Onis, M., Hallal, P.C., Blössner, M., Shrimpton, R. 2010. Worldwide Timing of Growth Faltering: Revisiting Implications for Interventions. *Pediatrics* 125: e473-e480.

Walker, S.P., Chang, S.M., Powell, C.E., Simonoff, E., Grantham-McGregor, S.M. 2007. Early Childhood Stunting Is Associated with Poor Psychological Functioning in Late Adolescence and Effects Are Reduced by Psychosocial Stimulation, *The Journal of Nutrition*, 137(11), 2464–2469, https://doi.org/10.1093/jn/137.11.2464

WHO Multicentre Growth Reference Study Group. 2006. *WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development.* Geneva, World Health Organization.

World Bank. 2012. World Development Report 2012: Gender Equality and Development. Washington, D.C.: World Bank Group.

Appendices:

Appendix A: First-stage estimates

Table A1: First-stage regressions for equation 3

	Ethiopia		India		Peru		Vietnam	
	HAZ_5	$F \times HAZ_5$	HAZ_5	$F \times HAZ_5$	HAZ_5	$F \times HAZ_5$	HAZ_5	$F \times HAZ_5$
Normal wealth at 5 (W_{5y})	0.063***	0.000	0.085***	0.000	0.230***	-0.000	0.185***	-0.000
	(0.022)	(0.015)	(0.023)	(0.014)	(0.020)	(0.014)	(0.032)	(0.021)
Interaction ($F \times W_{5y}$)	0.124***	0.187***	-0.000	0.085***	-0.000	0.221***	-0.048	0.137***
	(0.033)	(0.023)	(0.034)	(0.021)	(0.029)	(0.020)	(0.045)	(0.030)
Unpr. growth 1-5y. (g_{1_5y})	0.989***	0.004	0.966***	0.00	0.919***	0.00	1.008***	0.00
	(0.016)	(0.024)	(0.021)	(0.013)	(0.024)	(0.017)	(0.030)	(0.032)
Interaction $F \times g_{1\_5y}$	0.000	0.993***	0.026	0.992***	-.005	0.915***	-0.059	0.949***
	(0.011)	(0.016)	(0.032)	(0.020)	(0.034)	(0.023)	((0.048)	(0.032)
F-statistic	600.5	1176.2	265.2	965.8	367.5	909.2	182.3	461.01
P-value	0.000	0.000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
Observations	1412		1,734		1,692		1728	

Notes: Control variables include sex (F), the country dichotomous variables, wealth index at age 5, first born, mother's education, father's education, caste/ethnicity, and their interactions with the dichotomous variables on sex and the countries.
Standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels

Table A2: First-stage regressions for equation 4 for pooled sample

	HAZ_{12y}		$F \times HAZ_{12y}$		$Math_{8y}$		$F \times Math_{8y}$	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Unpredicted growth 1 to 5 (g_{1_5y})	0.485	66.24	0.000	0	0.633	4.24	0.000	0
Unpredicted growth 5 to 8 (g_{5_8y})	0.836	83.93	0.000	0	0.756	3.72	0.000	0
Unpredicted growth 8 to 12 (g_{8-12y})	1.045	99.63	0.000	0	-0.143	-0.67	0.000	0
Interaction with F (female) $F \times g_{1-5y}$	-0.066	-6.04	0.419	54.29	0.572	2.56	1.205	7.98
Interaction with F (female) $F \times g_{5-8y}$	-0.130	-8.99	0.706	69.29	-0.210	-0.71	0.546	2.74
Interaction with F (female) $F \times g_{8-12y}$	-0.045	-3.14	1.000	98.32	0.661	2.24	0.518	2.6
Normal wealth at 5 (W_{5y})	0.453	9.89	0.000	0	5.646	6.04	0.000	0
Interaction with F (female) $F \times W_{5y}$	0.043	0.66	0.496	10.8	1.396	1.05	7.042	7.83
F-statistic	1603.5		2804.2		195.6		937.2	
P-value	0.000		0.000		0.000		0.000	

Table A2: First-stage regressions for equation 4 for pooled sample

	$EGRA_{8y}$		$F \times EGRA_{8y}$		$PPVT_{8y}$		$F \times PPVT_{8y}$	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Unpredicted growth 1 to 5 (g_{1_5y})	0.524	3.15	0.000	0	0.716	4.22	0.000	0
Unpredicted growth 5 to 8 (g_{5_8y})	0.588	2.6	0.000	0	0.656	2.84	0.000	0
Unpredicted growth 8 to 12 (g_{8-12y})	-0.165	-0.69	0.000	0	0.250	1.03	0.000	0
Interaction with F (female) $F \times g_{1-5y}$	0.245	0.98	0.769	4.51	0.195	0.77	0.911	5.36
Interaction with F (female) $F \times g_{5-8y}$	-0.151	-0.46	0.437	1.94	-0.059	-0.18	0.597	2.66
Interaction with F (female) $F \times g_{8-12y}$	0.528	1.61	0.363	1.61	0.212	0.63	0.462	2.06
Normal wealth at 5 (W_{5y})	1.926	1.85	0.000	0	6.502	6.12	0.000	0
Interaction with F (female) $F \times W_{5y}$	4.079	2.75	6.005	5.9	1.670	1.1	8.172	8.06
F-statistic	120.6		815.8		109.1		839.3	
P-value	0.000		0.000		0.000		0.000	

Appendix B: Estimates for differences among countries

Sub-appendix B1: A description of instrumental variables for equation 5

For equation 5, the nutrition status at five and the interactions of nutrition status at five with F (for female) are treated as endogenous. In the pooled sample, the endogenous variable HAZ_5 for Ethiopia is referred to as the default. We use dichotomous variables with $S_j, j = \overline{1,3}$, to present the differences between the estimates for the countries. The India-based endogenous variables include $S_1 \times HAZ_5$ and $F \times S_1 \times HAZ_5$. The endogenous variables based on Peru and Vietnam are defined using S_2 and S_3 respectively. The excluded instruments are the preschool wealth (W_{5y}) and the unpredicted growth between ages one and five years (g_{1_5y}). Thus, the instruments related to Peru, for example, are $S_2 \times W_{5y}$, $S_2 \times g_{1\_5y}$, $F \times S_2 \times W_{5y}$, and $F \times S_2 \times g_{1\_5y}$. Recall that $S_i \times S_j = 0$ if $i \neq j$, and therefore, coefficients in the first-stage estimation for $S_j \times HAZ_5$ and $F \times S_j \times HAZ_5$ equal zeros for the instruments that is based on another country. That is the reason we keep fewer rows in the lower panels of Table C1.

Table B1: First-stage regressions for equation 5

	Default HAZ_5		$F \times HAZ_5$ (default)	
	Coef.	t	Coef.	t
Normalized wealth at 5 (W_{5y})	0.063	2.21	0.000	0
Interaction with ET $S_1 \times W_{5y}$	0.022	0.58	0.000	0
Interaction with PE $S_2 \times W_{5y}$	0.167	4.77	0.000	0
Interaction with VN $S_3 \times W_{5y}$	0.122	3.12	0.000	0
Interaction with F (female) $F \times W_{5y}$	0.124	2.88	0.187	6.53
'$F \times S_1 \times W_{5y}$	-0.124	-2.21	-0.102	-2.73
'$F \times S_2 \times W_{5y}$	-0.133	-2.59	0.034	0.98
'$F \times S_3 \times W_{5y}$	-0.171	-3.01	-0.050	-1.31
Unpredicted growth 1 to 5 (g_{1_5y})	0.989	47.59	0.000	0
Interaction with ET $S_1 \times g_{1\_5y}$	-0.023	-0.75	0.000	0
Interaction with PE $S_2 \times g_{1\_5y}$	-0.070	-2.2	0.000	0
Interaction with VN $S_3 \times g_{1\_5y}$	0.019	0.58	0.000	0
Interaction with F (female) $F \times g_{1\_5y}$	0.004	0.12	0.993	48.42
'$F \times S_1 \times g_{1\_5y}$	0.022	0.48	-0.001	-0.03
'$F \times S_2 \times g_{1\_5y}$	-0.008	-0.18	-0.078	-2.58
'$F \times S_3 \times g_{1\_5y}$	-0.063	-1.24	-0.044	-1.3
F-statistic	291.6		741.25	
P-value	0.000		0.000	

Table B1: First-stage regressions for equation 5 (continued)

	$S_1 \times HAZ_5$		$F \times S_1 \times HAZ_5$	
	Coef.	t	Coef.	t
Interaction with ET $S_1 \times W_{5y}$	0.085	4.67	0.000	0
'$F \times S_1 \times W_{5y}$	0.000	-0.01	0.085	5.1
Interaction with ET $S_1 \times g_{1\_5y}$	0.966	66.25	0.000	0
'$F \times S_1 \times g_{1\_5y}$	0.026	1.16	0.992	73.03
F-statistic	1156.6		1487.7	
P-value	0.000		0.000	

Table B1: First-stage regressions for equation 5 (continued)

	$S_2 \times HAZ_5$		$F \times S_2 \times HAZ_5$	
	Coef.	t	Coef.	t
Interaction with PE $S_2 \times W_{5y}$	0.230	12.76	0.000	0
'$F \times S_2 \times W_{5y}$	-0.010	-0.37	0.221	12.07
Interaction with PE $S_2 \times g_{1\_5y}$	0.919	56.49	0.000	0
'$F \times S_2 \times g_{1\_5y}$	-0.005	-0.2	0.915	57.05
F-statistic	937.2		1108.1	
P-value	0.000		0.000	

Table B1: First-stage regressions for equation 5 (continued)

	$S_3 \times HAZ_5$		$F \times S_3 \times HAZ_5$	
	Coef.	t	Coef.	t
Interaction with VN $S_3 \times W_{5y}$	0.185	7.73	0.000	0
'$F \times S_3 \times W_{5y}$	-0.048	-1.37	0.137	5.83
Interaction with VN $S_3 \times g_{1\_5y}$	1.008	50.33	0.000	0
'$F \times S_3 \times g_{1\_5y}$	-0.059	-1.9	0.949	45.29
F-statistic	505.2		568.9	
P-value	0.000		0.000	

Notes: Control variables include sex (F), the country dichotomous variables, first born, mother's education, father's education, caste/ethnicity, and their interactions with the dichotomous variables on sex and the countries. Standard errors are in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels

Table B2: 2SLS regressions for equation 5 of the outcomes at age eight, all children, with the interactions for female (F)

	Math		Reading		PPVT	
		Inter. $\times F$		Inter. $\times F$		Inter. $\times F$
Panel A: Estimates for Ethiopia as default category						
HAZ at age 5 (H_{5y})	0.732*** (0.271)	0.239 (0.400)	0.736** (0.301)	0.083 (0.444)	1.516*** (0.303)	0.455 (0.448)
Norm. wealth at 5 (W_{5y})	3.462*** (0.371)	-0.408 (0.559)	2.777*** (0.412)	0.027 (0.621)	4.545*** (0.416)	0.996 (0.626)
Panel B: Estimates for interactions $S_1 \times var$ ($S_1 = 1$, if India)						
HAZ at age 5 (H_{5y})	-0.050 (0.400)	0.859 (0.598)	-0.199 (0.444)	0.124 (0.663)	-1.010** (0.448)	-0.306 (0.669)
Norm. wealth at 5 (W_{5y})	-3.022*** (0.493)	1.029 (0.730)	-3.755*** (0.547)	1.992** (0.810)	-3.537*** (0.551)	-0.472 (0.817)
Panel C: Estimates for interactions $S_2 \times var$ ($S_2 = 1$, if Peru)						
HAZ at age 5 (H_{5y})	-0.044 (0.430)	0.463 (0.615)	0.029 (0.477)	-0.080 (0.682)	-0.943** (0.481)	-0.550 (0.688)
Norm. wealth at 5 (W_{5y})	-1.709*** (0.467)	0.486 (0.689)	-1.234** (0.518)	1.076 (0.765)	-3.161*** (0.522)	-0.455 (0.771)
Panel D: Estimates for interactions $S_3 \times var$ ($S_3 = 1$, if Vietnam)						
HAZ at age 5 (H_{5y})	0.026 (0.421)	0.781 (0.667)	-0.377 (0.467)	1.227* (0.740)	-0.781* (0.471)	0.258 (0.746)
Norm. wealth at 5 (W_{5y})	-0.781 (0.510)	-0.100 (0.745)	-0.779 (0.566)	-0.615 (0.827)	-1.922*** (0.571)	-1.052 (0.834)
Number of observations	6566		6566		6566	
R-squared (within)	0.51		0.40		0.39	

Note: HAZ at age five (H_{5y}), and its interactions with F, S_1, S_2, S_3 are treated as endogenous. Control factors include first born, mother education, father education, caste/ethnicity and as well as interactions with F, S_1, S_2 and S_3.
***, **, and * denote significance at the 1%, 5%, and 10% levels

Sub-appendix B2: Description of instrumental variables for equation 6

For equation 6, the endogenous variables include HAZ at age 12 and the lagged test score outcomes at age eight. If C_{15y} is the math score (reading/PPVT), then the endogenous variables are H_{12y} and $Math_{8y}$ ($EGRA_{8y}/PPVT_{8y}$). We refer to endogenous variables H_{12y}, $Math_{8y}$, $EGRA_{8y}$, and $PPVT_{8y}$ based on the pooled sample as the default to limit the number of tables presented. Also based on the pooled sample are the default instruments of the preschool wealth (W_{5y}), the unpredicted growth between ages one and five years (g_{1_5y}), and those in the following periods from five to eight and from eight to 12, g_{5_8y} and g_{8_12y} correspondingly. In addition to the default ones, we use the country-based instruments similar to that in Appendix C1. For instance, the set of India-based instruments consists of $S_1 \times W_{5y}$, $S_1 \times g_{1\_5y}$, $S_1 \times g_{5\_8y}$, $S_1 \times g_{8\_12y}$, as well as their interactions with F(for female). The India-based and the Peru-based instruments are defined using S_2 and S_3 respectively.

Table B3a: First-stage regressions for equation 6 for default endogenous variables

	HAZ_{12}		$Math_{8y}$		$EGRA_{8y}$		$PPVT_{8y}$	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Normal wealth at 5 (W_{5y})	0.234	2.28	11.542	4.92	7.951	3.06	15.046	5.75
Interaction with IN $S_1 \times W_{5y}$	0.257	2	-11.329	-3.87	-15.240	-4.69	-12.454	-3.81
Interaction with PE $S_2 \times W_{5y}$	0.164	1.3	-7.119	-2.47	-4.690	-1.46	-11.417	-3.54
Interaction with VN $S_3 \times W_{5y}$	0.093	0.7	-2.579	-0.85	-1.771	-0.53	-4.864	-1.44
Unpredicted growth 1 to 5 (g_{1_5y})	0.407	32.79	0.546	1.92	0.584	1.85	1.481	4.67
Interaction with IN $S_1 \times g_{1\_5y}$	0.048	2.7	0.075	0.19	-0.147	-0.33	-1.062	-2.35
Interaction with PE $S_2 \times g_{1\_5y}$	0.153	8.31	0.048	0.11	0.104	0.22	-0.983	-2.1
Interaction with VN $S_3 \times g_{1\_5y}$	0.105	5.39	0.198	0.45	-0.173	-0.35	-0.967	-1.95
Unpredicted growth 1 to 5 (g_{5_8y})	0.644	38.75	0.374	0.98	0.456	1.08	1.191	2.81
Interaction with IN $S_1 \times g_{5\_8y}$	0.193	8.02	0.837	1.52	0.070	0.11	-0.778	-1.27
Interaction with PE $S_2 \times g_{5\_8y}$	0.323	12.96	0.023	0.04	0.178	0.28	-0.833	-1.31
Interaction with VN $S_3 \times g_{5\_8y}$	0.295	11.33	0.437	0.73	0.180	0.27	-0.205	-0.31
Unpredicted growth 1 to 5 (g_{8_12y})	1.057	42.33	0.945	1.66	0.713	1.13	0.157	0.25
Interaction with IN $S_1 \times g_{8\_12y}$	0.005	0.18	-1.373	-1.93	-0.633	-0.8	-0.083	-0.1
Interaction with PE $S_2 \times g_{8\_12y}$	-0.034	-1.1	-1.047	-1.47	-0.942	-1.19	-0.139	-0.17
Interaction with VN $S_3 \times g_{8\_12y}$	0.036	1.19	-1.416	-2.07	-1.412	-1.86	0.320	0.42
F-statistic	877.87		84.53		54.94		52.35	
P-value	0.000		0.000		0.000		0.000	

Table B3a: First-stage regressions for equation 6 for default endogenous variables (continue)

	$F \times HAZ_{12}$		$F \times Math_{8y}$		$F \times EGRA_{8y}$		$F \times PPVT_{8y}$	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Interaction $F \times W_{5y}$	0.642	6.49	12.990	5.67	11.146	4.32	18.795	7.46
Interaction $F \times S_1 \times W_{5y}$	-0.345	-2.77	-11.150	-3.86	-9.322	-2.86	-13.740	-4.32
Interaction $F \times S_2 \times W_{5y}$	-0.058	-0.48	-7.128	-2.56	-4.841	-1.54	-12.435	-4.06
Interaction $F \times S_3 \times W_{5y}$	-0.392	-3.1	-3.137	-1.07	-5.939	-1.8	-9.090	-2.82
Interaction $F \times g_{1\_5y}$	0.371	30.6	0.868	3.09	0.678	2.14	1.729	5.59
Interaction $F \times S_1 \times g_{1\_5y}$	-0.149	-8.16	0.048	0.11	-0.588	-1.23	-1.835	-3.94
Interaction $F \times S_2 \times g_{1\_5y}$	0.167	9.54	0.404	1	0.005	0.01	-1.298	-2.92
Interaction $F \times S_3 \times g_{1\_5y}$	0.201	10.14	0.921	2	0.893	1.72	-0.295	-0.58
Interaction $F \times g_{5\_8y}$	0.579	35.23	-0.008	-0.02	-0.170	-0.4	0.022	0.05
Interaction $F \times S_1 \times g_{5\_8y}$	-0.082	-3.46	1.434	2.61	1.486	2.4	1.061	1.75
Interaction $F \times S_2 \times g_{5\_8y}$	0.455	18.78	0.873	1.56	0.738	1.17	0.269	0.44
Interaction $F \times S_3 \times g_{5\_8y}$	0.295	11.45	-0.831	-1.39	-0.085	-0.13	0.521	0.79
Interaction $F \times g_{8\_12y}$	1.046	48.97	0.514	1.04	0.668	1.2	1.079	1.98
Interaction $F \times S_1 \times g_{8\_12y}$	0.006	0.23	0.649	1.03	0.062	0.09	0.137	0.2
Interaction $F \times S_2 \times g_{8\_12y}$	-0.017	-0.6	-0.388	-0.6	-1.134	-1.55	-1.356	-1.9
Interaction $F \times S_3 \times g_{8\_12y}$	0.070	2.64	-0.584	-0.95	-0.324	-0.47	-1.223	-1.8
F-statistic	1697.62		399.17		349.58		377.74	
P-value	0.000		0.000		0.000		0.000	

Table B3b: First-stage regressions for equation 6 for India-based endogenous variables ($S_1 = 1$)

	$S_1 \times HAZ_{12}$		$S_1 \times Math_{8y}$		$S_1 \times EGRA_{8y}$		$S_1 \times PPVT_{8y}$	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Normal wealth at 5 (W_{5y})	0.000	0	0.000	0	0.000	0	0.000	0
Interaction with IN $S_1 \times W_{5y}$	0.490	9.75	0.213	0.12	-7.289	-3.74	2.592	1.44
Interaction with PE $S_2 \times W_{5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction with VN $S_3 \times W_{5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Unpredicted growth 1 to 5 (g_{1_5y})	0.000	0	0.000	0	0.000	0	0.000	0
Interaction with IN $S_1 \times g_{1\_5y}$	0.455	65.59	0.621	2.6	0.436	1.62	0.419	1.69
Interaction with PE $S_2 \times g_{1\_5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction with VN $S_3 \times g_{1\_5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Unpredicted growth 1 to 5 (g_{5_8y})	0.000	0	0.000	0	0.000	0	0.000	0
Interaction with IN $S_1 \times g_{5\_8y}$	0.837	88.65	1.211	3.72	0.525	1.44	0.413	1.22
Interaction with PE $S_2 \times g_{5\_8y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction with VN $S_3 \times g_{5\_8y}$	0.000	0	0.000	0	0.000	0	0.000	0
Unpredicted growth 1 to 5 (g_{8_12y})	0.000	0	0.000	0	0.000	0	0.000	0
Interaction with IN $S_1 \times g_{8\_12y}$	1.062	87.15	-0.428	-1.02	0.080	0.17	0.075	0.17
Interaction with PE $S_2 \times g_{8\_12y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction with VN $S_3 \times g_{8\_12y}$	0.000	0	0.000	0	0.000	0	0.000	0
F-statistic	3634.8		275.0		169.0		259.0	
P-value	0.000		0.000		0.000		0.000	

Table B3b: First-stage regressions for equation 6 for India-based endogenous variables ($S_1 = 1$) continue

	$F \times S_1 \times HAZ_{12}$		$F \times S_1 \times Math_{8y}$		$F \times S_1 \times EGRA_{8y}$		$F \times S_1 \times PPVT_{8y}$	
	Coef.	t	Coef.	t	Coef.	t	Coef.	t
Interaction $F \times W_{5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times S_1 \times W_{5y}$	0.297	9.11	1.840	1.14	1.824	0.97	5.054	3.16
Interaction $F \times S_2 \times W_{5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times S_3 \times W_{5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times g_{1\_5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times S_1 \times g_{1\_5y}$	0.222	46.64	0.915	3.89	0.089	0.32	-0.106	-0.45
Interaction $F \times S_2 \times g_{1\_5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times S_3 \times g_{1\_5y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times g_{5\_8y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times S_1 \times g_{5\_8y}$	0.497	80.21	1.426	4.67	1.316	3.66	1.084	3.56
Interaction $F \times S_2 \times g_{5\_8y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times S_3 \times g_{5\_8y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times g_{8\_12y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times S_1 \times g_{8\_12y}$	1.052	148.27	1.163	3.32	0.730	1.77	1.216	3.49
Interaction $F \times S_2 \times g_{8\_12y}$	0.000	0	0.000	0	0.000	0	0.000	0
Interaction $F \times S_3 \times g_{8\_12y}$	0.000	0	0.000	0	0.000	0	0.000	0
F-statistic	10054.4		275.0		169.0		259.0	
P-value	0.000		0.000		0.000		0.000	

Table B4: F-statistics of first-stage regressions for equation 6

HAZ_{12}	$F \times HAZ_{12}$	$S_1 \times HAZ_{12}$	$F \times S_1 \times HAZ_{12}$	$S_2 \times HAZ_{12}$	$F \times S_2 \times HAZ_{12}$	$S_3 \times HAZ_{12}$	$F \times S_3 \times HAZ_{12}$
877.87	1697.62	3634.81	10054.38	1212.79	1331.67	953.71	1012.05

$math_8$	$F \times math_8$	$S_1 \times math_8$	$F \times S_1 \times math_8$	$S_2 \times math_8$	$F \times S_2 \times math_8$	$S_3 \times math_8$	$F \times S_3 \times math_8$
84.53	399.17	274.99	360.02	550.55	605.95	953.08	1101.56

$egra_8$	$F \times egra_8$	$S_1 \times egra_8$	$F \times S_1 \times egra_8$	$S_2 \times egra_8$	$F \times S_2 \times egra_8$	$S_3 \times egra_8$	$F \times S_3 \times egra_8$
53.94	349.58	169.00	212.22	518.86	600.74	1110.27	1294.60

$ppvt_8$	$F \times ppvt_8$	$S_1 \times ppvt_8$	$F \times S_1 \times ppvt_8$	$S_2 \times ppvt_8$	$F \times S_2 \times ppvt_8$	$S_3 \times ppvt_8$	$F \times S_3 \times ppvt_8$
52.35	377.74	258.97	328.39	1289.97	1505.86	924.33	1111.98

Notes: Control variables include sex (F), the country dichotomous variables, wealth index at age 5, first born, mother's education, father's education, caste/ethnicity, and their interactions with the dichotomous variables on sex and the countries.

Table B5: 2SLS regressions for the outcomes at age 15, with the interactions for female (F) and countries' dichotomous variables

	Math		Reading		PPVT	
		Inter. × F		Inter. × F		Inter. × F
Panel A: Estimates for Ethiopia as default category						
HAZ at age 12 (H_{12y})	0.232 (0.435)	0.021 (0.582)	-0.527 (0.522)	0.900 (0.672)	-0.026 (0.216)	0.025 (0.293)
Norm. wealth at 12 (W_{12y})	-0.152 (0.773)	0.963 (0.986)	-0.793 (1.005)	2.584** (1.234)	0.288 (0.353)	0.195 (0.515)
Panel B: Estimates for interactions $S_1 \times var$ ($S_1 = 1$, if India)						
HAZ at age 12 (H_{12y})	0.813 (0.571)	-1.845 (1.132)	1.689*** (0.627)	-2.143** (1.024)	0.097 (0.296)	0.037 (0.456)
Norm. wealth at 12 (W_{12y})	1.313 (0.924)	-1.685 (1.368)	2.473** (1.097)	-3.360** (1.574)	-0.272 (0.571)	0.528 (0.753)
Panel C: Estimates for interactions $S_2 \times var$ ($S_2 = 1$, if Peru)						
HAZ at age 12 (H_{12y})	0.399 (0.566)	-0.849 (0.814)	1.065 (0.662)	-1.057 (0.877)	0.251 (0.283)	-0.055 (0.384)
Norm. wealth at 12 (W_{12y})	0.147 (1.166)	-1.206 (1.460)	0.833 (1.383)	-2.721 (1.835)	0.270 (0.539)	0.905 (0.728)
Panel D: Estimates for interactions $S_3 \times var$ ($S_3 = 1$, if Vietnam)						
HAZ at age 12 (H_{12y})	0.023 (0.530)	-0.209 (0.737)	0.917 (0.607)	-1.212 (0.852)	0.240 (0.274)	0.004 (0.376)
Norm. wealth at 12 (W_{12y})	1.328 (1.142)	-0.978 (1.432)	1.051 (1.374)	-1.401 (1.733)	-0.343 (0.490)	-0.123 (0.707)
Number of observations	6566		6566		6566	
R-squared (within)	0.32		0.21		0.84	

Note: HAZ at age 5 (H_{5y}), and its interactions with F, S_1, S_2, S_3 are treated as endogenous. Control factors include firth born, mother's education, father's education, caste/ethnicity and as well as interactions with F, S_1, S_2 and S_3.
***, **, and * denote significance at the 1%, 5%, and 10% levels

Appendix C: Estimates for controls

Table C1: 2SLS regressions for equation 3 of the outcomes at age eight, for all children

	Math		Reading		PPVT	
		Inter. × F		Inter. × F		Inter. × F
Panel A: Ethiopia						
If first child of mother	-0.133 (0.540)	0.108 (0.788)	-0.222 (0.669)	1.310 (0.977)	-0.293 (0.974)	1.220 (1.421)
Mother completed primary education	1.802*** (0.617)	0.705 (0.889)	1.003 (0.764)	0.961 (1.102)	5.515*** (1.112)	-1.194 (1.603)
Father completed primary education	1.173** (0.564)	0.363 (0.795)	1.202* (0.699)	0.209 (0.985)	1.891* (1.017)	-1.700 (1.433)
Panel A: India						
If first child of mother	0.621 (0.544)	-0.140 (0.803)	2.018*** (0.611)	-1.590* (0.902)	0.934* (0.564)	-0.693 (0.833)
Mother completed primary education	3.166*** (0.673)	-0.413 (0.988)	1.922** (0.757)	-0.412 (1.111)	1.525** (0.699)	0.542 (1.026)
Father completed primary education	1.347** (0.632)	0.468 (0.928)	0.886 (0.710)	0.432 (1.043)	1.954*** (0.656)	-0.983 (0.964)
Panel C: Peru						
If first child of mother	0.933* (0.495)	0.319 (0.706)	0.837 (0.572)	-0.566 (0.816)	0.096 (0.281)	0.257 (0.400)
Mother completed primary education	2.447*** (0.629)	-0.251 (0.897)	3.582*** (0.726)	-1.508 (1.036)	2.125*** (0.356)	-1.074** (0.508)
Father completed primary education	2.730*** (0.686)	-1.219 (0.972)	3.609*** (0.792)	-0.936 (1.123)	2.204*** (0.388)	-1.015* (0.551)
Panel D: Vietnam						
If first child of mother	0.083 (0.463)	0.885 (0.668)	1.180*** (0.435)	-0.190 (0.628)	1.127** (0.479)	-1.018 (0.692)
Mother completed primary education	1.906*** (0.665)	-0.290 (0.948)	2.417*** (0.625)	-0.446 (0.891)	3.195*** (0.688)	-0.450 (0.981)
Father completed primary education	2.015*** (0.656)	-0.268 (0.945)	0.316 (0.617)	-0.109 (0.889)	1.135* (0.679)	-0.300 (0.978)
Panel E: All countries						
If first child of mother	0.440* (0.256)	0.324 (0.370)	1.180*** (0.286)	-0.326 (0.413)	0.544* (0.292)	-0.167 (0.422)
Mother completed primary education	2.403*** (0.325)	-0.075 (0.469)	2.158*** (0.362)	-0.251 (0.523)	3.069*** (0.370)	-0.434 (0.534)
Father completed primary education	1.769*** (0.317)	-0.093 (0.454)	1.258*** (0.353)	0.023 (0.507)	2.161*** (0.361)	-1.065** (0.517)

Notes: Control variables include sex (***F***), nutrition status at five, household wealth at five, caste/ethnicity, and their interactions with the dichotomous variables on sex and the countries

***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table C2: 2SLS regressions for equation 4 of the outcomes at age 15, for all children

	Math		Reading		PPVT	
		Inter. × F		Inter. × F		Inter. × F
Panel A: Ethiopia						
If first child of mother	0.959	0.036	1.677*	0.982	0.540**	-0.337
	(0.594)	(0.868)	(0.950)	(1.455)	(0.272)	(0.405)
Mother completed primary education	0.405	-1.200	2.577**	0.011	-0.768	0.629
	(0.861)	(1.232)	(1.309)	(1.887)	(0.529)	(0.666)
Father completed primary education	-0.756	1.150	-0.217	1.721	-0.022	0.991**
	(0.675)	(0.979)	(1.133)	(1.608)	(0.312)	(0.421)
Panel A: India						
If first child of mother	0.315	0.219	0.359	0.273	0.379	-0.040
	(0.565)	(0.844)	(0.750)	(0.974)	(0.344)	(0.437)
Mother completed primary education	1.664	-1.341	2.066***	-0.772	-0.112	0.565
	(1.231)	(1.838)	(0.722)	(1.225)	(0.543)	(0.739)
Father completed primary education	1.488**	-1.163	1.074*	1.096	-0.172	1.306*
	(0.741)	(1.245)	(0.632)	(1.089)	(0.608)	(0.702)
Panel C: Peru						
If first child of mother	-0.568	-0.683	0.185	-0.353	0.642	-0.250
	(0.627)	(0.871)	(0.612)	(0.805)	(0.393)	(0.560)
Mother completed primary education	1.635	-2.719**	2.104	-2.040	0.461	0.868
	(1.046)	(1.338)	(1.391)	(1.590)	(0.826)	(0.989)
Father completed primary education	0.884	-0.962	1.919	-1.644	0.671	-0.125
	(1.119)	(1.374)	(1.388)	(1.662)	(0.846)	(1.030)
Panel D: Vietnam						
If first child of mother	0.474	-0.441	-0.288	1.016	-0.026	0.788**
	(0.725)	(1.067)	(0.791)	(1.122)	(0.253)	(0.349)
Mother completed primary education	1.498	0.715	-0.628	1.614	0.141	0.493
	(1.150)	(1.623)	(1.219)	(1.710)	(0.448)	(0.611)
Father completed primary education	0.716	0.557	2.883***	-2.077	0.633*	-0.454
	(1.196)	(1.676)	(0.958)	(1.380)	(0.358)	(0.503)
Panel E: All countries						
If first child of mother	0.081	-0.289	-0.134	0.758	0.380**	0.222
	(0.314)	(0.462)	(0.514)	(0.645)	(0.173)	(0.247)
Mother completed primary education	0.864	-0.780	1.234	-0.285	-0.281	0.477
	(0.571)	(0.777)	(0.792)	(0.978)	(0.357)	(0.464)
Father completed primary education	0.440	0.093	1.314**	0.039	-0.105	0.463
	(0.475)	(0.662)	(0.536)	(0.728)	(0.282)	(0.363)

Notes: Control variables include sex (***F***), nutrition status at five, household wealth at five, caste/ethnicity, and their interactions with the dichotomous variables on sex and the countries
***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

[1] *Source*: Evan et al. (2020). The evidence is based on data from 126 countries, excluding all countries that were founding members of OECD.

[2] Among the few studies on this topic, Aurino et al. (2019a) find gender differences in the associations between food insecurity and learning achievements at 12 years in India are not statistically significant and Aurino et al. (2019b) find almost no significant gender differences in relations between nutritional status in the first 1000 days and cognitive skills at age 15 in the four Young Lives countries.

[3] The claim refers to data in the first decade of the 21st century. S*ource*: 2017 OECD report.

[4] In Ethiopia, Peru, and Vietnam, sites were selected from national sampling frames. For India, at the start of Young Lives, the sentinel sites were from the state of Andhra Pradesh only. However, in 2014, Andhra Pradesh was divided in two to form a new state, Telangana, and the sampled households were located in both states.

[5] Data on an Older Cohort also were collected each survey round. The Older Cohort was about eight years of age in the first round. Because of the emphasis in this study on early and mid-childhood as well as early adolescence, we consider only the Younger Cohort.

[6] For Ethiopia, first-cycle primary (Grades 1–4) is used.

[7] The t-test for differences in HAZ at age 5 of girls between the two country groups equals 6.48 (p-value <0.0001).

[8] The three exceptions are reading for India and Vietnam and PPVT for India.