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Early nutrition and later cognitive achievement in developing countries

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Early nutrition and later cognitive achievement in developing countries

Final Version

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This study uses longitudinal data from 8,000 children in four developing countries (Young Lives Survey) to explore the linkages between nutritional status and later cognitive achievement on preschool children. Using multivariate regression analysis, a positive association between early nutrition (measured by Height-for-Age WHO Z-scores) and later preschool cognitive achievement is found in all the study countries. Similar evidence is found for school age children. Results control for a wide array of child, parental and household characteristics and include cluster fixed effects to account for between-community heterogeneity. These results suggest that, compared to well-nourished children, children that became malnourished early in life are in cognitive disadvantage before school enrolment.

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² The data for this analysis comes from the Young Lives Survey, a longitudinal study investigating the changing nature of childhood poverty. Young Lives is core-funded by the Department for International Development (DFID).

1. INTRODUCTION

It is estimated that, in developing countries, around 26 percent of children under five years of age are growth retarded by international standards (UNICEF 2004). Linear growth retardation is considered evidence of inadequate nutrition over a long period of time (chronic malnutrition). Several studies show that malnutrition during the first years of life can have long-lasting cognitive implications (Grantham-McGregor et al 2007 provides an up-to-date review of these studies). Compared to well-nourished children, children that were malnourished early in life are more likely to start school late, to have lower schooling attainment and to score poorly in cognitive tests (Glewwe and Jacoby 1995, Alderman et al 2006, Glewwe et al 2001, Pollit et al 1993, Walker et al 2000, among others). The key insight from this evidence is that a child's learning productivity at school seems to be partially determined by parental investments in health and nutrition during infancy. It is unknown whether these effects are reversible. If they are not, early malnutrition could become a bottleneck for subsequent investments in education.

This study provides new evidence of the nutrition-learning nexus, with a specific focus on preschool cognitive achievement. Results are based on multivariate regression analysis, using longitudinal data drawn from the Young Lives Survey, an international project that is tracking the livelihoods of children in Ethiopia, India, Peru and Vietnam. Section 2 summarizes the analysis carried out and the key findings. Section 3 describes the sample and the empirical methodology applied. Section 4 reports key results from the statistical analysis. Full results are reported in the Appendix.

2. SUMMARY

The central part of the analysis focuses on the study of a group of 8,000 children born in the year 2000-1 that are being tracked by the Young Lives Project in four countries. Complementary evidence is also presented for 3,700 children born in 1994-5 for which information on schooling outcomes is available (evidence for this older cohort was first reported in Dercon 2008). Malnutrition levels observed for the 2000-1 cohort during the first two years of life are revealing of the size of the problem. When these children aged 6-18 months, average malnutrition rates ranged from 10% in Vietnam to 31% in Ethiopia (see Table 1 in Section 3). For some specific sub-groups, such as those children living in rural Peru or in rural Ethiopia, average malnutrition rates are around 40% (for those aged 12-18 months). While samples are not nationally representative, they are informative of the living standard conditions faced by children in these countries.

Methodology

Ordinary Least Square (OLS) methods are used to determine the existence of association between nutritional status and later cognitive achievement in each country sample. Children raw scores in the Peabody Picture Vocabulary Test

(PPVT) is the main outcome of interest. Results control for an extended set of child, parental and household characteristics that are important to determine both nutritional and cognitive outcomes. Essentially, this implies to disentangle the effect that aspects such as monetary poverty has on cognitive achievement from the effect that early nutrition has on the same outcome. Community (cluster) characteristics are also controlled for through the inclusion of cluster fixed effects. Since nutrition was estimated four years before cognitive achievement was measured, bias due to a simultaneous determination of nutritional status and cognitive achievement is ruled out.

Results

A positive, strong association is found between Height-for-Age during the first two years of life and cognitive achievement four years later. In particular, this study finds that a one standard deviation increase in early Height-for-Age (standardized using World Health Organization most recent growth references) explains between 4 and 12 percent of the PPVT standard deviation in each country (4.7% in Peru, 12.2% in India, 7.5% in Vietnam and 4.2% in Ethiopia as shown). The magnitude of the nutrition effect is relatively important compared to the marginal contribution of other determinants of cognitive achievement. The vast majority of these children were not enrolled in school by the time the PPVT was administered.

When focusing on the 1994-5 cohort, analogous evidence is found for a later stage of childhood (see also Dercon 2008). Controlling for a similar set of child, household and community characteristics, nutrition measured at 7-8 years of age is found to be strongly associated to schooling attainment four years later in all the study countries and to PPVT raw scores in Vietnam and Ethiopia. These results reinforce initial findings and suggest that the association between nutrition and cognitive outcomes carry over during later stages of childhood.

2. METHODOLOGY

2. 1. Data and measurement variables

Sample

Data was collected for the Young Lives Project, an international project tracking the livelihoods of children in Peru, Vietnam, Ethiopia and the state of Andhra Pradesh (India), funded by the Department of International Development. In each country, two cohorts of children were selected: a *young cohort* (born in 2000-1) and an *older cohort* (born in 1994-5) of sample size 2,000 and 1,000 (700 in Peru), respectively. The first phase of data collection took place in the second half of 2002, when children in the young (older) cohort aged 6-18 months (7-8 years). The second phase occurred between late 2006 and the first months of

2007, when children in each cohort aged 4-5 and 11-12 years, respectively. All the samples are cluster stratified, with 20 clusters (sentinel sites) selected in each country³. The sampling design of the project is described in detail in the Young Lives sampling reports (Escobal and Flores 2008, Kumra 2008, Nguyen 2008 and Outes-Leon and Sanchez 2008)⁴. Country samples were generally not designed to be nationally representative. Although the samples have a pro-poor bias (i.e., poor areas were purposively over-sampled and wealthiest areas were excluded from the sample), each captures a sufficiently wide range of households across the wealth distribution, so that meaningful comparisons can be made between poor, less-poor and non-poor households.

A common problem in longitudinal studies arises due to household attrition, which can lead to biases in the results if the attrited households are systematically different compared to non-attrited households. However, this is unlikely to be a problem in this survey. On the one hand, attrition rates between rounds in the YL survey are relatively low by international standards. In the young cohort, only 3.1% of the children were lost or dropped out in the samples on average (3.7% in Peru, 2.5% in India, 1.1% in Vietnam and 3.6% in Ethiopia), and only 1.8% in the older cohort (3.6% in Peru, 1.3% in India, 0.8% in Vietnam and 1.9% in Ethiopia, respectively). On the other hand, evidence suggests that attrited households do not differ systematically from non-attrited households based on observable characteristics (Dercon and Outes-Leon 2008). While differences in unobservable characteristics can not be ruled out *a priori*, the low attrition rates found suggest that potential biases in the results due to attrition are likely to be only of minor importance.

Cognitive and nutrition measures

As the interest lies in assessing long-term nutritional effects, Height-for-Age as observed in the first phase of data collection is used to measure children nutritional history in the first years of life. This is based on the notion that linear growth retardation is, primarily, the result of an inadequate nutrition over an extended period of time⁵. In order to assess how a child's Height-for-Age compares to that of a healthy child of the same age, growth curves reference for children recently developed by the World Health Organization (WHO 2007 standards) are used. Based on this growth references, 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 healthy child of the same age and sex; extremely stunted is the analogous term when child's height is 3 standard deviations below the norm.

³ Within each cluster, 100 households with at least one child aged 6-18 months at the time of the survey were asked to participate –analogously for the older cohort, with 50 households with at least one child aged 7-8 year-old chosen in each cluster-.

⁴ <http://www.younglives.org.uk/pdf/publication-section-pdfs/technical-notes-pdfs>

⁵ See, for instance, United Nations Standing Committee on Nutrition and World Health Organization (WHO) statement at http://www.who.int/childgrowth/endorsement_scn.pdf

**Table 1:
YL nutritional rates by country**

	Peru cohort	India cohort	Vietnam cohort	Ethiopia cohort
Stunting levels				
Young cohort				
Round 1 (6-18 months of age)	17.1	19.3	9.8	29.2
By Area of Residence				
<i>Urban</i>	11.0	11.6	4.1	21.4
<i>Rural</i>	29.0	21.9	11.0	33.3
By Age-Group				
<i>6-12 months</i>	10.5	13.4	5.7	20.1
<i>12-18 months</i>	23.6	24.4	13.5	37.1
Rural by Age-Group				
<i>6-12 months - Rural</i>	18.9	15.1	6.8	24.2
<i>12-18 months - Rural</i>	38.6	27.5	15.2	41.5
Round 2 (4-5 years of age)	31.5	33.8	23.3	29.7
<i>Urban</i>	19.3	20.2	7.5	21.1
<i>Rural</i>	55.3	38.2	27.1	34.3
n (panel sample)	1963	1950	1970	1913
Older cohort				
Round 1 (7-8 years of age)	26.1	31.6	27.4	30.3
Round 2 (11-12 years of age)	28.5	31.8	29.6	28.8
n (panel sample)	685	994	990	979

Note: Samples are not nationally representative. Panel sample corresponds to children present in both 2002 and 2006-7 rounds. Height-for-Age Z-scores based on latest WHO standards.

In the Young Lives samples, the average proportion of children classified as moderately stunted at age 6-18 months fluctuates between 9.8% (in Vietnam) and 29.2% (in Ethiopia) as shown in Table 1. In all countries, the prevalence of stunting increases as children age and are remarkably high in rural areas. For instance, in rural Ethiopia, the prevalence of stunting for the sub-sample of children aged 12-18 months was 41.5%. A similar proportion is observed for the children of the same age-group in rural Peru (38.6%).

To measure cognitive achievement, raw scores on the Peabody Picture Vocabulary Test (PPVT) and the Cognitive Development Assessment – Quantity Test (CDA-Q) were used⁶. Cueto et al 2008 discuss in length the validity and

⁶ The PPVT is a test of receptive vocabulary adaptable according to age. In each question, the child has to choose from four pictures the one that, she thinks, matches a word verbally

reliability of these tests as applied in the YL samples. It is important to mention that, due to differences in the underlying population of reference, PPVT scores can not be compared across countries.

In addition to PPVT and CDA-Q scores, school grade attainment was used as a measure of schooling achievement for the older cohort.

2. 2. Empirical methodology

Ordinary Least Squares (OLS) are used to assess the association between nutritional status and later cognitive achievement. A linear regression with the following characteristics is estimated,

$$CA_{ijt} = \alpha + \phi_j + \beta H_{ijt-1} + \delta X_{ij} + u_{ijt} \quad (1)$$

where CA_{ijt} represents the cognitive outcome of a child 'i' in cluster 'j', measured in period 't'; H_{ijt-1} stands for nutritional status in period 't-1' of the same child in the same cluster (*Height-for-Age Z-score*); vector X_{ij} stands for child, parental and household characteristics; ϕ_j are characteristics of cluster 'j' that are invariant over time; and, u_{ijt} are the residuals of the estimation. Vector X_{ij} includes: (a) child's sex, age, birth order, native tongue, disability status and whether or not she has attended pre-school (in the young cohort) or school (in the older cohort); (b) caregiver's relationship to the child (whether or not she is the mother), age, years of education, ethnicity (caste in India), marital status and disability status; (c) household size, sex of the head of the household, housing quality index access to services index, household consumption per capita (in logs) and household vulnerability to shocks^{7, 8}.

These controls are added to capture child and household heterogeneity that might explain differences in both nutrition and cognitive differences across children. In particular, it is important to control for household consumption per capita to disentangle the effect of monetary poverty on cognitive achievement from the effect of nutrition on the same outcome. Similarly, body mass index is included as a control to make a distinction between the effects of short-term and long-term nutritional status on cognitive outcomes, as only the latter is of interest

expressed by the interviewer. In turn, the CDA-Q is a test that measures the understanding of children about quantity-related concepts and includes math questions for the *older* cohort.

⁷ Housing quality and access to services are measured using the housing quality index and the access to services index, respectively. The former is an equally weighted composite of household type of roof, floor and walls. The latter is an equally weighted composite of household access to the following services: water, toilet facilities and electricity. Both indexes are normalized to be in the 0-1 range.

⁸ Household vulnerability to shocks is proxied by the prevalence of shocks such as natural disasters, crop failure, death of livestock, price shocks, job loss, illness of a family member and the like.

here. In addition, cluster fixed effects are included to account for cluster characteristics that are constant over time. Finally, note that since nutrition (as well as most of the controls) are lagged four years in relation to the outcome of interest, this rules out *endogeneity* due to simultaneity.

3. RESULTS

Tables 2 and 3 provide a summary of the OLS results obtained for the young and older cohort, respectively. Full results are reported in Appendix I and II. For the young cohort, results show that early nutrition is positively correlated to PPVT scores in all the study countries and to CDA-Q scores in India and Ethiopia. These results are statistically significant at the 10% level. In particular, a one standard deviation increase in early Height-for-Age is associated with an improvement in PPVT scores that represents between 4 and 12 percent of the PPVT standard deviation (4.7% in Peru, 12.2% in India, 7.5% in Vietnam and 4.2% in Ethiopia as shown in Table 2).

Table 2
Young cohort: OLS marginal effects of early nutrition (measured at 6-20 months of age) on later cognitive achievement

Country	Cognitive achievement at 4-5 year-old					
	PPVT score			CDA-Q score		
	Coefficient	S.E.	Std. Coeff.	Coefficient	S.E.	Std. Coeff.
Peru	0.661 **	0.258	0.047	0.049	0.045	0.030
India	2.541 ***	0.485	0.122	0.168 ***	0.040	0.107
Vietnam	1.484 ***	0.455	0.075	0.021	0.043	0.011
Ethiopia	0.464 *	0.249	0.042	0.130 ***	0.034	0.094

note: *** p<0.01, ** p<0.05, * p<0.1

Results derived from OLS regression with clustered standard errors robust to heteroskedasticity. With cluster fixed effects. Controls included in the estimation are: **(A) Child controls:** Child's age; Child's sex; Child's Birth order; Child attended preschool; Child has some type of disability, Round 2; Child's BMI Z-score, Round 2; **(B) Caregiver controls:** Caregiver's age, Round 1; Caregiver's highest grade reached (years of education), Round 1; Caregiver's relationship to the child (whether or not is the mother); Caregiver disability status, Round 1; **(C) Core household controls:** Head of the household is female, Round 1; Household size, Round 1; Housing Quality Index, Round 1; Access to Services Index, Round 1; Log Household expenditure per capita, Round 2; **(D) Health controls:** Antenatal care during pregnancy; Birth Place; Doctor/Nurse assisted at delivery; **(E) Household shocks in round 2 (in the last 4 years):** Food shortage; Large increases in input prices; Large decreases in output prices; Death of livestock; Loss of income source; Natural disasters (drought, rain or flooding, frosts or hailstorms); Crop failures; Death of family member; Illness of family member; Divorce or separation within family; **(E) Ethnicity (Peru):** Child's first language; Mother's first language; **(E) Ethnicity (India):** Child's first language; Mother's caste; **(E) Ethnicity (Vietnam):** Child's first language; Mother's first language; **(E) Ethnicity (Ethiopia):** Child's first language; Mother's first language; **Other controls:** Area of residence is rural. See full results in Appendix 1.

This marginal contribution is smaller than the contribution of other determinants of cognitive achievement such as caregiver's level of schooling –whose marginal impact represents around 12-20 percent of the PPVT standard deviation- and household consumption per capita. Nevertheless, it is relatively more important than the marginal contribution of other household characteristics such as access to basic services (see Appendix I, Table 1.1).

Similar results are found for the older cohort, with Height-for-Age at 7-8 years of age strongly associated to school grade attainment in all the study countries; to PPVT scores in Vietnam and Ethiopia; and, to CDA-Q scores in Vietnam. In this case, a (one standard deviation) increase in past nutrition is associated to an increase in school grade attainment that represents between 14 and 20 percent of the school grade attainment standard deviation (13.6% in Peru, 16.4% in India, 17.2% in Vietnam and 20.3% in Ethiopia). This represents between 0.1 and 0.3 additional years of schooling (0.15 in Peru, 0.17 in India, 0.13 in Vietnam and 0.33 in Ethiopia). Notably, in this case nutrition arises as one of the most important inputs to explain variation in cognitive outcomes, with a marginal contribution that is higher than that corresponding to caregiver's level of schooling (see Appendix II, Table 2.3).

Table 3
Older cohort: OLS marginal effects of past nutrition (measured at 7-8 years of age) on later cognitive achievement and school attainment

Country	Cognitive achievement at 11-12 year-old								
	PPVT score			CDA-Q score			School Attainment (Years of Education)		
	Coefficient	S.E.	Std. Coeff.	Coefficient	S.E.	Std. Coeff.	Coefficient	S.E.	Std. Coeff.
Peru	0.982	0.815	0.051	0.077	0.062	0.042	0.146 ***	0.044	0.136
India	0.732	1.106	0.019	0.052	0.069	0.024	0.161 ***	0.040	0.164
Vietnam	3.987 ***	1.166	0.118	0.176 ***	0.056	0.095	0.137 **	0.058	0.172
Ethiopia	2.124 **	0.916	0.072	0.106	0.072	0.055	0.263 ***	0.036	0.203

note: *** p<0.01, ** p<0.05, * p<0.1

Results derived from OLS regression with clustered standard errors robust to heteroskedasticity. With cluster fixed effects. Controls included in the estimation are: **(A) Child controls:** Child's age; Child's sex; Child's Birth order; Child attended school, Round 1; Child has some type of disability, Round 2; Child's BMI Z-score, Round 2; **(B) Caregiver controls:** Caregiver's age, Round 1; Caregiver's highest grade reached (years of education), Round 1; Caregiver's relationship to the child (whether or not is the mother); Caregiver disability status, Round 1; **(C) Core household controls:** Head of the household is female, Round 1; Household size, Round 1; Housing Quality Index, Round 1; Access to Services Index, Round 1; Log Household expenditure per capita, Round 2; **(D) Household shocks in round 2 (in the last 4 years):** Food shortage; Large increases in input prices; Large decreases in output prices; Death of livestock; Loss of income source; Natural disasters (drought, rain or flooding, frosts or hailstorms); Crop failures; Death of family member; Illness of family member; Divorce or separation within family; **(D) Ethnicity (Peru):** Child's first language; Mother's first language; **(D) Ethnicity (India):** Child's first language; Mother's caste; **(D) Ethnicity (Vietnam):** Child's first language; Mother's first language; **(D) Ethnicity (Ethiopia):** Child's first language; Mother's first language; **Other controls:** Area of residence is rural. See full results in Appendix 1.

As a final remark, it is important to note that while OLS allows to control for observable characteristics, results can still be biased due to household unobservable characteristics correlated with both nutrition and cognitive outcomes. For instance, some parents might be better at raising healthy, well-educated children. Since this is not observable, this might lead to an upward bias in OLS results. The results presented in this study can only show association between nutrition and later cognitive achievement, not causation.

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