Long-term implications of undernutrition on non-cognitive skills: evidence from four developing countries

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Abstract

Both cognitive and non-cognitive skills matter to understand labour market outcomes. However, it is unclear how non-cognitive skills are produced and what is the role played by household investments in this process. Motivated by suggestions from the medical literature and by the skills formation model proposed by Cunha and Heckman (2007, 2008), in this paper we use longitudinal data from children growing up in developing country contexts to study the role of early nutritional history in shaping psycho-social competencies. We estimate a linear conditional demand function for non-cognitive skills, linking height-for-age at the age of 7-8 to psycho-social competencies measured at the age of 11-12, controlling for a wide array of potential co-founders at the child, household and community level. The main finding is that height-for-age predicts survey-based measures of self-efficacy, self-esteem and aspirations. In the case of self-esteem and aspirations, results hold after controlling for an extended set of household wealth controls, strongly suggesting that the nutrition effect found goes beyond the effect that household poverty has on the same outcomes. While we find suggestive evidence that the nutrition effect acts partially through a cognitive channel, direct effects remain.

1 Introduction

Evidence shows that there are returns to personality traits and to other psycho-social attributes in the labour market (Bowles et al. 2001; Heckman et al. 2006) and in other dimensions of life as well (Trzesniewski et al. 2003). Explicitly accounting for non-cognitive skills has helped to explain substantial variation across earnings of otherwise similar individuals (Bowles et al. 2001). Moreover, recent evidence supports the notion that both cognitive and non-cognitive skills are shaped during early stages of the life cycle and that complementarities arise across both types of skills (Cunha and Heckman 2007, 2008).

While this evidence suggests that non-cognitive skills play an important role to explain labour market outcomes and social behaviour, little is known about how this type of skills is initially acquired. Cunha and Heckman show, essentially, that non-cognitive skills measured early in life are persistent over time. However, the type of early household investments that play a role in the acquisition of these skills is largely unknown. In this paper, we pose one specific question: what is the role of health and nutrition in the formation of psycho-social competencies? In particular, we ask whether early undernutrition, a situation faced by a high proportion of children growing up in poverty and with known long-term cognitive implications (Glewwe et al. 2001; Alderman et al. 2006), might also be playing a role in the development of psycho-social skills. There is already evidence showing that early stunted children behave differently compared to non-stunted children, being generally less social, more apathetic and less willing to explore at early ages (see Grantham-McGregor et al. 1999, pg.67) and with behavioral problem at later ages (Chang et al. 2002). It seems then natural to test whether differences in early nutrition lead to differences in the acquisition of psycho-social competencies.

To explore the linkages between nutritional investments and psycho-social competencies, conceptually we follow a human capital accumulation approach whereby a child's non-cognitive skills in a given period are determined by the stock of physical health and skills accumulated in previous periods and by other parental investments. This is akin to the skills production function proposed by Cunha and Heckman, however the novel aspect is the addition of a lagged physical health stock in the model. We consider this to be a missing input in the skills formation model. We aim at testing the role of nutritional investments in the child during the early stage of childhood on non-cognitive skills acquisition, thus reconciliating recent evidence on skills formation with evidence from the early childhood development literature.

To estimate the relationship of interest, we use longitudinal data from around 3,300 children drawn from the Young Lives country surveys. These surveys provides comparable information at the child, household and community level for four cohorts of children in Peru, India, Ethiopia and Vietnam. Data were collected when children were in their transition from mid to late childhood, at ages 7-8 and 11-12 years. We use physical height measured at a relatively early stage to proxy a child's early nutritional history (Martorell 1999, pg. 289). To measure psycho-social competencies, we focus on three survey-based indicators, each reflecting different competencies that have all been recognized to reflect important non-cognitive dimensions of adolescent development, and that correlate well with future social and economic opportunities: self-esteem, self-efficacy and educational aspirations (Stajkovic and Luthans 1998; Trzesniewski et al. 2003; Goldsmith et al. 1997; Gutman and Akerman 2008). Whilst not a complete set of competencies to describe social and psychological development, these indicators are relevant in the context of children growing up in developing countries.

To empirically assess the relationship between height-for-age and our available non-cognitive measurements, we use OLS methods to estimate a linear conditional demand function for non-cognitive skills, linking nutrition status at the age of 7-8 to psycho-social outcomes at the age of 11-12, controlling for child, parental and household and community characteristics that act as determinants of non-cognitive investments. We start with a baseline specification and then progressively add more structure to the estimated equation to illuminate the pathways through which a child's early nutritional history could play a role in the acquisition of skills. The baseline specification controls for basic characteristics of the child (age, sex, ethnicity, disability status, school enrolment) the caregiver (age, sex, ethnicity, education) and the household (household size, access to basic services, holding of durable goods), among other aspects. In addition, the estimation includes cluster fixed effects to account for the role of community characteristics. This initial setup, while basic, controls for some of the key correlates of early undernutrition, a feature intrinsically correlated to poverty. We use this specification to provide a first glance at the relationship of interest for each of the selected non-cognitive indicators.

In the next part of the analysis we proceed to check the robustness of the results. We first discuss under which scenarios the estimation of the coefficient of interest in the parsimonious specification could be biased. A main concern is that of unobservable household heterogeneity; while the initial specification controls for dimensions of household wealth traditionally observed in national household surveys, it does not directly account for the role of the household budget in driving parental investments in the child. Nor do the results control for the household psychosocial environment. In both cases, the argument is that there could be an inter-generational mechanism at place, whereby poor parents with low non-cognitive skills raise malnourished children with low non-cognitive skills. Another area of concern in the initial specification is related to child unobservables; in particular, short-term nutritional deficits might be correlated with height-for-age and, arguably, with non-cognitive skills. For instance, stunted children are more likely to be wasted and wasting can be linked to poor performance in psycho-social tests in a way that is unrelated to the accumulated effect of a child's long-term dietary habits. To deal with these possibilities, we present results for an extended specification where we add as controls contemporaneous household consumption expenditure (in per capita terms), lagged household-level occurrence of shocks –as a measure of household vulnerability, another dimension of poverty–, contemporaneous body mass index –as a measure of current nutritional status– and measurements of maternal psycho-social competencies analogous to the outcomes (i.e., maternal aspirations, self-efficacy and self-esteem) –to proxy for the household psychosocial environment.

We also consider the possibility that our results could be reflecting the impact of relative height on non-cognitive skills rather than the long-term implications of investing in early nutrition. That is, stunted children could have poorer non-cognitive skills simply because they are more likely to be bullied by their taller peers. Were this to be the case, a similar relationship between height-for-age and skills could be found even in populations of healthy children. While it is impossible to rule out this possibility with the information at hand, we try to deal with this concern by re-estimating our model for sub-samples that only include communities where stunted children are not a minority, and, thus, are less likely to be treated differently because of their relative height. In addition, we directly control for whether a child is bullied by his/her school peers, reasonably ruling it out as a mediating factor.

Finally, we analyze to what extent the linkage between height-for-age and non-cognitive skills could be mediated by schooling performance. As suggested by the nutrition literature, height-for-age predicts both age of school enrolment (Glewwe and Jacoby 1995) and cognitive achievement (Alderman et al. 2006; Glewwe et al. 2001). In turn, a satisfactory school performance could improve a child's aspirations and self-esteem. We test this aspect of the skills formation model by adding to the full specification lagged levels of reading skills, writing skills and age of school enrolment.

Based on this empirical approach, we find that height-for-age is strongly correlated with the available measurements of non-cognitive skills. Specifically, in the pooled sample, using the baseline specification, we find that a marginal increase in height-for-age as observed at the age of 7-8 predicts higher levels of self-esteem, self-efficacy and school aspirations at the age of 11-12. Using the full set of controls, we still obtain a statistically significant nutrition effect on school aspirations and self-esteem, but no longer on self-efficacy: in the latter case the point estimate is virtually unchanged, but imprecisely estimated. The fact that these results persist when controlling for household material wealth and household psychosocial environment is striking. While inter-generational poverty is ultimately likely to govern the process –as suggested by the fact that household expenditure per capita and maternal non-cognitive skills turn out to be key determinants of a child's non-cognitive skills–, the estimated effect is above and beyond the direct effect that household poverty has on non-cognitive skills acquisition.

Moreover, we test and do not reject the hypothesis that the nutrition effects estimated are the same across the four study countries, reinforcing our prior that there is an underlying mechanism linking long-term nutritional investments and non-cognitive skills. The magnitude of the nutrition effects are as follows: keeping other factors constant, a one standard deviation increase in height-for-age increases school aspirations by about 7.5% of the standard deviation of school aspirations. An analogous marginal increase in height-for-age leads to an improvement in self-esteem that represents 3.5% of the standard deviation of the self-esteem score. Our analysis also unveils part of the mechanism through which nutritional investments exert an effect over non-cognitive skills. We find suggestive evidence that the nutrition effect is partially mediated by the effect that nutrition has on the accumulation of cognitive skills. However, direct effects remain.

While our results can not be interpreted in a causal sense, they are certainly suggestive of a relationship between early undernutrition and later psychosocial status and of some of the pathways through which this relationship is established.

This chapter is organized as follows. Section 2 provides a conceptual motivation of our study, sketches a simple human capital model to explain our ideas and describes the empirical methodology. Section 3 describes the data and provides a discussion on the validity and stability of the psycho-social indicators used in the estimations. Sections 4 and 5 present the main findings and robustness checks. Section 6 further explores the channels of transmission of the nutrition effect and section 7 concludes.

2 Conceptual and empirical framework

2.1 Conceptual framework

There are two strands of the literature on human capital accumulation that are relevant for this study. The first one is the literature on early child development, which stresses the importance of nutritional investments during the *in utero* period as well as during the first three years of life as causally linked to later cognitive achievement, educational attainment and, ultimately, productivity and wages (Alderman et al. 2006; Almond 2006; Glewwe et al. 2001; Grantham-McGregor et al. 1991, 1997; Pollitt et al. 1993; Maluccio et al. 2009). The case made by these studies is based on evidence from low-income countries, where mild and severe malnutrition is still widespread. A second strand of the literature is the one initiated by Cunha and Heckman (2007, 2008), later extended in Cunha et al. (2010). The authors develop a conceptual framework to understand the accumulation of human capabilities and the novelty of their approach is the explicit incorporation of non-cognitive skills in a model of human capital accumulation. They assume that both cognitive and non-cognitive skills are produced on the basis of household investments, the influence of environment and innate endowments. They establish the notion that cognitive and non-cognitive skills are self-reinforcing and that complementarities across skills can arise over time. To test this model, they use longitudinal data from children growing up in the US, finding evidence of both self-productivity and complementarity across both types of skills.

In this study, we aim at linking these two strands of the literature. In particular, we argue that the skills formation model proposed by Cunha and Heckman misses one key feature highlighted in the early childhood development literature: the role of early nutrition. By explicitly incorporating a physical health stock in the skills formation model, it is possible to illuminate different pathways through which early nutrition could be driving the accumulation of non-cognitive skills, a linkage already suggested in the medical literature (Grantham-McGregor et al. 1999; Chang et al. 2002).

To set up ideas about the hypothesized relationship between physical health and non-cognitive skills, we sketch a human capital technology where these two variables are explicitly linked. Denote the stock of psycho-social skills (hereafter, non-cognitive skills) in a given period t as S_t^P. Suppose S_t^P is acquired through the following technological process,

$$S_t^P = f^P(H_{t-1}, S_{t-1}^C, S_{t-1}^P, I_t^P) \tag{1}$$

where H_{t-1}, S_{t-1}^C and S_{t-1}^P stand for health, cognitive and non-cognitive skills accumulated up to t-1 (respectively), I_t^P denotes contemporaneous parental investments in psycho-social skills and $t = 1, 2, , T$. An analogous equation can be defined for the production of cognitive skills in period t,

$$S_t^C = f^C(H_{t-1}, S_{t-1}^C, S_{t-1}^P, I_t^C) \tag{2}$$

whereas health can be assumed to be determined purely in terms of lagged health and health parental investments,

$$H_t = f^H(H_{t-1}, I_t^H) \tag{3}$$

This framework follows closely the skills formation model proposed by Cunha and Heckman (2007, 2008), extended to account for the role of lagged health and nutrition. In particular, the sketched technology features a situation in which past health act as an input for current cognitive and non-cognitive skills. Given that this model allows for skills complementarities, this implies that the effect of past health, H_{t-k}, on S_t^P is direct as well as indirect, through the effect that health has on S_{t-1}^C and S_{t-1}^P between periods $t-k$ and $t-1$. Another essential feature of this technology is that the accumulation of non-cognitive skills is shaped by parental investments, $I_t = (I_t^H, I_t^P, I_t^C)$. The optimal allocation of I_t over $t = 1, 2, , T$ can be modeled as part of a maximization problem whereby parents decide how to allocate resources between consumption and investments in the child over time subject to preferences, budget constraints and initial conditions. Initial conditions can include child and household exogenous characteristics that affect the rate of return of these investments (for instance, child's genes endowment, household cognitive and non-cognitive environment, etc). Assuming the utility function and equations 1, 2 and 3 satisfy the regularity conditions, a maximization process would yield optimal allocations for consumption and investments as a function of preferences, prices and initial conditions.

2.2 Empirical framework

Our empirical analysis focuses on one dimension of physical health: nutritional status. We aim at testing the relationship between non-cognitive skills in a given period *t* and the nutritional history of a child up to period *t-1*. For us, *t* represents the late childhood period and *t-1* the mid childhood period, so that many years separate *t* from *t-1*. We use the previously sketched model as a conceptual framework, but with the caveat that we lack information to estimate the skills production function. In particular, we do not observe S_{t-1}^{P}. More generally, we find the estimation of human capital production functions to be problematic because, in practice, many inputs at the child, household, school and community level not considered in our sketched model but that can realistically alter S_t^P are unobserved to the econometrician, implying that technology parameters can generally not be recovered.

In the context of human capital models, technology parameters refer to biological linkages between inputs and outputs. As a consequence of an exogenous increase in one input parents are likely to adjust the investments devoted to the child –that is, inputs are realigned. While we consider the estimation of the technology parameter linking nutritional status to non-cognitive skills to be out of reach, the overall effect of a change in nutritional status –a combination of a biological effect and behavioral adjustments, coined as the "policy effect" by (see Todd and Wolpin 2003, pg. F6)– can still be estimated and is of practical relevance. The focus in this case is on estimating a conditional demand function for non-cognitive skills (conditional on nutritional status).

For the empirical analysis, we estimate the following linear equation,

$$S_{ij,t}^{P}|H_{ij,t-1} = \beta H_{ij,t-1} + \delta X_{ij,t} + \alpha_j + \mu_{ij,t} \tag{4}$$

where subscript j stands for the cluster where child i lives (added ahead of the clustered structure of the sample), α_j represents cluster characteristics that are constant over time, $X_{ij,t}$ is a vector of child and household predetermined characteristics (a full description of the variables included is reported in section 4) and $\mu_{ij,t}$ is the error term. Model specification 4 measures the overall effect of nutrition on non-cognitive skills. The inclusion of vector $X_{ij,t}$ is a way to account for parental investments. Specifically, elements included in this vector are interpreted to be determinants of parental investments. In section 4 we draw special attention to the elements included in this vector in order to reasonably alleviate concerns of unobservable determinants of parental investments leading to a bias in the estimation of β, the coefficient of interest. To estimate equation 4 we use longitudinal data from four developing countries. The survey data is suitable to measure a number of non-cognitive skills at age 11-12 and its relationship with nutritional status at age 7-8. Since the same questionnaire was administered in each country, we estimate country level results as well as results for the pooled sample.

3 Data characteristics

3.1 The sample

Data come from the Young Lives Project, a project tracking the livelihoods of four cohorts of children in India (Andhra Pradesh), Ethiopia, Peru and Vietnam. In each of these countries, a cohort of approximately 1,000 children (700 in Peru) born in 1994-5 was selected for the study. A multi-stage sampling procedure was used. Firstly, twenty clusters were selected within each country; at random in Peru and based on a number of predetermined criteria in the other three countries.[1] Secondly, within each cluster, a village/town (or a group of villages/towns) and a group of eligible households within each village/town was chosen at random, respectively. [2] For simplicity, onwards we use the terms cluster and community indistinctively

While the samples (with the exception of Peru) were not selected to be representative, their wide geographical and ethnical coverage make them informative of the living conditions faced by the population in each of the selected countries. Approximately 50 households were selected in each cluster and in-depth information was collected for the eligible child (aged 7-8 at the time of the baseline survey) within each household.[3] The sampled children and their caregivers were interviewed twice: in 2002, when they aged 7-8 years; and, in 2006-7, when they aged 11-12 years. The survey provides information on a variety of aspects related to child development, including child and maternal indicators of perceptions, attitudes and aspirations, child cognitive test scores, child and maternal anthropometric measures, as well as wide array of information on child, family and other contextual characteristics. Attrition

[1] Clusters are small geographical units. The exact definition depends on the country (districts in Peru, communes in Vietnam, mandals in Andhra Pradesh and weredas in Ethiopia).

[2] The household eligibility criterion consisted in having a child aged 7-8 year old at the time of the first data collection

[3] If there was more than one eligible child, the final selection was made at random

in the samples is exceptionally low: only 1.4% of the children were lost or dropped out in the samples between the two rounds on average, with the Peru sample facing attrition of 3.5% and the Vietnam sample only 0.5%.

3.2 Measurements variables

3.2.1 Undernutrition

Crucial to the analysis is the availability of a valid measurement of early nutritional investments. As a proxy we use physical height observed at the age of 7-8. This variable is informative of height at an earlier age and linear growth retardation at the first few years is, primarily, the result of an inadequate nutrition over a long period of time (Martorell 1999). Thus, height-for-age at 7-8 is reasonably informative of the history of early nutritional investments. We use the growth curves reference for school-aged children recently developed by the World Health Organization (WHO 2007 standards). Based on this growth reference, a child of a given age and sex is catalogued as moderately stunted (chronically malnourished) if her (his) height is ranked 2 standard deviations below the median height corresponding to a well-nourished child of the same age and sex; severe stunted is the analogous term when child's height is 3 standard deviations below the norm. For the purpose of calculation, this implies re-expressing height-for-age in terms of height-for-age Z-scores. In the Young Lives country samples, the percentage of children classified as moderately stunted at 7-8 years old fluctuates around 30 per cent (see table 1). For the estimations, we chose to use the height-for-age variable in its continuous form (as opposed to the binary variable based on the -2 S.D. cut-off point) to fully exploit the information conveyed by this variable.

3.2.2 Measurements of psycho-social traits

Using survey data, we construct a set of indicators that intend to approximate children' competencies in the following non-cognitive dimensions: (a) self-efficacy; (b) self-esteem; and, (c) school aspirations. These dimensions have all been found to correlate well with future social and economic opportunities: for self-efficacy, see Stajkovic and Luthans (1998); for self-esteem, see Trzesniewski et al. (2003) and Goldsmith et al. (1997); and, for aspirations, see Gutman and Akerman (2008). They are thought to be shaped early in life, to be heavily influenced by experiences and the environment and

Table 1: YL sample poverty levels and nutritional rates by country

	Peru	India	Vietnam	Ethiopia
	(1)	(2)	(3)	(4)
Indicators of poverty				
Relative poverty	25.5	6.8	9.5	9.9
Wealth index	0.51	0.34	0.44	0.17
Nutritional status				
Percentage of stunted children				
12-13 years	28.7	32.3	29.7	29.0
7-8 years	26.3	31.6	27.4	31.4

Notes: relative poverty is defined as the proportion of households with per capita consumption below 50 per cent of country median consumption. The wealth index used comprises information on housing quality, holding of consumer durables and access to services. Source: Young Lives country reports and own estimations.

to become more stable as adolescence is reached (see op.cit.). The influence of genes as a determinant has not been ruled out.

The concepts of self-esteem and self-efficacy have been extensively studied in the field of psychology, particularly the former. Self-esteem is related to a person's overall evaluation of her own worth. In turn, self-efficacy is related to a person's sense of agency or mastery over his life. Individuals hold beliefs about whether outcomes are due to their own efforts or the result of luck, fate, or the intervention of others. Individuals who believe that outcomes are due to their own efforts have a high "internal" locus of control (Maddux 1991), i.e., a high sense of agency.

To measure these two psycho-social traits, we estimated indicators based on respondents' degree of agreement or disagreement with a number of statements. The degree of agreement is measured on a 4-point Likert scale that ranges from strong agreement to strong disagreement. In turn, answers to these statements are used to construct individual average scores on self-efficacy and self-esteem. Statements used for the construction of each index were drawn from the educational psychology literature, although they were adapted and extensively tested during piloting for use with children across different cultures. For self-esteem, the statements explored in the Young Lives survey focused largely on positive and negative dimensions of pride and shame. They are effectively an adapted version of the Rosenberg Self-Esteem Scale (Rosenberg 1965), more focused on specific dimensions of children living circumstances (housing, clothing, work, school): "I feel proud to show my friends or other visitors where I live", "I am ashamed of my clothes", "I feel proud of the job done by the head of household", "I am often embarrassed because I do not have the right books, pencils or other equipment for school", "I am proud of my achievements at school", "I am embarrassed by/ashamed of the work I have to do", "I am ashamed of my shoes", "I am worried that I don't have the correct uniform" and "The job I do makes me feel proud". The self-esteem index is the average score of the above items (with negative statements recoded in the inverse order). In the case of self-efficacy, we focused on three statements explored in the Young Lives survey: "If I try hard I can improve my situation in life", "I like to make plans for my future studies and work" and "If I study hard at school I will be rewarded by a better job in future". The self-efficacy index is the average score of the above items. The fact that a higher number of items is available for the calculation of the self-esteem index in comparison to the self-efficacy index suggests that the latter measure is likely to contain more measurement error.

Another competence that interest us is related to a child's educational aspirations. Quaglia and Cobb (1996) define aspirations as the "ability to identify and set goals for the future, while being inspired in the present to work toward those goals". As such, this concept is linked to ambition. To measure educational aspirations, in the Young Lives Survey each child is asked how far they hope to get in educational terms. The answer is expressed in equivalent years of education, asking for the highest grade of education that the child hopes to complete.

One concept often assessed in the context of psychological tests is internal consistency (sometimes called reliability or homogeneity). The notion is that, in a homogenous psychological test, items measure the same thing (Cronbach 1951). The Cronbach's alpha, a statistic based on the correlation of different items of the same test, is deemed a test of internal consistency in the sense that a relatively high alpha (above 0.70) supports the notion that there is a common factor behind answers to different items. Table 2 reports the standard deviation for each of the selected indicators by country as well as the Cronbach's alpha for the pooled sample. This statistic is close to 0.7 in the case of self-esteem.

Table 3 gives the mean educational aspirations for each country with the standard deviation in brackets. The high expectations at the age of 12 by these children is remarkable, with on average more than 15 years of education aspired to.

Table 2: Self-efficacy, Self-esteem and Inclusion: Standard Deviation and Cronbach's alpha

	Peru	India	Vietnam	Ethiopia	All
	(1)	(2)	(3)	(4)	(5)
Indicator:					
Self-efficacy	0.66	0.75	0.74	0.70	0.72(0.47)
Self-esteem	0.52	0.56	0.58	0.55	0.55(0.67)
n	682	992	983	978	3635

Each cell reports the standard deviation. In the case of the pooled sample, Cronbach's alpha is reported in brackets. Underlying items for each measure transformed with mean zero and variance one. Generated measure is simple average.

Table 3: School aspirations: descriptive statistics

	Peru	India	Vietnam	Ethiopia	All
	(1)	(2)	(3)	(4)	(5)
Mean	15.17	15.07	15.60	15.36	15.31
S.D.	(1.80)	(2.99)	(2.57)	(2.78)	(2.63)
n	666	907	952	936	3461

Notes: school aspirations are expressed in terms of the number of years of schooling the child hopes to get.

4 Main Results

Table 4 (appendix) reports simple pair-wise correlations between height-for-age and the three selected psycho-social indicators. Results are reported by country and for the pooled sample. In the pooled sample, the correlation is positive and statistically significant for all the psycho-social dimensions included. On a country by country basis, we find that height-for-age is positively correlated to school aspirations in all countries; to self-esteem in Peru, India and Vietnam; and, to self-efficacy in Vietnam. In all cases, the sign of the effect is positive, as expected.

To empirically assess the role of nutritional status in later acquisition of psychosocial competencies, we proceed to regress each of the selected measurements on lagged height-for-age using the following specification,

$$S^P_{ij,t}|H_{ij,t-1} = \beta H_{ij,t-1} + \delta X_{ij,t} + \alpha_j + \mu_{ij,t} \tag{5}$$

where $S^P_{ij,t}$ stands for non-cognitive skills measured at 11-12 years (aspirations, self-efficacy and self-esteem) of child i from cluster j measured in period t; $H_{ij,t-1}$ stands for height-for-age at 7-8 years; we use community fixed effects to deal with community heterogeneity represented by α_j; the set of controls used in the baseline specification - $X_{ij,t}$ - are: (a) child's sex, age, birth order, disability status, native tongue and whether the child is currently attending school; (b) caregiver's relationship to the child, age, years of education, ethnicity (caste in India), marital status and disability status; and, (c) household size, sex of the head of the household, housing quality (wall, floor and roof building materials) and access to services (water, electricity and toilet facilities). We include current school attendance because it is at school where the child socially interacts with other children of her age. Clearly, not being enrolled could be correlated both with malnutrition and psycho-social dimensions of the child. Similarly, child's disabilities associated to nutritional problems could lead to a deficit of psycho-social skills.

The nutrition marginal effects obtained from estimating this baseline specification are reported in table 5 (appendix), columns 1 to 3, for the pooled sample and for each of the study countries. Focusing on the pooled sample, we find that height-for-age remains associated to school aspirations, self-efficacy and self-esteem. Because variables on both sides of the regression are standardized with mean 0 and variance 1, the nutrition marginal effects can be interpreted in terms of the proportion of the standard deviation of the outcomes explained by height-for-age. An increase of 1 standard deviation in height-for-age, keeping everything else constant, tends to increase school aspirations, self-efficacy and self-esteem by 10.1%, 3.9% and 5.2% of the standard deviation of school aspirations, self-efficacy and self-esteem scores, respectively. F-tests are reported to assess the null hypothesis that the nutrition effect is the same across countries. The hypothesis is only rejected in one case (school aspirations) and as additional controls are added –see subsection below– the hypothesis is never rejected. This reinforces the notion that there is an underlying mechanism linking height-for-age and non-cognitive skills that is common across countries.

5 Robustness checks

There are different reasons why the first set of results might be overstating the overall effect of nutritional status on the development of non-cognitive skills. At the household level, parental unobserved investments or household environment could be the driving force behind nutritional status and skills acquisition. For instance, malnutrition is more likely to arise in the context of materially deprived families and at the same time children raised in poverty might be less likely to achieve their psycho-social potential. This suggests that it could be the effect of household income level acting as a constraint in the rate of return of child investments and not a child's own nutritional status what is driving the previous findings. Given that the baseline specification imperfectly controls for household monetary resources this possibility can not be ruled out. Similarly, it could be the case that poor parents with low non-cognitive skills raise malnourished children with low non-cognitive skills. On the other hand, at the child level, it is possible that our results are picking up a short-term nutritional deficit associated to poverty, such as wasting, rather than the accumulated effect of child dietary habits over a long period of time.

To deal with these possibilities we present results for an extended specification. To disentangle more effectively the effect of past undernutrition on non-cognitive skills from the effect that living in a poor household has on the same outcomes, we include contemporaneous household consumption expenditure (in per capita terms, expressed in logs) and contemporaneous child body mass index as additional controls in the estimation. To take into account other dimensions of poverty, we also control for household vulnerability to a variety of economic shocks (natural disasters, changes in food availability, livestock died, crop failed, livestock stolen, crop stolen, job loss, loss of family income, severe illness or injury of one member of the family[4]). To deal with the potential influence of household psycho-social environment we resort to proxy variables. We add caregiver psycho-social indicators to proxy for the household environment in which the child develops her psycho-social competencies. These indicators are analogous versions to those defined for the child, constructed on the basis of statements reflecting caregiver's competencies in the areas of self-esteem and self-efficacy. In the case of educational aspirations, it measures the number of years of education the caregiver expects her child to achieve.

A summary of the nutrition effects re-estimated after adding these additional controls is presented in table 5, columns 4 to 6. Also, table 6 reports the marginal effects of a selected set of controls for the pooled sample estimations, with all the variables standardized to have mean and variance equal to 0 and 1 (respectively). Compared to the baseline specification, in this set of results the nutrition effect on self-efficacy becomes marginally insignificant in the pooled sample, albeit the point estimate differs only slightly. At the

[4]Reported when the child aged 7-8 years.

country-level, the nutrition effect on self-esteem in Vietnam is also lost. All the other results remain significant, though in some instances the coefficients are of a lesser magnitude, as expected. Comparing the baseline specification versus the extended one, the point estimates of the nutrition effects in the pooled sample reduce from 0.101 to 0.075 for school aspirations, from 0.052 to 0.035 for self-esteem and from 0.039 to 0.034 for self-efficacy. Results also show that household consumption expenditure is a strong correlate of non-cognitive skills (table 6). Since household income plays a role in the determination of nutritional status, it is natural that some of our previous results might lose strength once we control for it.

Another important result that arises from the analysis is that maternal non-cognitive skills (the caregiver is, typically, the mother) turn out to be the most important predictor of a child non-cognitive skills. The standardized coefficients for each of the selected maternal indicators (maternal aspirations, self-esteem and self-efficacy respectively) on the analogous child indicators are 0.377, 0.271 and 0.042, respectively. These results suggests the existence of an inter-generational mechanisms of transmission linking maternal to child non-cognitive skills. At the same time, that the results persist even after controlling for these aspects suggest they are not driven by this mechanism.

5.1 The role of relative height

As a final check, we consider an alternative interpretation of our results that, were it to be valid, would alter our conclusions. Given that we use height-for-age as a measure of long-term nutritional status, it is possible that our results could just be reflecting the impact of relative height on non-cognitive skills instead of the long-term implications of investments in early nutrition. This line of interpretation takes seriously the role of peers in determining a child's non-cognitive skills. For instance, if relatively small children are more likely to be bullied at the school, this could explain why stunted children (if they are indeed a minority) have poorer non-cognitive skills. But, were this to be the case, a similar relationship between height-for-age and non-cognitive skills could be found even in populations of healthy children. While it is impossible to entirely rule out this possibility with the available information, we deal with this concern in two ways. Firstly, we re-estimate our model for sub-samples where only children living in communities where stunted children are not a minority are included. Doing this reduces the likelihood that stunted children could be treated differently because of their relative height. Secondly, as a complementary strategy, we include a dummy variable to control for whether the child is bullied at school (self-reported).

The average community in the sample includes 50 children and many of these kids are, in practice, school peers. For our purpose, we focus on communities where more than 25% of children are stunted (results with a 10% threshold are also reported). Results are reported in table 7 (appendix). As it can be observed, our results still persist in these alternative specifications, with only minor changes in the coefficients.

6 On the channels of transmission

To be consistent with the human capital model sketched in section 2, it is important to discuss whether part of the nutrition effect on skills could be exerted indirectly through the effect that nutrition has on schooling dimensions that in turn can act as inputs of non-cognitive skills. This is likely to be the case. Compared to well-nourished children, malnourished children are more likely to spend less time in school due to delayed enrolment (Glewwe and Jacoby 1995) and are more likely to attain a low academic performance (Alderman et al. 2006; Glewwe et al. 2001). In turn, these aspects can arguably have a detrimental effect in the acquisition of non-cognitive skills due to the existence of complementarities across skills. This implies that the nutrition effect might be partially or entirely explained by the effect of nutrition on age of school enrolment and/or on cognitive skills.

To take into account this possibility, specification 5 is extended to include in the estimation cognitive and schooling related dimensions measured at the age of 7-8: timing of school enrolment, writing skills and reading skills. Although height-for-age and the selected cognitive skills were measured at the same time and this could lead to a problem of simultaneous determination, we argue that height-for-age conveys information about nutritional investments during the early childhood, whereas the acquisition of writing and reading skills reflect cognitive investments that took place at a later stage. In particular, we interpret writing and reading skills as measurements of schooling achievement. Whether or not the child started school at the age norm provides information about the time the child has spent in school.

Lagged schooling achievement and the timing of school enrolment are included using binary variables, whereby a variable takes the value of 0 if the child has a low (undesirable) level of a certain input (low reading skills, low writing skills or school enrolment off-age) and 1 otherwise. A child is considered to have high reading skills if able to read sentences (as opposed to only words or letters, or not being able to read at all) and high writing skills if able to write without difficulty and without errors.[5] While these are crude measures of schooling achievement, they are relevant in the context of low-income countries, where a significant fraction of children is unable to read and write properly. The proportion of children with low reading and writing skills in the pooled sample is 41% and 49%, respectively. Similarly, 25% of the sampled children are off-age (i.e., they were enroled at school after the norm-age). Only school aspirations and self-esteem are included in this part of the analysis as only in these two cases the relationship of interest remains statistically significant after adding the full set of controls. Results are reported in tables 8 for educational aspirations and table 9 for self-esteem.[6]

Both reading and writing skills at the age of 7-8 years are found to be predictors of educational aspirations and self-esteem. The nutrition effect obtained in the extended specifications is smaller in both cases: moving from 0.08 to 0.068 in the case of educational aspirations; and, from 0.032 to 0.022 in the case of self-esteem. While these results suggest that the nutrition effect is likely to be partially mediated by schooling achievement, the change in the coefficients can not be taken as large enough to claim that the entire nutrition effect is mediated by this channel. In particular, only in the latter case the coefficient becomes statistically insignificant –and by a borderline margin, as informed by the standard error of the coefficient.

We focused on the cognitive channel of transmission to be consistent with our conceptual model. However it is important to highlight that there could be other pathways through which the nutrition effect found is mediated that can not be explored due to data constraints. In particular, it is possible that well-nourished children attract more skills-related investments within the household and at school. Although the analysis only makes it possible to estimate the overall effect of nutrition on the acquisition of psycho-social competencies, and, thus, it is not possible to fully elucidate if there are biological effects –i.e., effects of undernutrition on brain structure, which governs behaviour–, we believe our results significantly improve the understanding of the process of skills formation in the context of developing countries while at the same time highlights a relatively unknown long-term implication of undernutrition.

[5] In each country, children were asked to read letters, words and sentences from a card and to write sentences under the supervision of the interviewer.

[6] Note that the sample is smaller than that used in the previous estimations. This is because of missing observations in the reading and writing tests (84 missing observations). Despite this, the same patterns found when using the original sample are also found in this new sample.

7 Conclusions

Empirical evidence and common sense indicate that non-cognitive skills are rewarded in the labour market, just in the same way that cognitive skills are. Although it is relatively well understood how cognitive skills are produced, the analogous process for non-cognitive skills has been hardly explored. Based on suggestions from the medical literature, we test the role of nutrition in shaping non-cognitive skills during early stages of the life cycle. We find evidence of a robust, positive, correlation between height-for-age measured during mid-childhood (7-8 years of age) and non-cognitive skills measured during the last stage of childhood (age 11-12, just when adolescence begins).

Although we are only equipped to show association, in our specification we control for a wide range of potential confounders. Even if poverty ultimately is likely to govern the process, the nutrition effect estimated is net of the direct effect that poverty has on non-cognitive skills (which is also found to be strong). Results also control for maternal non-cognitive skills, which reduces the probability that the nutrition-skills linkage found is the result of an intergenerational mechanism whereby poor mothers with low non-cognitive skills raise malnourished children with low non-cognitive skills. Finally, we find that the nutrition effect is only partially mediated by the effect that nutrition exerts on schooling achievement.

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8 Appendix

Table 4: Simple pair-wise correlations: Non-cognitive skills and height-for-age

	n	Grade Aspirations	Self Efficacy	Self Esteem
		(1)	(2)	(3)
Pooled sample	3279	0.161	0.043	0.101
		(0.028)***	(0.020)**	(0.026)***
Country samples				
Peru	640	0.131	-0.003	0.284
		(0.048)**	(0.052)	(0.063)***
India	856	0.122	0.035	0.086
		(0.039)***	(0.026)	(0.033)**
Vietnam	936	0.232	0.078	0.096
		(0.078)***	(0.034)**	(0.046)**
Ethiopia	847	0.143	0.047	-0.022
		(0.035)***	(0.053)	(0.051)
F-test eq. of coeff.				
F		1.88	0.77	3.64
p-value		0.140	0.516	0.016
Core controls		No	No	No
Cluster fixed effects		No	No	No
Additional controls		No	No	No

Each cell represents a different regression. Robust clustered standard errors are reported in brackets; *, **, *** denote significance at 10%, 5% and 1% levels.

Table 5: OLS results: Non-cognitive skills and height-for-age (main results)

	n	Baseline specification			Extended specification		
		Grade Aspirations	Self Efficacy	Self Esteem	Grade Aspirations	Self Efficacy	Self Esteem
		(1)	(2)	(3)	(4)	(5)	(6)
Pooled sample	3279	0.101	0.039	0.052	0.075	0.034	0.035
		(0.018)***	(0.020)*	(0.018)***	(0.019)***	(0.022)	(0.017)**
Country samples							
Peru	640	0.079	-0.019	0.103	0.060	-0.016	0.097
		(0.047)	(0.058)	(0.039)**	(0.046)	(0.057)	(0.042)**
India	856	0.055	0.024	0.043	0.034	0.010	0.030
		(0.037)	(0.026)	(0.025)	(0.043)	(0.035)	(0.028)
Vietnam	936	0.109	0.073	0.066	0.067	0.067	0.029
		(0.029)***	(0.030)**	(0.038)*	(0.027)**	(0.033)*	(0.037)
Ethiopia	847	0.124	0.055	0.013	0.110	0.054	0.010
		(0.031)***	(0.049)	(0.042)	(0.038)***	(0.051)	(0.036)
F-test eq. of coeff.							
F		2.39	1.08	0.61	1.72	1.10	0.87
p-value		0.075	0.364	0.609	0.171	0.353	0.459
Core controls		Yes	Yes	Yes	Yes	Yes	Yes
Cluster fixed effects		Yes	Yes	Yes	Yes	Yes	Yes
Consumption expenditure		No	No	No	Yes	Yes	Yes
Household shocks		No	No	No	Yes	Yes	Yes
Child's BMI		No	No	No	Yes	Yes	Yes
Maternal psycho-socials		No	No	No	Yes	Yes	Yes

Each cell represents a different regression. Robust clustered standard errors are reported in brackets; *, **, *** denote significance at 10%, 5% and 1% levels. Core controls include: housing quality index, access to services index, caregiver's age, caregiver's highest grade of schooling reached, whether caregiver is the mother, caregiver's disability status, gender of the head of the household, household size, child's age, child's sex, child's disability status, child's current school enrolment, child's birth order, area of residence, child's native tongue, mother's native tongue and mother's caste (in India).

Table 6: OLS pooled sample, detailed: Non-cognitive skills and height-for-age

	Baseline specification			Extended specification		
	Grade Aspirations	Self Efficacy	Self Esteem	Grade Aspirations	Self Efficacy	Self Esteem
	(1)	(2)	(3)	(4)	(5)	(6)
Selected controls						
Height-for-age	0.101	0.052	0.039	0.075	0.034	0.035
	(0.018)***	(0.018)***	(0.02)*	(0.019)***	(0.022)	(0.017)**
Caregiver's years of schooling	0.09	0.13	0.047	0.039	0.033	0.081
	(0.023)***	(0.022)***	(0.023)**	(0.022)*	(0.023)	(0.021)***
Access to services	0.095	0.103	0.047	0.047	0.034	0.071
	(0.028)***	(0.027)***	(0.025)*	(0.027)*	(0.025)	(0.026)***
Log-consumption per capita				0.079	0.059	0.07
				(0.02)***	(0.024)**	(0.019)***
Caregiver's aspirations				0.377		
				(0.032)***		
Caregiver's self-efficacy					0.042	
					(0.024)*	
Caregiver's self-mesteem						0.271
						(0.025)***
Obs.	3279	3279	3279	3279	3279	3279
R^2	0.157	0.166	0.079	0.267	0.085	0.239
Core controls	Yes	Yes	Yes	Yes	Yes	Yes
Cluster fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Consumption expenditure	No	No	No	Yes	Yes	Yes
Household shocks	No	No	No	Yes	Yes	Yes
Child's BMI	No	No	No	Yes	Yes	Yes
Maternal psycho-socials	No	No	No	Yes	Yes	Yes

Each cell represents a different regression. Robust clustered standard errors are reported in brackets; *, **, *** denote significance at 10%, 5% and 1% levels.

Table 7: OLS pooled sample: The role of relative height

	School aspirations				Self-esteem			
	Full sample		Comm. where % of stunted children above X		Full sample		Comm. where % of stunted children above X	
			X=%25	X=%10			X=%25	X=%10
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Height-for-age	0.075	0.075	0.069	0.08	0.035	0.03	0.051	0.039
	(0.019)***	(0.019)***	(0.026)***	(0.02)***	(0.017)**	(0.016)*	(0.023)**	(0.016)**
Child is bullied at school		-.015	-.024	-.017		-.440	-.487	-.433
		(0.042)	(0.061)	(0.043)		(0.051)***	(0.085)***	(0.056)***
Obs.	3279	3279	1757	3039	3279	3279	1757	3039
R^2	0.267	0.267	0.28	0.269	0.239	0.266	0.289	0.271
Core controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Consumption expenditure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household shocks	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's BMI	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maternal psycho-socials	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors, clustered at the sentinel site level; *, **, *** denote significance at 10%, 5% and 1% levels. Core controls include: housing quality index, access to services index, caregiver's age, caregiver's highest grade of schooling, whether caregiver is the mother, caregiver's disability status, gender of the head of the household, household size, child's age, child's sex, child's disability status, child's current school enrolment, child's birth order, area of residence, child's native tongue, mother's native tongue and mother's caste (in India).

Table 8: OLS pooled sample: School aspirations, schooling achievement and height-for-age

	OLS1	OLS2	OLS3	OLS4	OLS5
	(1)	(2)	(3)	(4)	(5)
Height-for-age	0.08	0.073	0.075	0.075	0.068
	(0.019)***	(0.019)***	(0.019)***	(0.019)***	(0.019)***
High reading skills		0.231			0.179
		(0.05)***			(0.053)***
High writing skills			0.153		0.092
			(0.035)***		(0.037)**
Child started school at the norm-age				0.14	0.089
				(0.057)**	(0.059)
Obs.	3195	3195	3195	3195	3195
R^2	0.27	0.276	0.274	0.271	0.278
Core controls	Yes	Yes	Yes	Yes	Yes
Cluster fixed effects	Yes	Yes	Yes	Yes	Yes
Consumption expenditure	Yes	Yes	Yes	Yes	Yes
Household shocks	Yes	Yes	Yes	Yes	Yes
Child's BMI	Yes	Yes	Yes	Yes	Yes
Maternal psycho-socials	Yes	Yes	Yes	Yes	Yes

Robust standard errors, clustered at the sentinel site level; *, **, *** denote significance at 10%, 5% and 1% levels. Core controls include: housing quality index, access to services index, caregiver's age, caregiver's highest grade of schooling, whether caregiver is the mother, caregiver's disability status, gender of the head of the household, household size, child's age, child's sex, child's disability status, child's current school enrolment, child's birth order, area of residence, child's native tongue, mother's native tongue and mother's caste (in India).

Table 9: OLS pooled sample: Self-esteem, schooling achievement and height-for-age

	OLS1	OLS2	OLS3	OLS4	OLS5
	(1)	(2)	(3)	(4)	(5)
Height-for-age	0.032	0.026	0.027	0.028	0.022
	(0.017)*	(0.017)	(0.017)	(0.017)	(0.016)
High reading skills		0.179			0.129
		(0.052)***			(0.056)**
High writing skills			0.138		0.094
			(0.04)***		(0.041)**
Child started school at the norm-age				0.107	0.065
				(0.059)*	(0.06)
Obs.	3195	3195	3195	3195	3195
R^2	0.237	0.24	0.24	0.237	0.242
Core controls	Yes	Yes	Yes	Yes	Yes
Cluster fixed effects	Yes	Yes	Yes	Yes	Yes
Consumption expenditure	Yes	Yes	Yes	Yes	Yes
Household shocks	Yes	Yes	Yes	Yes	Yes
Child's BMI	Yes	Yes	Yes	Yes	Yes
Maternal psycho-socials	Yes	Yes	Yes	Yes	Yes

Robust standard errors, clustered at the sentinel site level; *, **, *** denote significance at 10%, 5% and 1% levels. Core controls include: housing quality index, access to services index, caregiver's age, caregiver's highest grade of schooling, whether caregiver is the mother, caregiver's disability status, gender of the head of the household, household size, child's age, child's sex, child's disability status, child's current school enrolment, child's birth order, area of residence, child's native tongue, mother's native tongue and mother's caste (in India).