WORKING PAPER NO. 45

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An International Study of Childhood Poverty

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Contents

Abstract

In this paper, we use a longitudinal data set that follows three thousand children in Vietnam to study the economic significance of childhood poverty–cognitive achievement nexus. Focusing on the consequences of stunting, we look at height-for-age z-score (HAZ), and trace the impact of HAZ on child cognitive achievement independent of the source of HAZ's variation - whether it comes from the variation in child characteristics at birth and the environmental factors, or in the household characteristics (stature, socioeconomic status, etc.). An increase by a standard deviation of HAZ at the age of one expectedly leads to an increase by one fourth of a standard deviation of the log score in a widely-used test of language ability at the age of five. For a quantitative cognitive achievement test, the corresponding figure is 0.20. Our evidence suggests that some of the disadvantages in socioeconomic status are being transmitted across generations.

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The Author

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1. Introduction

In 2005, about one of three children in the developing world were either underweight or stunted. We do not see improvements being made very rapidly and expect the world will bear the burdensome consequences related to this matter. In the private domain, many parents with malnourished children fail to treat the issue in the best way because of poverty, or limited knowledge, or both. By and large, this can also be said of governments in developing countries. Ideally, policy makers should have good information on the cost-benefits of public investments, such as the national programmes aiming at the alleviation of child malnutrition. In practice, however, it is very difficult to assess the costs the society will gradually have to bear in connection with the consequences of malnutrition among today's children. There remains much for the world research community to do to come close to an accurate enough assessment of such costs. More realistically, however, the problem can be dealt with case by case, and through specific aspects of the consequences. The purpose of this paper is mainly to investigate consequences of early age stunting in children who were born in the first two years of the twenty-first century, and who are called the 'millennium children' in Vietnam. The effect of stunting on cognitive achievement is considered together with that of other dimensions of child poverty, such as household wealth, parents' education, and other household and community characteristics.

Vietnam is a low-income country with a high rate of stunting. There are, however, two unique attributes that merit a closer look in connection with the issue of stunting, which is based on height-for-age of children. First, the demographic characteristics that create the impression that short stature is natural for Vietnamese people and that genes should be mostly blamed for stunting. The problem is that this use of 'mostly' often misleads parents in the way they handle the health problems of their children. Secondly, economic growth in Vietnam over the last twenty years has been very good and has changed the position of Vietnam in the World GDP ranking table since the 1980s, when the mothers of the millennium children lived in severe economic conditions. It would be misleading if this were not linked to the height-for-age of their children. A researcher failing to do so may end up overestimating the explanatory power of other factors, of which genetics is likely to be one.

Many academic studies have documented the link between cognitive development and child malnutrition. Paxson and Schady (2007) studied the association between scores in a Spanish version of the Peabody Picture Vocabulary Test of Ecuadorian children and determinants that include variables on child health and nutrition, measures of parenting quality and the socio-demographic characteristics of the child and household. The authors pointed out that there is a possible association between measures such as wealth and parental education (as well as other variables) and the children's test scores because of the influence of unobserved variables on the explanatory variables as well as the test scores. Furthermore, Paxson and Schady maintain that 'the evidence to date indicates that both genetic and environmental factors contribute to child cognitive ability'. They conclude that 'children from wealthier households and with more educated parents have higher scores. The associations of test scores with wealth and maternal education are larger for older children, suggesting that these factors have cumulative effects on cognitive ability.'

Closely linked to cognitive achievement is the school outcome of the child. Glewwe, Jacoby and King (2001) present evidence based on longitudinal survey data on health and nutrition in the Philippine area of Cebu. They use the sum of Mathematics and English scores as the measure of the learning achievement of 1149 sibling pairs, of whom the younger siblings were enrolled in school by June 1994, to investigate the nutrition–learning nexus. They use econometric techniques to eliminate part of the learning-ability-related characteristics that are common among siblings, as well as application instruments to deal with the spurious correlation between nutritional status and achievement. Glewwe et al. made progress in estimating a causal relationship: better early childhood nutrition raises academic achievement.

For other measures of school outcomes, Alderman et al. (2006) use a data set on rural Zimbabwe and find that improvements in height-for-age in pre-schoolers are associated with the number of grades of schooling completed. In the case of Tanzania, Alderman et al. (2009) show that the degree to which malnutrition leads to reduced lifetime earning capacity is due to both delays in schooling and declines in total schooling. Furthermore, many studies have documented evidence which shows that cognitive performance can be regarded as a predictor of later school outcomes of children in developing countries (Grantham-McGregor et al. 2007).

One of the most prominent features we observed in the growing literature concerning the link between child cognitive achievement and the socioeconomic characteristics of a household is that the authors are careful not to interpret their results as having established causality. The biggest problem here is the presence of many unobserved factors influencing cognitive development which relate both to family features and the child's innate ability. Family biology characteristics are among such unobserved factors. According to Becker and Tomes (1986), '[B]oth biology and culture are transmitted from parents to children, one encoded in DNA and the other in a family's culture. Much less is known about the transmission of cultural attributes than of biological ones, and even less is known about the relative contributions of biology and culture to the distinctive endowment of each family.' In terms of the factors that form the focus of this study, however, recent literature also reflects that in practice it is very difficult to remove from the variable on stunting all of the attributes correlated with genetic characteristics, which are often not measurable or observable. This can be said of any reasonably meaningful instrument for the variable.

The main merits of this study include the method to tackle spurious correlations. We isolate our estimation from the spurious correlations that are caused by the linkage to factors related to parents' preference, ability and general resources, which have impacts on the height and cognitive development of the child from birth. It is an important feature of the variable on height-for-age that the marginal effect of its variation on child cognitive achievement is found independent of whether the variation is caused by difference in birthweight and environmental conditions, or by that in parents' education, or mothers' height or wealth. Our estimator for the effect of height-for-age is fairly robust. Into the debate on the childhood poverty–cognitive achievement nexus, we bring evidence from a country which has demographic and socioeconomic features that have not been considered in the literature in this area. In terms of policy implications, this study can either add to or verify the rationale of programmes aimed at reducing early childhood malnutrition.

The paper is organised into six sections, including this introduction. Section 2 presents the socioeconomic background of poverty in Vietnam in the two decades prior to the birth of the millennium children. Next, we discuss measures and data used for the empirical analysis in Section 3, and model specifications and estimation issues in Section 4. The results of econometric regression are presented in Section 5, and finally conclusions follow in Section 6.

2. The socioeconomic context and the effect of economic hardship since Reunification

In order to better understand the factors influencing the cognitive achievement of today's children, we have to trace back the social and economic conditions not only since the children were born, but back to the childhoods of their mothers. In fact, one cannot reject the connection between the attributes of today's children and their parents' anthropometric characteristics, which bear the marks of economic conditions over the last thirty years.[1] This impacts especially on the determinants of birthweight, which is an important factor in the likelihood of being stunted.

Most of the mothers of the children in the sample were born around 1975, the year of Vietnam's Reunification. After over a century of colonialism and continuous wars, there was little if any economic prosperity until recently. Internationally comparable economic statistics for the 1980s are scarce, mainly because the official exchange rates in those years are not useful for an estimation of real incomes. A couple of figures, however, show that the economy was one of the poorest in the world. In fact, 'a rough estimate of its GNP per capita in 1984, in 1984 U.S. dollars, is $117' (Glewwe et al. 2002). In comparison to two of the poorest economies reported by the World Bank in 1986, Vietnam was barely ahead of Ethiopia and just behind Bangladesh. Furthermore, a record of the U.S. Library of Congress also indicates that '[I]n 1984 United Nations nutrition specialist calculated the daily average food consumption among Vietnamese to be only 1,850 calories per day, nearly 20 per cent less than the generally accepted minimum daily standard of 2,300 calories. In 1985, the Vietnam Institute of Nutrition reported average daily intake at 1,940 calories.'[2] Given the stagnant economy, the rampant inflation in 1985-1986 made the food consumption of the poor even worse.[3]

The economic hardship was eased following the economic reform which was launched at the end of 1986, but it took some time for the country to reduce the poverty. The World Bank's statistics show that the poverty headcount rate (based on a 2,100-calorie poverty line) of Vietnam in 1988 was over 70 per cent (Dollar 2004). Even after five years of strong growth at about 8 per cent annually, as much as 58.1 per cent of the population lived under the poverty line in 1993. In 1999, Vietnam's GNP per capita had increased to $370 (in 1998 U.S. dollars), so that the economy was ranked 167 out of 206 countries (Glewwe et al. 2002). That was a year before the millennium children were born. It is clear that most of the mothers of the children in the study (the sample description is given in Section 3) had gone through poverty in their childhood.

Essential to this study is how the socioeconomic conditions of the 1980s impacted upon the parents' stature, which would in turn affect the height of the millennium children. There is

1 Data shows that the mothers of the children in our sample were born on average in 1975; the median year of birth is 1976.

2 *Source*: *U.S. Library of Congress*, see http://countrystudies.us/vietnam/46.htm

3 The rate of inflation in 1986 was 774 per cent. *Source*: State Bank of Viet Nam

empirical evidence on the linkage between income and the height of children in the 1990s, and we will assume that the economic hardship in the 1980s might have similarly impacted upon the parents of the millennium children. Glewwe et al. (2002) worked with data on children under five in two sets of the Vietnam Living Standard Surveys (VLSS) for 1993 and 1998 to investigate the impact of household income growth on child nutritional status in Vietnam. Their calculation shows that the incidence of stunting in the group of 0-60 month-old children in 1993 was 50.2 per cent, decreasing to 34.6 per cent in 1998. Glewwe et al. found, however, that 'growth in household expenditures accounts for only a small proportion of the improvement of children's nutritional status in Vietnam' over the period. Edmonds (2004), using the data on children under ten from the same VLSS, found that 'improvements in economic status can explain 60 per cent of the overall improvement in child nutrition and 74 per cent of the improvement in households below the poverty line in 1993'. The effect of the improvements in living standards on reduction in child malnutrition is found to be greater for the households who are near subsistence. More recently, O'Donnell, Nicolás and van Doorslaer (2009) worked with the same VLSS data sets with an aim to explain the 15 percentage point drop in stunting and the improvement in height-for-age among children under ten years old (in either round). O'Donnell et al. find that changes in the distribution of household per capita consumption (their measure of permanent income) 'can explain, in total, almost two-fifths of both the fall in the proportion of children stunted and the 20% increase in the mean height-for-age z-score'. O'Donnell et al.'s estimator is in line with the results of studies using cross-country data that generally imply that an increase in income by 1 per cent is associated with an estimated decline in the prevalence of malnutrition by half a per cent (Haddad et al. 2003). The impact of economic development is not only the increase of household income, but also the improvement in mean community consumption, water supply, sanitation quality, and other factors that matter for the growth of children.

Now let's assume the abovementioned linkage between income and the height of children can apply to the economic conditions of the 1980s and make use of it to assess the damage caused by economic hardship. We can't definitely determine the impact of this event on the health of mothers of millennium children because the baseline is unknown. In fact, we have no answer to the question of what is being compared to what. For the study at hand, fortunately, it is sufficient to prove that the impact is statistically significant. For that purpose, we may choose to compare the real path of economic growth to a hypothetical economy, which was then typical among the world's economies that would later be in line with 1999's GNP per capita for Vietnam. The main argument we seek here is that the mothers of the millennium children could have been taller by a statistically significant amount if they have lived in the baseline, which was commensurate with the average per capita income for a less developed country in the 1980s.

To simplify arguments, let's forgo some degree of strictness in being 'typical' and consider the following specific case, which resembles many realistic low income economies with low rates of growth through 1975 to 1999. The path of growth of GNP of the hypothetical economy is defined retrospectively as follows: first, it was identical to the actual GNP per capita of Vietnam from 1999 onward; secondly, between 1987 and 1998, the rate of GNP per capita growth was set at 2.5 per cent annually; and finally, its annual rates of GNP per capita growth in the 1975-1986 period were the same as those of Vietnam.

For the hypothetical economy, the GNP per capita in 1987 would be 34 per cent higher than the actual GNP per capita of Vietnam in the same year and that 34 per cent gap in income would be unchanged over the period of 1975 to 1987, owing to the assumption that the rates of growth are the same for the hypothetical economy as for the actual economy prior to 1987.

The GNP per capita in the hypothetical economy was not higher than U.S. $200 over the 1980s and was therefore among the world's poorest economies. Thus, it was not much better than the actuality.

As discussed earlier in this section, part of the gap in height-for-age of children between 1993 and 1998 is attributed to the gap in income (same economy, cross times), which, in percentage terms, is exactly the same as the gap in income between the hypothetical and the actual economies (same time, cross economies) over the 1975-1986 period. This is therefore a comparable difference with which height-for-age is associated. For the sample of this study, half the millennium children's mothers were less than 10 years old in 1985.[4] Let's recall the estimation by O'Donnell et al. (2009) that changes in the distribution of household per capita consumption can explain two-fifths of the 20 per cent increase (between 1993-98) in the mean height-for-age z-score for children who were younger than 10 years. It may imply that in the hypothetical economy, the mean height-for-age of the under-ten children would be greater by a statistically significant amount. In the years between 1975 and 1999, the income of the hypothetical economy was higher than that of the actual economy in Vietnam and the income gap impacted on the heights of children and teenagers. This implies that the economic hardship in the 1980s and earlier in Vietnam made a difference to the statures of the parents of the millennium children. To take into consideration only the economic conditions of 1999 onward would be to create a bias.

The anthropometric data of Vietnam demonstrates that there was almost no increase in the stature of Vietnamese adults over nearly half a century from 1938 to 1985, during which time the average height of grown men was stable at 160cm and that of grown women at 150-151cm (see Le Danh Tuyen 2005). For the 1993 sample of children studied by O'Donnell et al. (2009), the average height of the mothers is 151.79cm and that of the fathers is 161.87cm. Those figures are lower than the corresponding figures in the United States' CDC growth chart of 2000, according to which the fifth percentiles' height of 20-year-old girls was 152.4cm, and that of 20-year-old boys was 165.1cm.[5]

Data from Le Danh Tuyen (2005) also show that changes in the average height of boys and girls for the period from 1875 to 1984 were moderate. The average height of 9-year old boys in Vietnam in 1984 was 118.2cm. This is substantially lower than the standard height given by the US National Centre for Health Statistics (NCHS) in 2000, where the 50th percentile height is 133cm and the 5th percentile height is 124 cm. The average height of 14-year old girls in Vietnam in 1984 was 138.5cm, while the 5th and 50th percentiles of the NCHS points of reference were 150cm and 160cm respectively.

There could also be other reasons for the Vietnamese children being short in stature. However, one can hardly reject the impact of the socioeconomic conditions of the 1980s on the height-for-age of the then girls. The shortage in energy and nutrition intakes in the childhood of the future mother, together with adverse conditions such as wars, famine, and chronic poverty over generations, have had impacts on the millennium children's birthweight, which is an important determinant of child stunting to be discussed in depth in later parts of this study.

4 To be exact, among the Young Lives millennium children's mothers, 51.3 per cent were under ten in 1985.

5 *Source*: (US) National Center for Health Statistics and National Center for Chronic Disease Prevention and Health Promotion, 2000

3. The sample and measures

The sample for this study consists of 2,000 children in twenty sites (also called clusters) that are equally divided between five provinces.[6] In each of the clusters, simple random sampling was applied to select 100 children who were 6 to 18 months old at the time of Round 1 of the survey in September–November 2002. The clusters were chosen to cover all regions, rural and urban sectors, and to include a representative ratio of ethnic minorities.[7] The same children[8] were surveyed again from mid-December 2006 to mid-February 2007.[9] The data gathering was carried out by the staff of the Vietnam General Statistic Office, with technical support and supervision by experts from UK institutions such as the London School of Hygiene and Tropical Medicine, Oxford University. The data set contains a broad set of variables on characteristics of parents and children. Let's now describe the variables by group.

3.1. The dependent variables

The first dependent variable is the Peabody Picture Vocabulary Test (PPVT) raw scores. The PPVT was originally developed in 1959 by Dunn and Dunn. Since then, it has been updated and improved several times. The PPVT is used to measure vocabulary acquisition in individuals from 2.5 years old to adulthood. Children's scores in PPVT have also been widely used as a general measure of cognitive development in many studies, including Desai et al. (1989), Baydar and Brooks-Gunn (1991), Blau and Grossberg (1992), Parcel and Menaghan (1994), Rosenzweig and Wolpin (1994), Blau (1999) and McCulloch and Joshi (2002). Cognitive ability and achievement may be considered as a proxy for the child's learning ability and, to some degree, as a predictor of the individual's skills in the future. The PPVT used for this study was administered in Round 2 of data gathering, when the children were about five years old.

Quantitative score in the Cognitive Developmental Assessment (CDA) is the other dependent variable considered in this study. CDA was developed by the International Evaluation Association (IEA). The test has several subtests, including *Spatial Relations*, *Quantity* and *Time*. However, only the Quantity subtest was administered for the sample in this study. In the Quantity subscale, the task for the 5-year old children was to pick an image (given three or four of these) that best reflected the concept verbalised by the examiner (e.g. few, most, half, many, equal, a pair, nothing, etc.). This subscale has fifteen items and all were administered to the child. Quantitative score in the CDA will be also referred to as Cognitive Development Quantitative (CDQ) score.[10]

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6 The provinces are Phu Yen, Ben Tre, Lao Cai, Hung Yen, and the City of Da Nang.

7 The sample is poorer than average, rather than nationally representative.

8 Except for a fraction of sample, who are no longer in the project.

9 For a small number of children, who had migrated, the follow-up survey took place in March and April 2007.

10 Verbal and mathematic skills and achievement were measured using tests we developed or adapted from standardised international tests, such as the Peabody Picture Vocabulary Test (PPVT). We acknowledge that bias may arise when testing children with different languages and cultures using the same instruments, although measures were taken to adapt them to local contexts and languages and in no case were original standard scores used. Bias is an especially important consideration in testing children who speak minority languages. Reliability and validity results for our test administrations and concerns are presented and discussed in Young Lives Technical Note 15. In particular, the authors of this document recommend that results should not be compared across countries, or across groups with different maternal languages within countries.

3.2. Group G_1 of variables that relate to material conditions at birth, and socioeconomic and environmental impact since the mother's pregnancy

This group consists of variables on the child's basic characteristics, such as *gender*, *birthweight*, and *age in months*; *socioeconomic* and *environmental shocks* (to be explained below); as well as *community characteristics*, that are aggregately reflected in cluster dummies. For reasons to be discussed in Section 4, this group is intended to be used as an econometric model using explanatory variables that affect child height-for-age and cognitive development independent of parental behaviour and abilities that may affect child development after birth. Ideally, we would prefer to work only with variables that are not related to either biology or family culture factors. For application of econometric tools, however, it is important that the set variables under consideration are able to capture enough variations in the variable on height-for-age. For that reason, our analysis suggests that the inclusion of certain household factors is necessary. For that reason, we forgo some degree of rigidity (in terms of total independence of biology and family culture factors) for the sake of capturing data capable of yielding any results that are meaningful, at least in econometric terms. Our analysis suggests that birthweight can serve that purpose. The choice of birthweight is based on the presumption of its independence, in the sense that socioeconomic and environmental impacts are among the determinants of birth outcomes, and interventions can diminish the link, if any exists, between the birthweight of the child and the innate mental abilities of the parents.

Let's recall the economic hardship at the time when the millennium children's mothers were around ten years old, the high rate of stunting in the decade of the 1980s and the fact that the height of grown women in Vietnam was stable at 150cm over fifty years from 1938 to 1985. 'Short stature of the mother and poor maternal nutrition stores are associated with increased risk of intrauterine growth retardation' (IUGR) (see Victora et al. 2008), and that matters because, according to a study by Kramer, the child birthweight is governed by two major processes: duration of gestation and intrauterine growth rate. Low birth weight is thus caused by either being born prematurely or intrauterine growth retardation. 'In developing countries, the major determinants of IUGR are Black and Indian racial origin, poor gestational nutrition, low pre-pregnancy weight, short maternal stature, and malaria' (Kramer 1987a). In another study, Kramer (1987b) shows that 'maternal nutritional factors both before and during pregnancy account for over 50 per cent of low birthweight cases in many developing countries'.

Andersson and Bergström (2003) worked with a sample of 1477 women and child pairs to analyse maternal nutritional and socioeconomic factors as determinants of birthweight in infants from a rural African society characterised by a high rate of chronic malnutrition. They looked at the relations of maternal weight, gestational weight gain, parity, socioeconomic status and infant sex with birthweight. They found that '[M]aternal weight, representing the maternal long-term nutritional situation, was the most important independent determinant of birthweight, accounting for 13.0% of the variance in birthweight'. Andersson and Bergström's study implies that 'improved long-term nutritional situation and living conditions seems to be the most important prerequisites to counteract low birthweight in developing countries'. Furthermore, empirical research on cross country data has come to the conclusion that 'the percentage of low birthweight births among all births declines as national income rises' (Alderman et al. 2007).

Two variables that capture the socioeconomic or environmental shocks that happened to the household are formally defined in the Appendix. These two variables are not quite similar in nature and scale. First, *adverse events Round 1* is a dummy that equals 1 if, and only if, any of the events such as a *natural disaster*, *major losses in livestock* or *being victim of crime* happened since the mother became pregnant with the index child at the date of the survey in 2002 and that the child caregiver considered to affect household welfare seriously. These events are expected to have an impact on child malnutrition, but not directly on the test performance of the child. Secondly, *total adverse events between rounds* is defined as the total of the 14 dummies standing for events that happened between 2002 and 2006 (listed in Appendix). Any such dummy equals 1 if the corresponding event is considered by the caregiver to be one of the three that most affect the welfare of the household, otherwise (if the event did not happen or was among 11 less damaging ones) it equals zero. These variables include, in addition to more detailed data on natural disasters, economic shocks, such as changes in the prices of either inputs or outputs related to the household production activities. We do not include events such as household members' illnesses, deaths or divorce, because such events may well be correlated with household members' innate mental ability or home environment.

Finally, the cluster dummies carry information about the level of the overall development of the community, not only in infrastructure, but also in village tradition and culture, which have always been important factors in human capital development in rural areas of Vietnam. A probit regression of poverty (the incidence of household consumption under the international poverty line) on household characteristics, socioeconomic and environmental shocks, and the cluster dummies demonstrates that, of the coefficients of the 19 cluster dummies (with one cluster serving as a baseline), seven are statistically significant at 1 per cent and four of the others are statistically significant at 5 per cent. Cluster dummies are thus a good indication of household poverty.

3.3. Group G_2 of variables that reflect some of the child's parents' innate mental abilities and home environment characteristics

The second group of explanatory variables consists of: *household wealth indexes* in both rounds*, mother's education*, *father's education*, *mother's ethnicity* and *mother's height*. The expansion of the model through the addition of these variables serves two purposes. First, the new model incorporates the influence of other family members' innate mental ability and home environment, in addition to birthweight. Secondly, it may provide evidence as to whether the estimators in the model using only variables in group G_1 suffer from a misidentification problem, e.g., through omitting some factors that could be important determinants of either height-for-age or cognitive achievement.

Household wealth index is an important measure of child poverty. The wealth index is the sum of three components that are the measures on *housing quality*, *consumer durables* and *services*. The components are calculated as scaled values (0 to 1). The measure of house quality is based on the type of material the floor, roof and walls were made of, and the number of rooms relative to household size. The service component is the average of the dummy variables on the availability of electricity, piped water, fuel for cooking and toilet. Finally, the measure on consumer durables is the sum of the dummy variables on the household use of radio, TV, refrigerator, bicycle, motorcycle, car, mobile phone, landline phone and fan. The data are gathered to calculate wealth indexes in both rounds.

In order to separate those impacts from what we are interested in, we run an Ordinary Least Squares (OLS) regression of wealth indexes on the variables of G_1 to make *residuals*. Only the *residuals of wealth indexes* are used in group G_2, not the whole conception of the wealth index, and the justification for that is that for the model used for group G_2, we are interested in the way the wealth indexes capture the innate abilities and the behavioural features of household members. Household wealth is the result of a process of accumulation upon which socioeconomic shocks, as well as community characteristics (village culture, infrastructure, access to services, etc.), have had important impacts. The residuals are what have not been captured by the variables in group G_1, and if significant, they would add dimensions containing information on certain characteristics of family members. For reasons to be discussed later, the residual of the *wealth index in Round 2* is used as an endogenous explanatory variable, while that of Round 1 plays the role of an instrument.

Mother's education is defined as the number of years the child's mother went to school if she finished education at or before upper secondary school. If her level of education is equivalent to vocational technology school or university, the variable is 13 or 14 correspondingly. *Father's education* is defined similarly.

The next explanatory variable is the dummy on *mother being ethnic majority*. Ethnicity concerns both biological and culture characteristics. In Vietnam, some ethnic groups are clearly poorer than others. Finally, *mother's height* may be an important factor behind the child's height-for-age, and therefore the child's state of stunting. The variables on parental education, mother's ethnicity and mother's height are all treated as exogenous.

3.4. Group G_3 of other variables on family and community characteristics

This group of variables is intended for a model with more straightforward policy implications. For that purpose, the variables are in commonly used form. The *whole* wealth indexes (recall that the residuals of these indexes belong to group G_2) in Rounds 1 and 2 are part of group G_3. Also included in group G_3 are community characteristics, which characterise groups of specific clusters. To define such dummies, the clusters are divided into groups, based on site description in documentation of the Young Lives project. The characteristics are: *urban*, *good infrastructure*, *most isolated*, *central*, *Mekong*, *coastal*, and *farm-only income*.

Table 1: *Description of variables*

Variable	Mean	Std. Dev.	Used as	Used in Model
Log PPVT score	3.8	0.48	Dependent	A, B, C
Cognitive development quantitative	10.03	2.49	Dependent	D
Male	0.5	0.5	Exogenous	All
Birthweight (grams)	3101.2	445.5	Instrument	All
Months old	63.7	3.7	Exogenous	All
Height-for-age at R1 (standardised)	-0.5	1.2	Endogenous	All
If adverse events before Round 1[11]	0.13	0.35	Exogenous	All
Total adverse events between rounds	0.99	1.1	Exogenous	All
Residual of wealth index - Round 1	0	0.14	Instrument	B
Residual of wealth index - Round 2	0	0.13	Endogenous	B
Wealth index - Round 1	0.46	0.24	Instrument	C
Wealth index - Round 2	0.52	0.19	Endogenous	C
Mother being ethnic majority	0.86	0.35	Exogenous	B and C
Mother's education	6.8	3.8	Exogenous	B and C
Father's education	7.5	3.8	Exogenous	B and C
Mother's height	152.5	19.8	Exogenous	B and C
Urban	0.21	0.41	Exogenous	C
Good infrastructure	0.40	0.49	Exogenous	C
Most isolated	0.05	0.22	Exogenous	C
Central Region	0.40	0.49	Exogenous	C
Coastal	0.21	0.41	Exogenous	C
Mekong Delta	0.20	0.40	Exogenous	C
Farm-only income	0.10	0.30	Exogenous	C

Source: Young Lives data 2002 and 2007

The variable *urban* describes the nature of the location where the child lived when Round 1 of the survey took place. The urban children consist of those in the city of Da Nang, and a small number of others who live in the district centres. *Good infrastructure* is the feature of the children living in either the province of Hung Yen or the urban sector. The dummy variable of *most isolated* is used to characterise the condition of children in the Pa Cheo and Ban Xeo s in the province of Lao Cai, which are the poorest and the most difficult to reach from any major city. Next, *central region* is the dummy variable that equals 1 if, and only if, the child was in either Da Nang or Phu Yen in 2002. Furthermore, three sites in the province of Phu Yen and another site in Ben Tre are called *coastal* because of their location near the sea. All the clusters in Ben Tre belong to the *Mekong Delta* region, which has its own socioeconomic features. Finally, *farm-only income* describes a district in the province of Hung Yen, where non-farm incomes are limited. Table 1 contains a description of all variables used in this study.

11 See Appendix for definition.

All the variables in groups G_1, G_2 and G_3 are used in the three models to be described in Section 4. Model A will use the variables in group G_1 only. Model B will use the variables in groups G_1 and G_2. Model C employs the variables in group G_3, a part of G_1 (except the cluster dummies), the wealth indexes, and a part G_2 (except the residuals of wealth indexes). Above all, the cognitive test score as the dependent variable, and the birthweight, which serves as the instrument for the height-for-age z-score (HAZ) are included in all the models. Lastly, in Model D we use the explanatory variables in group G_1 in addition to the dependent variable of CDQ.

4. The models and methodologies

4.1. The model on the impact of early age stunting on cognitive achievement

For the measure of child cognitive achievement, we study the following linear function of the explanatory variables:

$$\ln(c_i) = \alpha + \sum_{k=1}^{N} \beta_k x_i^k + \varepsilon_i \quad (1)$$

$$\varepsilon_i = u_i + v_i \quad (2)$$

where c_i stands for cognitive achievement, presented by the PPVT test score of the i^{th} child, α is a constant, N is the number of factors included in the model, x_i^k presents the measure of the k^{th} factor for the i^{th} child, u_i is the total effects of unobserved factors, and v_i is a white noise. The factors are among the variables listed in Table 1, which also demonstrates which model the variables are in as well as the roles they play. The coefficients β_k of the variables on height-for-age z-score, wealth indexes, parental education and others need to be estimated.

The model with equation (1), however, is likely to suffer from the problem of endogeneity. The reasons for this include the linkages between the child's HAZ, parents' preference, parents' ability and the ability of the child. For instance, some parents are not able to provide adequate conditions for the development of their children, physically or intellectually. Others prefer having more children to having fewer but better educated children. Such behaviour will cause lower HAZ and lower cognitive skills, even if there is no direct causal effect of HAZ on those skills. Obviously, many factors related to innate mental ability and home environment are not observed, and if they correlate to both the HAZ in equation (1) and u in equation (2), the results of an OLS regression can be biased.

Likewise, the household wealth index, which is intended to reflect certain aspects of household heads' abilities, can cause problems of endogeneity. The literature suggests that parents adjust investments in 'inputs' to child development in response to the perceived ability of the child. These investments could be 'compensatory' – children with slow cognitive development could receive more and better food, or extra parental attention; or 'complementary' – more resources could be devoted to the brightest children (Paxson and Schady 2007). If one looks at the investment in child human capital as an alternative to that in housing or consumer durables in the house, it would mean a negative correlation between household wealth and child cognitive achievement. However, according to Glewwe et al. (2001), 'it would seem safe to assume that parents in developing countries cannot detect their children's mental acuity, and thus cannot make nutritional allocations accordingly, prior to age two'.[12] Regarding such behaviour of parents, we choose to treat the wealth index of Round 2 as endogenous and that of Round 1, when none of the children were older than 18 months, as exogenous.

To overcome the problem of endogeneity in relation to the behaviour and ability of parents, which will have affected the child's cognitive development from birth, we apply the method of two-stage least squares (2SLS). The purpose of the 2SLS is to eliminate the influences of the factors which are left out of the model, because they are either unobservable or correlated to the unobservable and therefore cause further methodological complication. We need variables that play the role of instruments for the endogenous variables of *HAZ* and *wealth index Round 2*, if used. As discussed previously, the instruments are *birthweight* and *wealth index Round 1*, respectively.

Let's now look more closely at the three models of 2SLS regressions of verbal cognitive achievement. Model A, which works with the variables in group G_1, is intended to cover all the explanatory variables that can be affected by policy intervention. All the exogenous variables are purportedly independent of the influences of home environment and parents' mental abilities. In contrast, the variable of HAZ is endogenous, as previously discussed, and we use *birthweight* as the instrument variable for it. The variable of *birthweight* can be interpreted as an aspect of the material conditions at birth which is free of influences by the home environment and the behaviour of family members since the birth of the child. If the result of Model A regression is found to be robust, it would imply that there is a pathway for the factors (birthweight, the community and the environmental variables), through height-for-age to cognitive achievement, separate from family-specific influences.

Model B expands upon Model A by including the additional variables in group G_2. The additional factors may serve as evidence as to whether the 2SLS estimators of Model A have suffered from a misidentification problem, particularly if the absence of some important factors has made a difference to the results. In addition to *height-for-age*, as used in Model A, Model B also uses the other endogenous variable of *residual* of *wealth index Round 2*.[13] The residuals of wealth indexes carry information on the household members' ability to create wealth, given their socioeconomic, environmental and community conditions. By its nature, the residual of the wealth index for either round is independent of all the variables in group G_1, and therefore actually adds new dimensions to the model, if the first-stage OLS regression of *wealth index Round 2* reveals an economic significance of any explanatory variables. Other variables in Model B are *mother's education*, *father's education*, *mother's ethnicity* and *mother's height*, all of which are unchanged since the birth of the child.

Finally, for Model C, the endogenous variables are *HAZ* and *wealth index Round 2* (instead of the residual as in Model B). The instruments are *birthweight* and *wealth index Round 1*. Other explanatory variables are *mother's education*, *father's education*, *mother's ethnicity*, *mother's height* and the community characteristics. The variables in Model C are more commonly used than those in B.

12 See Glewwe et al. (2001), footnote on page 348.

13 See Section 3 for the meaning of residual.

4.2. The model on the impact of early age stunting on achievement in CDQ

We use Model D to study the impact of early age stunting on the Cognitive Development Quantitative test administered to the 5-year old children. The equation under consideration is the same as (1) and (2), except the cognitive achievement c_i is now CDQ score, instead of PPVT as in Models A, B and C. In fact, we use the explanatory variables and the instrument of Model A for Model C.

5. The results of regressions

5.1. The impact of early age stunting on the verbal cognitive achievement of the child

Let's first see if we get any evidence on the independence of Models A, B and C. Statistics in first-stage regression show that Model B in fact has more dimensions than Model A, and that this is because the first-stage OLS regression of the *residual of wealth index Round 2* has P-value for its F-statistics less than 0.001, and several explanatory variables, including those on parents' education, with statistical significance under 1 per cent.

That the evidence for Model C differs from the others is also clear. It implies that the difference between Models C and A includes the fact that the P-value for its F-statistics for the first-stage OLS regression of *wealth index Round* 2 is less than 0.001. Furthermore, the significance at 1 per cent of the coefficient for the variable on *total adverse events between rounds,* the first-stage OLS regression of *wealth index Round 2,* may serve as evidence of Model C being different from Model B, as the coefficient for the same variable is found to be statistically insignificant in the corresponding first-stage OLS regression of the *residual of wealth index Round 2* (in Model B). This is more or less expected with respect to the difference in nature of the (whole) wealth index and the residual of the wealth index, which is independent of environmental shocks. Other evidences for Models B and C differing substantially from Model A include the fact that the variable on *mother's height* is found to be statistically significant at 1 per cent in first-stage OLS regression of the HAZ in both Models B and C. It implies that the genetic characteristic of *mother's height* has a significant contribution to the variation of the linear prediction of HAZ, which plays the role of HAZ in the second stage of the 2SLS and should therefore affect the HAZ coefficient estimated by the 2SLS. The results of 2SLS regressions are demonstrated in Table 2, which also includes the test statistics that are important for judgements on reliability of estimators. All the test statistics such as *under-identification test*, *weak identification test*, *weak-instrument-robust inference* and *over-identification test of all instruments* are all favourable enough to suggest the results are reliable.

The focus of this study is the effect of HAZ. Across the models under consideration, given that the minimum standard error of the coefficients equals 0.031, none of the coefficients of HAZ differ from that of Model A (which is 0.106, see Table 2) by more than half of the minimal standard, and therefore the hypothesis that the coefficient of HAZ is the same in Models A, B and C cannot be rejected. This fact can be interpreted as evidence for the consistency of the estimator of the coefficient of HAZ. Let's recall that HAZ and the factors of its linear prediction had been determined prior to Round 1 and the test administered in Round 2, and that through 2SLS, the influences of the behaviour of household members and the family environment over the period after the child's first birthday are separated from the estimation. Despite the variety in the pattern of influences by family factors on the linear prediction of the HAZ in the first stages, the resulting estimator of the final stages of the 2SLS regressions is consistent.

Table 2: *Results of 2SLS regressions on verbal cognitive achievement*

Dependent variable: Log of PPVT raw score at age of five

	Model A			**Model B**			**Model C**		
	Coef.	**Std. dev.**		**Coef.**	**Std. dev.**		**Coef.**	**Std. dev.**	
HAZ at the age of one	0.106	0.031	***	0.104	0.040	***	0.118	0.043	***
Male	0.046	0.019	**	0.051	0.021	**	0.062	0.022	***
Months old	0.035	0.004	***	0.035	0.004	***	0.035	0.004	***
If adverse events before R1	-0.049	0.034		-0.047	0.035		0.012	0.037	
Total adverse events 2002-6	-0.017	0.012		-0.010	0.013		0.009	0.014	
Mother's education				0.017	0.005	***	0.013	0.005	***
Father's education				0.015	0.004	***	0.013	0.004	***
Mother ethnic majority				0.109	0.051	**	0.151	0.051	***
Mother's height				-0.004	0.003		-0.004	0.003	
Wealth index R2: residual				0.196	0.165				
Wealth index R2							0.167	0.178	
Urban							0.134	0.054	**
Good infrastructure							0.163	0.047	***
Most isolated							-0.596	0.091	***
Central							-0.273	0.046	***
Coastal							-0.172	0.035	***
Mekong							-0.229	0.043	***
Farm-income only							-0.428	0.078	***
Number of observations	1479			1252			1252		
Under-identification test	131.9, P-val = 0.000			88.5, P-val = 0.000			80.5, P-val = 0.000		
Weak identification test	135.7 (10% maximal IV size: 16.38)			44.8 (10% maximal IV size: 7.03)			41.0 (10% maximal IV size: 7.03)		
Weak-instrument-robust inference	Stock-Wright S P-val: 0.001			Stock-Wright S P-val: 0.010			Stock-Wright S P-val: 0.003		
Over-identification test of all instruments	Equation exactly identified			Equation exactly identified			Equation exactly identified		

Notes: '***', '**', and '*' denote statistical significance respectively at the, 0.01, 0.05 and 0.1

The implication of this is important: the impact of HAZ on the log of the child's PPVT score is independent of the source of the variation of HAZ, whether because of the variation in birthweight and environmental factors (by the variables in G_1), or of that in household characteristics (by the variables in G_2). It also implies that the effect of HAZ at age one on cognitive achievement at age five is independent of the innate mental ability of the child's parents. Given the consistency of the effect of HAZ, we may choose the estimator from Model A. For the chosen coefficient of 0.106, an increase in the height-for-age z-score by a standard deviation of this would lead to an increase of 0.24 standard deviation of the log PPVT score for the child.

The next variables of main interest in this study are on parents' education, which is an important aspect of household socioeconomic status. The results of regression presented in Table 2 clearly show that the effects of parental education are all strongly statistically significant. If we take the coefficients of the parents' education from the results of Model C regression, which are more conservative than those for Model B, we find that an increase in mother's education by a standard deviation would lead to an increase by 9.4 per cent of standard deviation for the log PPVT score.[14] For father's education, the figure is 9.8 per cent. If the results of Model B regression are applied, the changes in child cognitive outcome would be 11 per cent of the standard deviation of the log PPVT score at the effect of an increase by a standard deviation of either mother's or father's education.

In terms of the other characteristics of the child's mother, ethnicity does make a difference to child performance on the cognitive test, even though the statistical significance varies. More in-depth study may be required to explain the ethnic gap. Height of the mother, on the other hand, does not seem to affect the child's cognitive outcome. It is, however, an important factor behind the linear prediction of HAZ, which is the result of the first stage, and ultimately works on the test score indirectly. In fact, in the first-stage regression, the effect of mother's height on the HAZ of the child is strongly positively correlated in all the models including this factor.

Even though the coefficient of the wealth index is positive, its effect is statistically insignificant in both capacities (the *residual of wealth index Round 2* in Model B and the *wealth index Round 2* in Model C).

With respect to other child characteristics, boys performed better than girls in PPVT. The results also clearly demonstrate that *age* makes a difference to children's scores, and this is consistent across models. The effect of birthweight, which acts as an instrument in all models, works through the HAZ, as revealed in first-stage regressions, is consistently strong.

Adverse events, such as natural disaster, death of livestock, or being the victim of crime over the period from the child's conception to the time of data gathering in Round 1, have an insignificant negative impact on the performance of the child. The total direct effect of adverse events which happened to the household over the years between rounds of data gathering is not found to be statistically significant either. The shocks between the rounds of data gathering, however, did influence the wealth index, and therefore had an indirect insignificant effect through household wealth on child cognitive achievement.

Community characteristics are important factors in child cognitive achievement. Unsurprisingly, children who live in urban areas or in areas with a good infrastructure (urban or the Red River Delta province of Hung Yen) do better than children in other areas. The children in the most isolated site, which is also the district with the highest rate of poverty, have a clear disadvantage in comparison to the children elsewhere. Furthermore, *farm-income only* has become a conception of development in Vietnam. It also means an area with little non-farm employment. The communities whose income comes mainly from rice are found to be relatively poor and backward. *Farm-income only* communities are often far from prosperous centres, with which they have only weak socioeconomic ties. Finally, an explanation of the significance of the effects of variables such as *Central, Coastal and Mekong* may go beyond the mainly econometric nature of this study.

14 Standard deviation is 3.78, or close to the difference in the number of schooling years of a mother educated to the level of lower secondary school as against a mother educated to primary school level only.

5.2. The results for quantitative cognitive achievement

To investigate the impact of early age stunting on quantitative cognitive achievement at age five, we use the explanatory and instrument variables of Model A, with the CDQ score being the dependent variable. The robustness of regression, indicated by test statistics, is found to be similarly favourable to those for the estimation of Model A.

Table 3: *Results of 2SLS regressions of quantitative cognitive achievement*

Dependent variable: CDQ test score at age of five

Variable	Coefficients	Std. Err.	
HAZ at age one	0.434	0.170	**
Male	0.039	0.102	
Months old	0.138	0.019	***
If adverse events before R1	-0.118	0.177	
Total adverse events 2002-6	0.002	0.065	

Number of obs = 1673; Under-identification test: 139.5
Weak identification test: 143.3 (10% maximal IV size: 16.38)
Weak-instrument-robust inference Stock-Wright P-val: 0.01
Over-identification test: equation exactly identified

The result of regression is presented in Table 3. Most importantly, the effect of height-for-age at age one is found to be statistically significant. An increase in the height-for-age z-score by its standard deviation would lead to an increase by 0.20 standard deviation of the CDQ score.

6. Conclusions

We have demonstrated that stunting in early childhood, which is represented by the child height-for-age z-score, has negative effects on child cognitive development beyond the short run. The impact of height-for-age z-score on the cognitive achievement of the child has been considered through backward and forward linkages so that the reliability of results can be checked. The impact of early age stunting on cognitive achievement is found to be independent of the source of the variation in HAZ, whether it is due to differences in birthweight and environmental factors, or to household characteristics (wealth and parental education, in particular). The effect of HAZ on cognitive achievement is estimated independent of the influences of the parents' innate mental ability and home environment from the birth of the child. We find that an increase by a standard deviation of height-for-age at age one is found to lead to an increase by 24 per cent of the standard deviation of the log score in the Peabody Picture Vocabulary Test at age five. For the cognitive development assessment quantitative test, we find that an increase in the height-for-age z-score by a standard deviation leads to an increase of twenty per cent in the standard deviation of the quantitative cognitive achievement. The effect of stunting on both verbal and quantitative cognitive achievement is statistically significant. These results may be interpreted as another piece of evidence for the desirability of policy intervention in favour of poor pregnant women and babies in danger of becoming malnourished.

With respect to the factors directly concerned with the household socioeconomic status, we find the effect of wealth index on child cognitive achievement to be statistically insignificant, but that of parents' education to be strong in all the settings considered here. If the mother added four years to her schooling (for instance, by completing lower secondary school instead of stopping at the completion of primary school), it would be expected to lead her child to higher cognitive achievement at age five by as much as ten per cent of the standard deviation of his/her log of PPVT raw score. The effect of the father's education is roughly the same.

With a multidimensional conception of poverty that includes measures such as nutrition, parental education, household wealth and other factors, the way that poverty is transmitted across generations becomes clearer than the (one-dimension, monetary only) conception of poverty. Our study also points to other causes of an intergenerational poverty trap, such as living in a poor community with characteristics such as poor infrastructure, isolation and lack of income variety. Such characteristics make a difference to the cognitive development of the child.

The idea of intergenerational transmission of poverty can carry over macroeconomic aspects in some senses. For a prolonged economic crisis, such as Vietnam experienced in the 1980s, the total damage is not only the lost output, which can be made up for by a subsequent period of growth at a high rate; other consequences, such as damage to health and short stature, may be more costly to reverse. Long-run aspects of human welfare loss such as these should be taken into account in the cost-benefit analysis of social protection programmes in favour of the chronically poor in times of economic crisis.

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Appendix

Definition of variables on the environment shocks

Adverse events Round 1: Since the mother became pregnant with the index child, have there been any big events or changes that decreased the welfare of the household?

1. A natural disaster
2. Livestock died
3. Victim of crime

Total adverse events between rounds: Total of dummies that stand for the events listed below. A dummy variable equals 1 if the corresponding event happens in the years between rounds of data gatherings and it is considered by the caregiver to be one of the three most important events in terms of impact on the welfare of the household in the four years prior to Round 2.

1. In the last four years, has the household been a victim of crime resulting in death or disablement of a working adult household member?
2. Have large increases in input prices affected the household in the last four years?
3. Have large decreases in output prices affected the household in the last four years?
4. Has livestock dying affected the household in the last four years?
5. Have you experienced drought in the last four years?
6. Have you experienced too much rain or flooding in the last four years?
7. Have you experienced erosion in the last four years?
8. Have you experienced frosts or hailstorms in the last four years?
9. Have you experienced pests or diseases that affected crops before they were harvested in the last four years?
10. Have you experienced crop failures in the last four years?
11. Have you experienced pests or diseases leading to storage losses in the last four years?
12. Have you experienced pests or diseases affecting livestock in the last four years?
13. Has fire affected the building you live in during the last four years?
14. Has the building you live in collapsed in the last four years?

Young Lives is an innovative long-term international research project investigating the changing nature of childhood poverty.

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