Cognitive Development Among Young Children in Ecuador: The Roles of Wealth, Health and Parenting*

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Abstract

We examine the relationship between early cognitive development, socio-economic status (SES), child health, and parenting in a developing country. Using a sample of over 3000 pre-school age children from Ecuador, we analyze determinants of children's scores on a widely-used test of language ability. Household socioeconomic characteristics, in particular wealth and parental education, are "protective"—children from wealthier households and with more educated parents have higher scores. This is especially true for older children. Child health and parenting quality are associated with test scores, and account for a portion, although not the majority, of the association between SES and cognitive development.

JEL codes: I12, O12

I. Introduction

A growing body of research suggests that low levels of cognitive development in early childhood have adverse long-term consequences for adult wellbeing. Research based on the 1958 British cohort study shows that performance on mathematics and reading tests at age 7 predict test scores at later ages, as well as educational attainment and wages as adults (Connolly et al., 1992; Currie and Thomas, 1999; Robertson and Symons, 2003). Evidence from a later-born cohort indicates that tests administered as early as 22 moths of age are also associated with adult education outcomes (Feinstein, 2003). Several of these authors find that the predictive effects of test performance in childhood on adult education and wages are particularly large for children from households with lower socioeconomic status (SES) (Currie and Thomas, 1999; Feinstein, 2003).[1] These results underscore the importance of understanding the determinants of cognitive development, especially among poor children.

Research on both industrialized and developing countries has focused on identifying environmental factors that affect cognitive development. A common finding in the US literature is that higher SES, as measured by income, wealth, or parental education, is associated with better cognitive development of children.[2] The extent to which this association is causal is a topic of live debate. More resources for children, better parenting skills, increased cognitive stimulation of children, and lower incidence of maternal depression and stress have all been proposed as "pathways" from high SES to high levels of cognitive development of children.

In contrast with the US literature, research on developing countries has placed greater emphasis on child health as a determinant of cognitive development and little emphasis on parenting. Numerous studies report an association between cognitive development and malnutrition (Powell et al., 1995; Pollitt et al., 1997), iron deficiency (Lozoff et al., 2000; Grantham-McGregor and Ani, 2001; Stoltzfus et al., 2001) and, more recently, other micronutrients such as zinc, iodine and vitamin B-12 (Black, 2003). Helminth infections have also been implicated as a route through which SES affects cognitive development. Children infected with intestinal helminths are more likely to be malnourished, and to have iron deficient anemia, which could impair their ability to learn (Dickson et al., 2000; Miguel and Kremer, 2004).

The emphasis on child health in developing countries is understandable—the health problems children face may be so pressing that other factors are of secondary importance. However, there are a number of important questions that have received little attention in poor countries. First, while there is abundant evidence that children in poorer households are generally in worse health (for reviews, see Behrman and Deolalikar, 1988; Strauss and Thomas, 1998), little is known about socioeconomic gradients in cognitive development. If poorer children in developing countries grow up with poorer cognitive skills, leading to lower incomes in adulthood, which in turn influence the cognitive skills of their own children, then low levels of cognitive development in early childhood may be one way in which poverty is transmitted across generations. Second, the way in which low socioeconomic status interacts with poor health and inadequate parenting behavior in determining child cognitive development in poor countries is not well understood. Yet these interactions are critical for the design of appropriate policies. Third, there is a large body of research on the determinants of low educational attainment among school-aged children in developing countries (for a review, see Glewwe, 2002). A common finding is that children from poorer households are less likely to go to school, less likely to make satisfactory progress conditional on school attendance, and less likely to learn and acquire skills in school. However, if the factors that affect school performance (and eventually earnings) are determined at earlier ages, then policies that focus on school-aged children may be less effective than those that concentrate on children at younger ages.

This paper examines the role of SES, child health and parenting in the cognitive development of 3,153 Ecuadorean children who were 36 to 71 months old at the time of assessment. The children in our sample are predominantly poor—all live in household that fall into one of the lower three quintiles of a nationwide wealth index, and the majority are from the bottom two quintiles. Cognitive development is assessed using the *Test de Vocabulario en Imágenes y Peabody* (TVIP), the Spanish version of the Peabody Picture Vocabulary Test (PPVT), a test of vocabulary recognition that has been widely used as a general measure of cognitive development.[3] The data we use contains measures of SES, including household composition, maternal and paternal education, housing characteristics and household assets; direct assessments of child health, including blood hemoglobin levels and child height and weight, as well as maternal reports of breastfeeding duration; and measures of parenting quality, including parental responsivity and punitiveness, time spent reading to the child, and the number of other children in the household.

Our analysis contributes to the existing literature in a number of ways. First, we document a clear association between SES and cognitive development among poor children in Ecuador. Moreover, we show that the associations between many components of SES and cognitive development become larger with the age of the child. For example, the association between maternal education and the TVIP scores is more than twice as large among older children in our sample, aged 54-71 months, than among younger children, aged 36-53 months. The same is true for household wealth. Although we cannot rule out all other alternatives, a plausible explanation for this finding is that the effect of high SES on cognitive development is cumulative, so that children from poorer children and those with less educated parents fall increasingly behind their peers as they approach school-age.

Second, we show that some measures of child health, in particular hemoglobin levels, and some parenting measures, in particular parental responsivity and punitiveness and whether children are read to, are strongly associated with cognitive development. Health and parenting account for a portion, but not all, of the associations between measures of SES and test scores.

Third, our estimation method explicitly accounts for censoring in the test scores: In our sample, as in many samples of poor children, a fraction of children are unable to make any progress on the test, or receive raw scores that are so low given their ages that their scores cannot be normed. Rather than exclude these children from the analyses—which would result in biased estimates of the associations between cognitive development, SES, health and parenting quality—we present estimates using censored regression and censored least absolute deviations methods. Our results indicate that the use of methods that do not account for censoring understate the importance of SES, health and parenting quality on child cognitive development.

II. Sample and Measures

Our sample includes 3,153 children in 158 parishes in six provinces in Ecuador.[4] We briefly describe some important features of the Ecuador setting and of our sample, and then turn to a discussion of the measures of cognitive development, SES, child health, and parenting quality.

Sample: Ecuador is a lower-middle income country. In 2002, its per capita GDP was US $ 1,796, about half the population-weighted Latin American average of US $ 3,740. Inequality is high (the Gini coefficient is 0.44), although not especially so by Latin American standards. Poverty is widespread. An estimated 18 percent of the population lives on less than a dollar per person per day, and more than 40 percent live on less than two dollars per day (World Bank, 2004).

Overall health indicators for Ecuador are roughly on par with those of other Latin American countries. Life expectancy is 72 years, and infant mortality is 33 per thousand live births—very close to the mean values for the region. Ecuador does worse on measures of child nutrition: One of every four children under the age of five has low height-for-age (stunting), a figure that is comparable to other "Andean" countries in the region (Bolivia, Peru) but is far above the Latin American average of 15 percent, and one in ten children has low weight-for-height (wasting), a very high figure by regional standards. Preventable, communicable diseases such as diarrhea and acute respiratory infections are the main source of morbidity and mortality among children in Ecuador (Vos et al., 2004). Intestinal parasitic infections (IPIs) are also widespread: One recent study finds that more than 90 percent of children in a study area in the rural highlands of Ecuador were infected with one or more pathogenic IPIs, and more than one-half the children were infected with helminths (Sackey, Weigel, and Armijos, 2003). We are not aware of any published studies that measure hemoglobin levels or cognitive development among pre-school children in Ecuador.

The sample we use contains urban and rural children, and is drawn from a survey conducted between October 2003 and September 2004. This survey is intended as a baseline for an evaluation of the *Bono de Desarrollo Humano*, the largest social transfer program in Ecuador. The existing transfer program is poorly targeted, so that many non-poor families receive transfers and many poor families do not receive benefits. The government of Ecuador is in the process of redesigning the *Bono*, so that families in the bottom two quintiles of the nation's wealth distribution will be added to the program roster and those in the top three quintiles will be removed. In addition, to receive transfers families with pre-school children will be required to take them for regular health center visits, and families with older children will be required to enroll them in school. The planned evaluation will focus on new entrants to the social transfer program who have pre-school but no school-age children (and so will be bound by the requirement to take pre-school children to health clinics); as a consequence, these groups where over-sampled. Of the children in the sample, 82 percent are in the bottom two quintiles of the wealth distribution; 98 percent have no school-age siblings; and none received social transfers in the six months prior to the survey. The sample therefore consists primarily of children from young, poor families.[5]

Because of these selection criteria, our sample of families are poorer, on average, than families with young children in Ecuador as a whole, and poorer than families in the parishes included in this study. Table 1 shows means of selected characteristics for households in our sample, and for households from two other data sources: The 1999 *Encuesta de Condiciones de Vida* (ECV), the most recent nationwide multi-purpose household survey conducted in Ecuador, and the 2001 Population Census. We selected households with at least one pre-school child in the ECV and the Census, and calculated nation-wide averages using the ECV, and averages for households in the same parishes included in our sample using the Census.[6] A comparison of columns 1 and 2 indicates that, relative to the national average, households in our sample tend to be worse off: They have fewer rooms, and are less likely to have access to services such as piped water and flush toilets, are more likely to have dirt floors, and are less likely to have assets like a fridge, oven, or TV. Table 1 also suggests that households in our sample are generally worse off than other households in these parishes, especially when the comparison group is limited to households in the Census who do not have children aged 6 or older (column 4).

A sub-sample of 3,153 children was used for the analyses in this paper: First, we selected 3,854 children who were between the ages of 36 and 71 months of age at the time of the survey—the TVIP was not administered to younger children. Second, because the TVIP is administered in Spanish, we excluded 79 children whose mothers spoke a language other than Spanish (even if they spoke Spanish as well), or who were reported by their mothers to speak a language other than Spanish.[7] This selection ensures that Spanish was the primary language of children being tested. An additional 552 children were excluded because of missing information on the control variables used in the analyses. In most cases, missing values were due to non-completion of the health assessments, either because children were not present in the household at the time of the interview or the mother refused permission for the health assessment, most often for the blood draw required to measure hemoglobin. The children excluded due to missing information are similar to those who were not excluded: Tests that the two groups live in households with the same average levels of wealth and parental education could not be rejected. Finally, we excluded 70 children who were present at the time of the interview but were not administered the TVIP. The group of children who did not take the TVIP was on average younger (by 7 months) and belonged to families with significantly less wealth and lower parental education. It is likely that children in this group would have performed poorly on the TVIP had they been tested. If so, the statistics we show below on means and medians of test scores are biased upward.

Measures: Descriptive statistics are shown in Table 2. Our outcome measure is a child's score on the TVIP. The TVIP is a test of receptive language that is frequently used to evaluate Spanish-speaking pre-school children (Munoz et al., 1989; Umbel et al., 1992). Children are shown a series of slides, each of which contain four pictures, and asked to point to or otherwise identify a picture that corresponds to a word stated by the interviewer. Later slides are gradually more difficult, and the test stops when the child has made six mistakes in the last eight slides. Test items have been selected for their universality and appropriateness to Spanish-speaking communities, and the test has been widely used in Latin American countries and with Spanish-speaking children in the U.S.

Our analysis examines how performance on the TVIP differs across children of different ages, which requires the use of age-normed scores. The TVIP has not been normed for samples of Ecuadorean children. We standardize the raw scores on the test using the norms published by the test developers, which are based on samples of Mexican and Puerto Rican children.[8] These norms are set so that the mean should be 100 and the standard deviation 15 at each age.

An important feature of the TVIP is that there is a minimum raw score that can be normed for children of each age. For children less than 60 months of age, normed scores are available for raw scores of 1 or more. For these children, the normed scores that correspond to a raw score of 1 declines with age. For example, a raw score of 1 translates into a normed score of 87 for 36-month-old children, and into a normed score of 57 for those aged 59 months. For children aged 60 months and older, the minimum raw score that can be normed rises with age, from a value of 2 for 60-month-olds to 9 for 71-month-olds. For these children, the minimum raw score always corresponds to a normed score of 55.

The existence of these "minimum" scores is a challenge for our analysis. A fraction of children in our sample—11 percent overall—do not attain the minimum raw score that can be normed. Some of the younger children in our sample have a raw score of 0—indicating that they were not advanced enough to make any progress, even though an attempt was made to administer the test—and some of the older children have raw scores below the minimum that can be normed for their age group.[9] A common practice is to exclude such children from analyses, but this will generally result in biased parameter estimates. Instead of dropping these children, we assign them the minimum normed score for that age. The score assigned to these children is censored, and represents an *upper* bound on the child's language ability. We then adopt estimation methods, discussed in more detail below, that account for this censoring.

Including the censored values, average performance on the TVIP test is low: The mean of 86.4 indicates that, on average, the children in our sample are nearly 1 standard deviation below the mean of the group used for norming the TVIP. Eleven percent of children in the sample have censored TVIP scores. When the censored group is excluded, the mean TVIP score rises to 88.1, still well below the normed mean.

Explanatory variables fall into one of three broad categories: Socio-demographic variables, measures of child health and nutrition, and measures of parenting quality. The socio-demographic variables include the age of the child in months and the child's gender, and measures of socio-economic status. The two most important measures of SES we focus on are wealth and parental education. The education of the parents is given in single years, and the wealth index we use is a composite measure of household assets and dwelling characteristics, aggregated by principal components.[10] We also include an indicator for whether the child's father lives at home. Twenty-nine percent of the children in our sample have absent fathers. Despite high levels of internal and international migration in Ecuador (World Bank, 2004), migration is responsible for relatively few absent fathers in our sample. Of all children with absent fathers, only 121 had fathers who were reported to have migrated to another country or province, 30 had fathers who were deceased, and the rest had fathers who were reported to be separated from or to have never resided with the family. In addition to wealth and parental education, we include the mother's age as a socioeconomic variable because it may be an indication of unmeasured labor market potential if women who are more productive choose to postpone childbearing. Maternal age may also have an impact on child health if children born to very young or very old mothers are at greater risk of health problems, and it may be associated with parenting skills. Finally, we include the number of adults in the household. Many families contain older relatives (the average number of adults is 3.1), and children with absent fathers typically live with their mothers and other relatives, such as grandparents.

We use four measures of a child's health and nutritional status: Height-for-age and weight-for-height *z*-scores, altitude-adjusted hemoglobin levels, and the number of months the child was breastfed. The *z*-scores were computed using the US Centers for Disease Control (CDC) growth charts. On average, children have a height-for-age *z*-score that is 1.2 standard deviations below the US norms, and 23.4 percent of children in the sample are stunted (height-for-age *z*-score less than –2). Consistent with other evidence on Ecuador, stunting (low height-for-age) is more common than wasting (low weight-for-height). Hemoglobin levels were measured in the field using pin-prick tests, and values were corrected for elevation by merging our sample with data on the mean altitude of the parish. Elevation-adjustment was done with the CDC guidelines (CDC, 1989). The average elevation-adjusted hemoglobin level is 11.1, exactly equal to the threshold value that is often used to define anemia for children in this age range. Using this threshold, 48.0 percent of children in the sample are anemic. Breastfeeding duration is based on retrospective questions asked of the mother for each of her children; the average duration of reported breastfeeding is 5.7 months.

We use three measures of parenting quality in our analysis. The first is based on the widely-used Home Observation for Measurement of the Environment (HOME) scale (Bradley, 1993; Caldwell and Bradley, 1984; Bradley et al., 2001). This is constructed from 11 items that are assessed by interviewers at the close of the interview, and measures punitiveness (for example, whether parents yelled at or hit children during the interview), and responsivity to children (for example, whether they responded to and encouraged children in a positive way during the interview). Each item is scored as a dichotomous variable; the final scale ranges from 0 to 11, with higher values corresponding to less responsive and harsher behavior. Low values are more common than high values: The mean HOME score is 2.3, 31.8 percent of children have parents with a score of 0, and 85.9 percent have scores of 5 or less. The second measure of parenting quality is an indicator for whether the child was read to in the week before the survey. Seventy-three percent of the children were not read to, even though only a very small number of mothers in our sample—56 out of 3,153—were illiterate. Finally, we include a variable for the number of other children in the household. More children in the household may imply less parental time per child.[11] Close child spacing, resulting in more children, may also have negative implications for child health and development.

III. Methods

We start by specifying the TVIP score to be a function of the child's age, gender, and a set of child and household characteristics that may influence test scores:

(1) $$TVIP_{ia} = \alpha_a + \lambda I(Male) + X_{ia}\beta + \varepsilon_{ia}$$

where $TVIP_{ia}$ is the TVIP score of child i of age a, α_a is an age fixed effect (in months), λ captures systematic differences in test scores between boys and girls, and X_{ia} is a set of child and household characteristics. We begin by showing results when X_{ia} includes only SES, and then add measures of child health and the parenting the child receives.

The age fixed effects in (1) allow the TVIP score to vary in a flexible way across children of different ages, but impose the restriction that associations between the variables included in X_{ia} and the TVIP score do not vary with the age of the child.[12] This restriction may be unrealistic if SES has cumulative effects on cognitive development—so that longer "exposures" to poverty or parents with low levels of education have increasingly large effects on test scores. Our sample is not large enough to allow the coefficients included in β to differ in a completely flexible way for each month of age. Instead, we estimate (1) separately for younger children, aged 36 to 53 months, and older children, aged 54 to 71 months, and test for differences in the coefficients in the X_{ia} across the two age groups.

We present estimates of (1) using three estimation methods. OLS, censored normal (maximum likelihood) and censored least absolution deviation (CLAD) techniques. OLS estimates are likely to be biased due to the presence of censored test scores. Typically, censoring leads to OLS estimates that are biased toward zero, since variation in the censored test score masks the true effects of independent variables on actual cognitive ability.

Models that explicitly account for censoring can be specified as follows:

$$(2) \qquad TVIP^{c}_{ia} = \begin{array}{ll} TVIP_{ia} & if \ \ \alpha_a + \lambda I(Male) + X_{ia}\beta + \varepsilon_{ia} > c_a \\ c_a & if \ \alpha_a + \lambda I(Male) + X_{ia}\beta + \varepsilon_{ia} \le c_a \end{array}$$

where $TVIP^{c}_{ia}$ denote the observed value of verbal ability, $TVIP_{ia}$ denote the true value (as expressed by (1)), and c_a is the censoring threshold—the minimum normed score for children of age *a*. Censored normal estimates of (2) are consistent only if the error term is normally distributed and homoscedastic. We have no reason to believe that these conditions will be fulfilled. The CLAD estimates represent a nonparametric alternative to maximum likelihood. The CLAD estimation procedure is iterative: First, (1) is estimated as a quantile (median) regression, using the full sample including censored observations. Then, observations with predicted values of the dependent variable below c_a are “trimmed” from the sample, and the quantile regression is re-estimated. The process of trimming and estimating is repeated until the parameter estimates converge; standard errors are bootstrapped using 100 replications.[13] CLAD estimates have a clear advantage over the censored normal estimates—they assume only that the error term has a median of zero, and will be consistent even if errors are neither normal nor homoscedastic.

Most of the results shown below rely on the age-normed scores, which make comparisons across age groups possible. However, to ensure that our results are not sensitive to the norming procedure, we estimated all models using the raw scores. In this case, only those children with raw scores of zero are treated as having censored test score information. Estimates of the associations between the raw scores and our key measures of SES, health and parenting are qualitiatvely similar—in terms of the relative magnitudes of coefficients and significance levels—to those based on age-normed scores. We also estimated models that treated the 70 children with missing TVIP scores (i.e. who were present at the time of the survey but were not administered the TVIP test) as “censored”, again with little effect on the results.

Although our results provide useful information on the associations between test scores, SES, child health and parenting quality, they must be interpreted with caution. As is stressed by Todd and Wolpin (2004) in an article on cognitive development, strong assumptions are required to draw causal inferences from results based on observational data, especially from a single cross-section. While these issues are well-understood, several are worth highlighting.

First, it is possible that associations between measures of SES (as well as other variables) and test scores are driven by unobserved variables that influence both SES and test scores. For example, parents with higher cognitive ability may achieve higher SES, and their children may inherit their higher ability, producing a spurious correlation between child cognitive ability and SES. There is a large literature on this issue, mainly from industrialized countries, that relies on studies of twins, siblings, or adopted children to tease apart the effects of SES and innate ability (Plomin, 1994; Petrill, 2003).[14] The evidence to date indicates that both genetic and environmental factors contribute to child cognitive ability, and that maternal warmth and socioeconomic status are among the environmental factors that are important (Petrill and Deater-Deckard, 2004).

Second, the fact that cognitive development is a cumulative process complicates the interpretation of the associations, especially for time-varying variables. A finding, for example, that low levels of hemoglobin are negatively associated with test scores of 4-year-old children would not necessarily indicate that this is a “critical age” at which iron deficiency has a large effect on development. The reason is that low hemoglobin at age 4 is likely to be correlated with low levels of hemoglobin at earlier ages (which have not been measured), and the association at age 4 could reflect the effects of iron deficiency at earlier ages. Complete histories of hemoglobin levels (and of the other time-varying factors we observe) would be required to identify “critical periods”.

Third, it may be that the treatment that children receive from their parents is affected by their cognitive ability. Economic models predict that parents adjust investments in “inputs” to child development in response to the perceived ability of the child (Becker and Tomes, 1976). 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. In either case, associations between the measures of child health and parenting and test scores could in part be driven by parents’ responses to their children’s cognitive ability. Again, with only one cross-section of data it is not possible to determine whether this is so.

IV. Results

Nonparametric analyses: We begin with a descriptive analysis of how TVIP scores vary across children of different ages. These results identify features of the data we will investigate in a multivariate framework, and highlight the importance of accounting for censoring. As shown in the top left-hand panel of Figure 1, the mean age-normed TVIP score declines from close to 95, at age 36 months, to less than 85, between 54 and 60 months, and flattens out thereafter.[15] This decline in the mean is accompanied by an increase in dispersion. The standard deviation of the TVIP score, shown in the top right panel of Figure 1, rises from 8 for the youngest children, to nearly 25 for the oldest children. Given that our sample is fairly homogeneous—most children are from poor households—it is not surprising that the standard deviation for children at the youngest ages in our sample is below 15, the value in the reference population that was used to norm the test. However, the homogeneity of the sample cannot account for the increasing dispersion with age that we observe. Another way to view the increasing dispersion of the test scores is to examine percentiles. The bottom left panel of Figure 1 shows the 90th, 50th, 25th and 10th percentiles of the TVIP scores at each age. The 90th percentile scores are relatively constant with age, and there are slight declines in the median. Scores for children at the 25th and 10th percentiles of the distribution decline sharply with age.

The decline in the mean TVIP score with age may in part be driven by censoring. As shown in the bottom right panel of Figure 1, nearly 25% of children at age 36 months have censored scores, which means that (for this age group) nearly a quarter of children were unable to answer a single question correctly. The prevalence of censoring declines from age 36 to age 50 months, and then increases again after 60 months, when the minimum raw score that can be normed rises. Censoring makes it impossible to examine age patterns in test scores among children with very poor language ability. Indeed, the 10th percentile line in the bottom left panel of Figure 1 simply traces out the minimum normed score possible for children aged 36 to 50 months and 66 to 71 months, since for these age groups the fraction of children with censored scores exceeds 10 percent. Because these censored scores contribute to the mean, the true age pattern in verbal ability in the absence of censoring could be quite different from that depicted in the top left panel of Figure 1. However, the 25th, 50th and 90th percentiles are unaffected by censoring throughout the age range, and the fact that the gap between the 25th and 90th percentiles increase with age provides evidence that the rising dispersion in test scores is a genuine feature of the data.

What factors are responsible for the increasing dispersion in test scores with age? As a first step to answering this question, we show medians of the TVIP score at each age after splitting the sample by wealth, education, and place of residence. In the top left-hand panel of Figure 2, the sample of children is broken down into four wealth quartiles. This figure shows little difference in the median TVIP scores across wealth groups at young ages, and large differences at older ages. None of the medians are contaminated by censoring—for every age-wealth group combination, the median exceeded the minimum score. Going counter-clockwise, the next two panels of Figure 2 present results for four schooling categories of the parents, corresponding to complete secondary school or higher, incomplete secondary, complete primary, and incomplete primary or less. These panels show an increasing dispersion in scores across children whose parents have different amounts of education. Censoring affects a handful of cells—marked on the graphs—but cannot account for the general patterns we observe. The last panel, finally, breaks the sample down by place of residence. The results shows that the decline in the median TVIP score with age affects children in both urban and rural areas, although rural children appear to have higher scores at older ages.

Figure 2 suggests that there are some characteristics of households which are "protective" of cognitive development. In households with more wealth, or households where the parents have completed secondary school or more, the TVIP score of older children is higher than the corresponding score for younger children. By contrast, in other households the scores drop dramatically with the age of the children. We next turn to multivariate regressions to analyze this point.

Socioeconomic status and cognitive development: We start by showing results from a probit regression of an indicator for whether the child's score was censored. The results, shown in column 1 of Table 3, indicate that censoring is not random: Poorer children, and children with mothers who have fewer years of schooling are more likely to be censored. Interestingly, we find that children whose fathers live at home are also more likely to have censored scores, a result for which we have no ready explanation. Overall, these results support the idea that regression results that ignore censoring are likely to be biased.

The second through fifth columns in Table 3 show OLS, censored normal, and CLAD estimates. Two variants of OLS are shown: The first restricts the sample to children whose scores are not censored, and the second includes the censored values, with censored scores set equal to c_a. Several key points emerge from these results. First, the different estimation methods yield similar qualitative patterns: The test performance of boys and girls is indistinguishable; all else equal, children from rural households do somewhat better than children from urban households; and children with wealthier families, more educated and older mothers, and more educated fathers, have higher test scores. TVIP scores are never significantly associated with an indicator for whether the father lives at home, and the number of adults in the household.

Second, although the signs and significance levels of the coefficients are similar across specifications, the magnitudes differ. The OLS estimates are smallest, and the CLAD estimates largest for two key measures of socioeconomic status—wealth and maternal education. For example, the coefficient on the wealth index is 24 percent larger in the CLAD than in the full-sample OLS, and the coefficient on maternal education is 26 percent larger. Ignoring censoring of the TVIP score appears to result in downward-biased estimates of the relationship between child cognitive development and key explanatory variables.

Third, estimates of the associations between measures of socioeconomic status and the TVIP scores are large. Using the CLAD estimates, which are the least likely to be biased, the results indicate that a 1-standard deviation increase in the wealth index is associated with an 8.3 point increase in the TVIP score. A 1-standard deviation change in maternal education is associated with an increase in the score of 3.3, and a comparable increase in paternal education with an increase of 2.0. Since wealth and parental education are positively correlated, these parameter estimates imply large differences in test scores across children from households with "low" and "high" SES. For example, a child whose family falls at the 90th percentile for wealth, maternal education and paternal education is predicted to have a score that is 35 points higher than a child at the 10th percentile for each of these variables. Similar results are obtained from estimates that use raw rather than age-normed scores: Children at the 90th percentile for wealth and parental education are predicted to get 24 more test items correct than children at the 10th percentile.

An examination of the estimated age coefficients from the different models (using age-normed scores) provides information on the effect of censoring on age patterns in test scores. As discussed above, the sharp declines in mean test scores from 36 to 57 months of age could simply reflect the fact that fewer older children in this age range have censored scores. Likewise, the "flat" test score after 60 months could be due to the fact that the minimum normed score is held constant from 60 to 71 months, and an increasingly large fraction of children are censored. Figure 3 graphs out the age effects from the full-sample OLS, censored normal and CLAD models. Coefficients have been normalized to zero at the youngest age. The results suggest that the patterns we observe—declining test scores from 36 to 57 months, and slight increases thereafter—are not driven by censoring. The censored normal and CLAD estimates are similar, and show a slightly smaller decline with age from 36 to 57 months than the OLS estimates. However, these results indicate that, all else equal, the test scores of 5-year-olds are roughly 10 points lower than those of 3-year-olds.

A plausible explanation for this decline is that the effects of SES on child cognitive development are cumulative, so that poorer children fall increasingly behind their wealthier counterparts.[16] To investigate this hypothesis, we split the sample into younger children—those aged 36 to 53 months at the time of the survey—and older children—aged 54 to 71 months, and re-estimate the models in Table 3. The results in Table 4 indicate that the associations between several measures of SES and cognitive development become larger with age. The coefficients on wealth and maternal education are more than twice as large for the sample of older children, and tests of the equality of coefficients (not shown) indicate that this difference is significant at the 1 percent level. The coefficients on the rural dummy, maternal age, and paternal education also tend to be larger for the older children, although these changes are generally not significant.

Health, parenting and cognitive development: We next examine how child health and parenting quality are related to test scores. We focus on how much of the associations between cognitive development and SES can be explained by the inclusion of health and parenting measures. It seems plausible that health and parenting are routes through which wealth and parental education influence children's cognitive development. Wealth is correlated with both measures of child health and parenting. For example, the correlation coefficient between our wealth index and the child's hemoglobin level is 0.24; correlations between wealth and other key measures are 0.13 (height-for-age); 0.08 (weight-for-age); -0.20 (HOME score); and 0.39 (whether the child is read to). Similar correlations exist between parental education and measures of child health and parenting.

The results, presented in Table 5, show estimates for the full sample and separately for the two age groups. We focus on the CLAD results because the estimated coefficients on the measures of SES were largest, and because the CLAD results are least likely to be biased. All regressions include the full vector of SES measures, but we only show the coefficients on three key measures of socioeconomic status—wealth, maternal education, and paternal education. For ease of comparison, the first column in each sample repeats the results in Table 3 (for the full sample) and Table 4 (for the younger and older samples). The second column is based on regressions that include the measures of child health, the third column on regressions that include the parenting measures, and the fourth column on regressions that include both the measures of child health and parenting.[17]

The results suggest that some, but not all, measures of child health are associated with TVIP scores. The health variables are always jointly significant, although only the measure of hemoglobin level is individually significant in all specifications. For the sample as a whole, a 1-standard deviation increase in hemoglobin levels is associated with an increase in the TVIP score of 2.2 points (1.9 points when the measures of parenting are included). Height-for-age and weight-for-height are both positively associated with the TVIP score, but the size and significance of these effects is sensitive to the inclusion of the parenting measures, with which they are both correlated (taller and heavier children are more often read to, have fewer siblings, and have better HOME scores). We find no evidence that the number of months a child is breastfed is associated with better cognitive outcomes. A possible explanation for this result is that breastfeeding works through its effects on height, a measure of long-run nutritional status. However, the duration of breastfeeding is also insignificant in models that exclude height, and even in those that exclude height, weight and hemoglobin. Finally, we find suggestive evidence that the associations between measures of child heath and test scores become stronger with age: The coefficients on the measures of height-for-age and hemoglobin status are larger for the sample of older children, although these differences are not significant.

The third column for each sample shows results that include the measures of parenting quality. These provide strong evidence that parenting quality is associated with child cognitive development. Children who live in households with fewer siblings have higher test scores, as do children whose parents receive lower (better) HOME scores, and children who are read to. Some of the estimated effects are large: In the full sample, a one-standard deviation in the HOME score increases the TVIP score by 1.9 points, and children who are read to have scores that are, on average, 4.8 points higher (4.1 points when the measures of child health are included). As with the measures of child health, the importance of parenting quality appears to rise with the age of the child, although the results are not estimated precisely enough for differences in the coefficients to be significant.

The results in Table 5 can also be used to assess the extent to which the measures of child health or parenting account for the associations between test scores and socioeconomic status. In the full sample, including the parenting measures reduces the coefficients on maternal education by 21 percent, and that on paternal education by 24 percent. By comparison, addition of the health measures reduces the coefficient on maternal education by 9 percent, and that on paternal education by 11 percent. These comparisons suggest that parenting behavior may be an important pathway from parental education to cognitive development. However, even controlling for child health and parenting there are still large associations between measures of SES and cognitive development. Finally, we find little evidence that the estimated association between health and cognitive development is biased when measures of parenting are not included. Adding parenting measures produces only slight reductions in the coefficients on hemoglobin and, although the coefficients on weight-for-height generally become smaller and less precisely estimated, those for height-for-age become *larger* in magnitude. These results are therefore consistent with both health and parenting having independent effects on cognitive outcomes.

V. Conclusion

In this paper, we present evidence of strong associations between socioeconomic status and the TVIP scores of pre-school children. These gradients become larger as children grow older. By the time poorer children arrive at the threshold of formal schooling, they are at a significant disadvantage—a disadvantage that may be further compounded if they attend lower-quality schools. This is a concern because cognitive development in early childhood has been shown to have negative effects on school attainment and on wage outcomes in adulthood. Our results also suggest that both child health and the quality of parenting are associated with cognitive development. Parenting quality—something that has received little attention in the research in developing countries—accounts for a substantial share of the association between socioeconomic status and cognitive development.

Our findings are based on a single cross-section of observational data, and interpretation of the associations we report is therefore subject to some uncertainty. To the extent that the relations are causal, they suggest that a three-pronged approach may be useful for improving cognitive development among young children in poor countries. First, programs that directly raise household SES may have high returns in terms of child development. Second, improving children's health should be given high priority, both for its own sake and because of its association with cognitive outcomes. There is, for example, strong evidence from a randomized experiment in Guatemala that protein supplementation in childhood results in long-run improvements in cognitive outcomes (Brown and Pollitt, 1996), although experimental evidence on the effects of iron supplementation (reviewed in Grantham-McGregor and Ani, 2001) and treatment for helminth infection (reviewed in Dickson et al., 2000) is more mixed. Third, programs and policies that increase the amount of cognitive stimulation children receive and improve the quality of their home environments may also be valuable. Only a small number of randomized control trials have been conducted that examine interventions in developing countries that aim at improving both health and parenting-cognitive stimulation, through home-based or center-based interventions (McKay et al., 1978; Waber et al., 1981; Grantham-McGregor et al., 1991 and 1997; Powell et al., 2004; see also Behrman et al. 2004 for an observational, non-experimental study from Bolivia). Several of these interventions have yielded promising results. For example, the recent study by Powell and colleagues, based on a sample of undernourished pre-school children from Jamaica, concludes that a home visiting intervention that provided children with cognitive stimulation yielded an increase of nearly one standard deviation in a global measure of development. In our sample, only a minority of children were read to, even though the fraction of parents who are illiterate was very small. Controlling for other characteristics, these children had significantly higher performance on the TVIP. These findings suggest there may be large returns to programs which improve parenting quality. More generally, our research underscores the need to understand how both child health and the home environment interact with socioeconomic status in determining cognitive development.

Endnotes

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[1] In much of this research, and in what follows, the term "SES" is used as shorthand to refer to a set of socioeconomic factors, including wealth, parental education, family structure and maternal age. We do not mean to suggest that the components of SES measure the same things, and the variables included in SES could be related to children's cognitive ability in quite different ways.

[2] Key references include Smith et al. 1997; Blau, 1999; Guo and Harris 2000; Waldfogel et al., 2002; Aughinbaugh and Gittleman, 2003; Baum, 2003; Ruhm, 2004; Taylor et al., 2004.

[3] Earlier studies that have used the PPVT include Desai et al., 1989; Baydar and Brooks-Gunn, 1991; Blau and Grossberg, 1992; Parcel and Menaghan, 1994; Rosenzweig and Wolpin, 1994; Blau, 1999; McCulloch and Joshi, 2002.

[4] The provinces are Azuay, Loja, and Pichincha in the sierra or highlands region of the country, and Esmeraldas, El Oro, and Los Ríos on the coast. Parishes, or "parroquias," are the smallest administrative units in Ecuador. There are 1,149 parishes in the country.

[5] The sample was constructed by randomly selecting "parishes"—the smallest administrative unit in Ecuador—within six regions in Ecuador (3 coastal and 3 in the highlands). The sample contains 1/3 urban and 2/3 rural parishes. Within parishes, we randomly selected households that had pre-school children, no school-age children, and were eligible to be new entrants to the social transfer program. These children account for 82% of the sample. To this, we added another group of households that had pre-school children and were slightly too wealthy to be eligible for the program. These children account for 18% of the sample. A small number of the wealthier households contain school-age siblings of the focal children. Our analyses are unaffected if this group is excluded.

[6] The ECV is a household survey, and has the advantage of having more detailed information than the Census. However, it is not large enough to produce reliable statistics for the sub-sample of parishes we use.

[7] On a national scale, 6.1 percent of the population of Ecuador consider themselves "indigenous", and 4.6 percent speak a language other than Spanish (León, 2003). However, younger adults are less likely than older adults to speak a language other than Spanish, and the provinces covered by the baseline do not have particularly large concentrations of indigenous populations—especially the three provinces on the coast. For both of these reasons, it is not surprising that our sample includes few families that are not exclusively Spanish-speaking.

[8] The TVIP has been normed to age 17 years. The samples used for norming consist of 1,219 Mexican children and 1,488 Puerto Rican children (http://www.agsnet.com/assessments/technical/tvip.asp).

[9] Children are taught how to do the test using two "training" slides that contain very simple items. Children proceed to the test only after they demonstrate, using the training slides, that they understand the test. Here, a score of zero indicates that the interviewer was unable to teach the child how to use the test, or that the child seemed to understand the training slides but was unable to get any answers correct on the test itself.

[10] Specifically, we took questions in the survey on the type of dwelling, the material of the floor, roof, and walls, and the number of rooms and their uses; the availability of piped water, toilet, shower, and lighting; the type of fuel used for cooking, and the way in which the household disposes of its garbage; and whether the household owned a sewing machine, refrigerator, stove, oven, blender, waffle-maker, iron, radio, TV, stereo, fan, AC unit, bicycle, motorcycle, car, typewriter, computer and washing machine (all of which were asked separately). Where a question had more than two possible responses (for example, "type of floor"), we generated dummy variables for each response. All of the questions were then aggregated by principal components. Our wealth index is given by the value of the first principal component. Estimates that use an alternative measure of wealth—constructed as the simple sum of durable goods—yield similar results.

[11] See Blake (1989) and Parcel and Menaghan (1994) on "resource dilution" caused by additional children in a household.

[12] We include age effects for the exact month of age up to 59 months, and then include age effects for whether the child was 60 or 61 months, 62 or 63 months, 64 or 65 months, 66 or 67 months, 68 to 69 months, and 70 or 71 months. We group the age effects for older children because there are relatively small numbers of children at the highest ages, and we had convergence problems with the nonparametric models presented below when a full set of age effects were included. The choice of two-month age groups for older children was chosen because the age norms for the TVIP are the same for children within each of these groups (e.g. the norms for children ages 60 and 61 months are identical).

[13] More information on CLAD estimators can be found in Powell (1984; 1986) and Chay and Powell (2001).

[14] Only 336 of the 2811 households represented in our sample have more than one child between the ages of 36 and 71 months, a sample size too small to estimate models with sibling effects. There are even fewer households with multiple children within the younger age group (50 households) or older age group (22 households).

[15] It is possible that changes in the mean TVIP scores with age that we observe represent shifts across cohorts, so that more-recently-born (younger) children have better cognitive outcomes than those who are earlier-born. We know of no changes in economic conditions, programs or policies that could have produced such an effect.

[16] Similarly, Case, Lubotsky and Paxson (2002) use data from the US to show that associations between family income and child health increase as children age.

[17] These models were also estimated using raw TVIP scores, with similar results. Results are available upon request.

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Appendix: Construction of HOME scale

The HOME scale is based on responses to a series of questions about how responsive and punitive parents are to children. It is coded by interviewers at the close of the assessment. The questions were answered only if at least one child was present and awake during the interview:

Responsivity:

1. Did the mother or father spontaneously say kind words or phrases to the children at least twice during the interview?
2. At least once, did the mother or father respond verbally to a child's vocalization?
3. At least once, did the mother or father tell the child the name of an object?
4. At least twice, did the mother or father spontaneously praise one of the children?
5. Did the mother or father convey positive feelings toward the children when they speak to or about them?
6. Did the mother or father caress or kiss one of the children at least once?

Punitiveness:

1. Did the mother or father yell at any of the children?
2. Was the mother or father annoyed with or hostile toward any of the children?
3. During the interview, did the mother or father hit any of the children?
4. During the interview, did the mother or father scold or criticize any of the children?
5. Did the mother or father forbid any of the children from doing something more than 3 times during the interview?

Each question received an answer or "yes" or "no". The HOME scale is equal to the number of answers of "no" on the responsivity items, plus the number of answers of "yes" on the punitiveness items. The alpha for the scale is 0.78. We experimented with including the two subscales for responsvity and punitiveness subscales in our models. The results are similar to the shown for the combined HOME scale, only the estimated coefficients on the subscales are less precisely estimated.

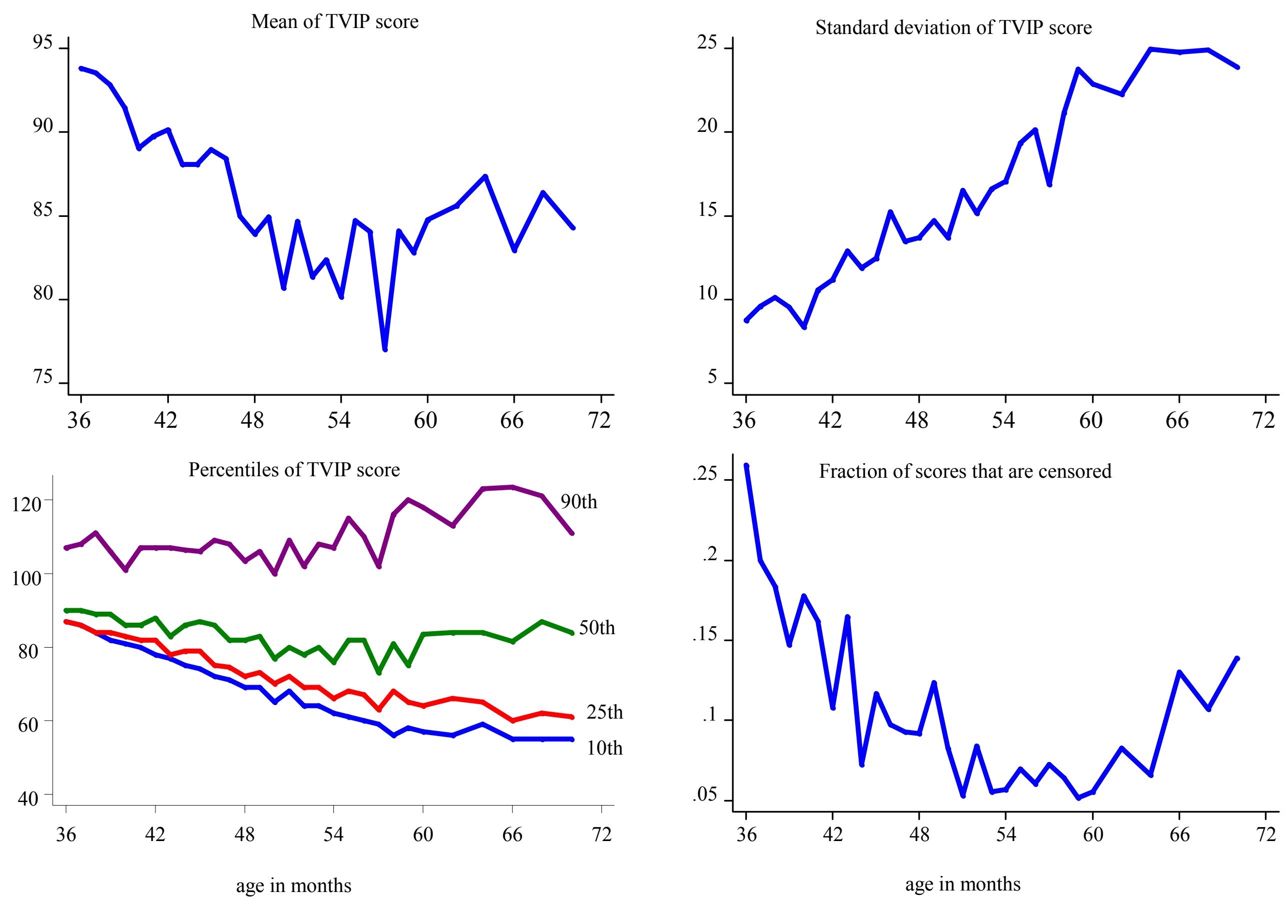

Figure 1: Normed TVIP Scores by Age

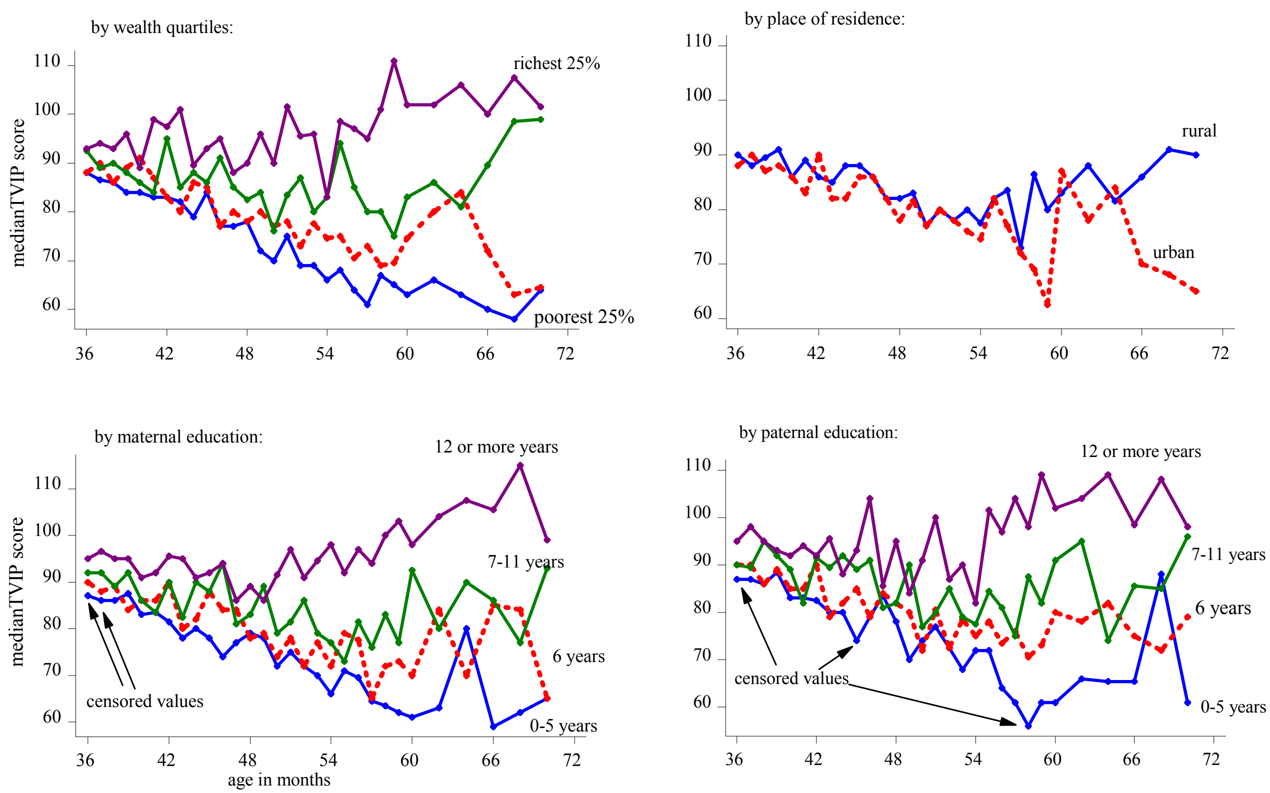

Figure 2: Median TVIP scores by wealth, parental education, and place of residence

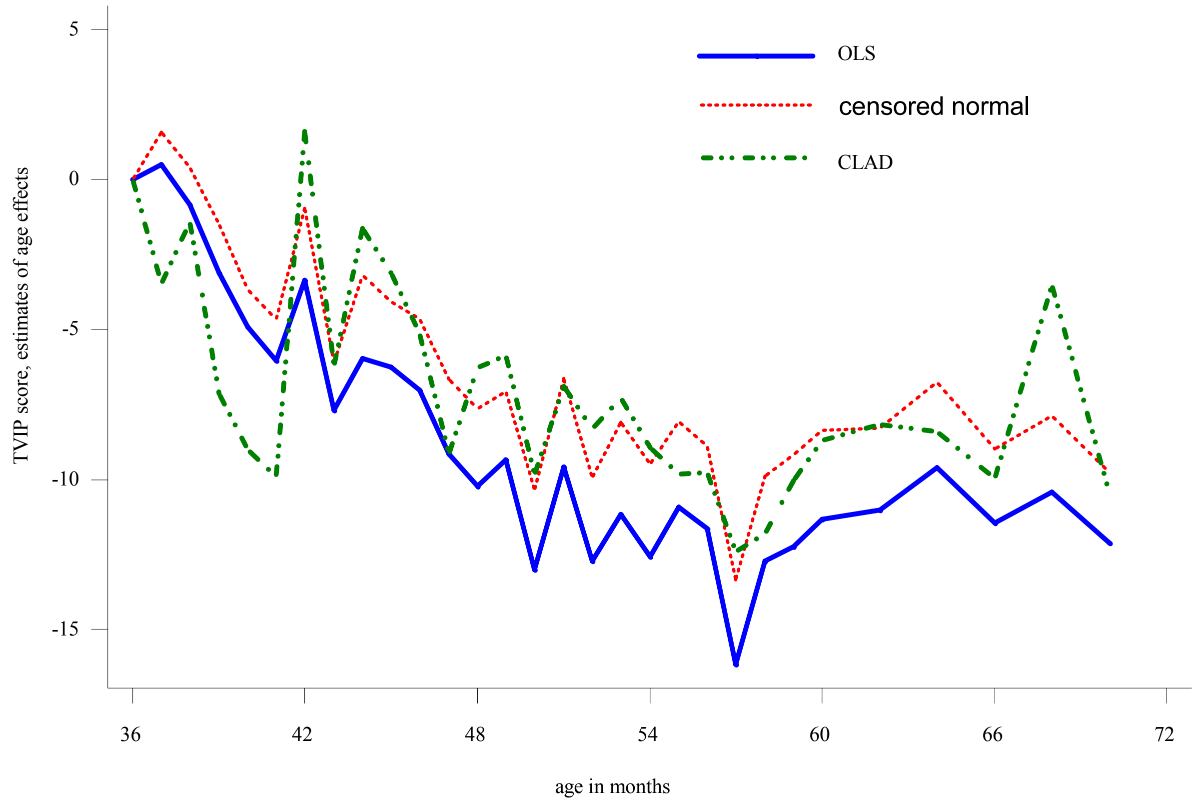

Figure 3: Age Effects in TVIP scores: OLS, censored normal, and CLAD models

Table 1: Comparison of the sample with national and parish-level averages

	Baseline Survey	1999 ECV	2001 Population census sampled parishes	
				No children age 6+
Mean household size	5.48	5.57	4.07	3.37
Number of rooms other than kitchen and bathroom	2.19	2.72	2.80	2.69
Fraction of households with piped water	0.72	0.77	0.69	0.74
Fraction of households with flush toilet	0.55	0.75	0.76	0.80
Fraction of households with dirt floor	0.13	0.14	0.10	0.07
Fraction of households with fridge or oven	0.44	0.52	n/a	n/a
Fraction of households with TV	0.73	0.82	n/a	n/a

Note: The column marked "1999 ECV" shows statistics for all households in the country with at least one child under the age of 6. The first column marked "2001 Population Census" shows statistics for all households in the sampled parishes with at least one child under the age of 6. The second column market "2001 Population Census" further excludes households with any children age 6 or older.

Table 2: Descriptive statistics (3,153 children ages 36 to 71 months)

	Mean	Standard Deviation	10th percentile	90th percentile
Standardized TVIP (M=100, SD=15)	86.4	17.1	65	110
Indicator: Standardized TVIP is censored	0.11	…	…	…
Child's age (months)	50.29	9.59	38	64
Indicator: Child is male	0.50	…	…	…
Household socioeconomic characteristics				
Wealth index	0.10	3.06	–3.85	4.26
Mother's years of education	7.89	3.53	4	12
Mother's age in years	25.54	6.33	20	33
Indicator: Father lives at home	0.71	…	...	…
Father's years of education	7.21	4.09	0	12
Number of adults in household	3.05	1.76	2	6
Indicator: Rural household	0.69	…	…	…
Child health measures				
Height-for-age *z*-score	–1.17	1.30	–2.70	0.33
Weight-for-height *z*-score	–0.17	1.24	–1.58	1.24
Hemoglobin level (elevation adjusted)	11.11	1.44	9.3	12.9
Months breastfed	5.67	3.30	1	12
Parenting measures				
Number of other children in household	1.44	1.33	0	3
HOME scale: parenting index (higher values represent harsher/less responsive parenting)	2.30	2.32	0	6
Indicator: Child is read to	0.27	…	…	…

Table 3: TVIP scores and household socio-demographic characteristics

Dependent Variable:	Indicator: TVIP score is censored	TVIP store			
	Probit	OLS Non-censored sample	OLS Full sample	censored normal	CLAD
Child is male	–0.017	–0.58	–0.20	–0.02	0.23
	(0.010)	(0.53)	(0.50)	(0.55)	(0.91)
Rural household	–0.010	3.02	3.03	3.00	2.93
	(0.011)	(0.59)	(0.56)	(0.61)	(1.05)
Wealth index	–0.017	1.92	2.02	2.24	2.72
	(0.002)	(0.11)	(0.10)	(0.11)	(0.20)
Mother's years of education	–0.008	0.69	0.73	0.82	0.92
	(0.002)	(0.09)	(0.09)	(0.10)	(0.17)
Mother's age in years	–0.0003	0.21	0.20	0.19	0.17
	(0.0009)	(0.04)	(0.04)	(0.05)	(0.08)
Father lives at home	–0.034	0.00	0.58	0.90	0.69
	(0.012)	(0.67)	(0.63)	(0.69)	(1.24)
Father's years of education	–0.0005	0.44	0.42	0.42	0.49
	(0.0017)	(0.09)	(0.09)	(0.10)	(0.17)
Number of adults in household	0.0013	–0.08	–0.07	–0.09	–0.14
	(0.003)	(0.16)	(0.15)	(0.16)	(0.24)
Observations	3153	2805	3153	3153	3153
Trimmed sample size					2628

Note: Numbers in parentheses are standard errors. All regressions include a set of indicators for months of age. CLAD estimates have bootstrapped standard errors, computed with 100 replications.

Table 4: TVIP scores and household socio-demographics, by age group

	Ages 36-53 months			Ages 54-71 months		
	OLS (full sample)	Censored normal	CLAD	OLS (full sample)	Censored normal	CLAD
Child is male	0.26	0.39	1.09	–1.08	–0.81	0.64
	(0.50)	(0.56)	(0.94)	(1.01)	(1.07)	(1.57)
Rural household	2.26	2.32	1.64	3.64	3.47	6.40
	(0.54)	(0.60)	(0.89)	(1.18)	(1.26)	(1.86)
Wealth index	1.40	1.58	1.52	2.99	3.24	3.50
	(0.10)	(0.12)	(0.20)	(0.20)	(0.22)	(0.34)
Mother's years of education	0.43	0.52	0.47	1.12	1.17	1.32
	(0.09)	(0.10)	(0.16)	(0.17)	(0.18)	(0.27)
Mother's age	0.16	0.15	0.05	0.267	0.27	0.21
	(0.05)	(0.05)	(0.07)	(0.07)	(0.08)	(0.12)
Father lives at home	0.29	0.55	1.06	0.35	0.73	0.03
	(0.63)	(0.70)	(1.09)	(1.24)	(1.31)	(2.25)
Father's years of education	0.32	0.32	0.51	0.55	0.54	0.47
	(0.09)	(0.10)	(0.14)	(0.18)	(0.19)	(0.27)
Number of adults in household	–0.16	–0.18	–0.19	0.06	0.04	–0.04
	(0.15)	(0.16)	(0.28)	(0.31)	(0.33)	(0.46)
Observations	1988	1988	1988	1165	1165	1165
Trimmed sample			1749			1122

Note: Numbers in parentheses are standard errors. All regressions include a set of indicators for months of age. CLAD estimates have bootstrapped standard errors, computed with 100 replications.

Table 5: TVIP scores, child health and parenting: CLAD estimates

	Full sample				Ages 36-53 months				Ages 54-71 months			
Wealth index	2.72	2.55	2.54	2.33	1.52	1.59	1.51	1.40	3.50	3.47	3.21	3.19
	(0.20)	(0.20)	(0.19)	(0.20)	(0.20)	(0.19)	(0.18)	(0.19)	(0.34)	(0.36)	(0.32)	(0.25)
Mother's years of education	0.92	0.85	0.73	0.63	0.47	0.38	0.29	0.23	1.32	1.29	0.99	0.93
	(0.17)	(0.16)	(0.15)	(0.16)	(0.16)	(0.12)	(0.14)	(0.13)	(0.27)	(0.26)	(0.28)	(0.21)
Father's years of education	0.49	0.44	0.37	0.35	0.51	0.37	0.34	0.31	0.47	0.26	0.38	0.21
	(0.17)	(0.15)	(0.15)	(0.15)	(0.14)	(0.15)	(0.13)	(0.14)	(0.27)	(0.27)	(0.22)	(0.26)
Height-for-age z-score		0.69		0.81		0.57		1.11		0.86		1.64
		(0.41)		(0.36)		(0.32)		(0.35)		(0.61)		(0.65)
Weight-for-height z-score		0.93		0.67		0.52		0.52		0.51		0.24
		(0.44)		(0.38)		(0.30)		(0.55)		(0.51)		(0.63)
Hemoglobin level		1.50		1.33		0.89		0.74		1.60		1.48
		(0.29)		(0.35)		(0.31)		(0.31)		(0.55)		(0.55)
Months breastfed		0.20		0.18		0.09		0.14		0.47		0.50
		(0.15)		(0.13)		(0.13)		(0.15)		(0.27)		(0.25)
Number of other children			–1.31	–1.20			–0.62	–0.63			–1.51	–0.86
			(0.47)	(0.44)			(0.36)	(0.33)			(0.81)	(0.60)
HOME score			–0.82	–0.82			–0.44	–0.54			–1.25	–1.04
			(0.24)	(0.24)			(0.20)	(0.18)			(0.43)	(0.35)
Indicator: Child is read to			4.76	4.10			3.83	3.79			5.77	5.58
			(0.98)	(1.04)			(0.94)	(0.94)			(1.94)	(1.58)
Health measures jointly insignificant		0.000		0.000		0.016		0.001		0.004		0.004
Parenting measures jointly insignificant			0.000	0.000			0.000	0.000			0.000	0.000
Observations	3153	3153	3153	3153	1988	1988	1988	1988	1165	1165	1165	1165
Trimmed sample	2631	2628	2574	2635	1749	1787	1773	1749	1122	1114	1107	1107

Note: Numbers in parentheses are bootstrapped standard errors, computed with 100 replications.. All regressions include: indicators for months of age; indicators of whether the child is male, the household is in a rural area, and the father lives at home; maternal age; and number of adults in household.