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Health and Schooling: Evidence and Policy Implications for Developing Countries

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Abstract—The direct interactions between health status and education have been neglected in both research and policy making. This paper exploits a unique panel data set to investigate the complementarities of health with school attainment and cognitive achievement. A series of anthropometric measures for individual students in rural Northeast Brazil are employed in educational performance models. The promotion models and value-added achievement models both demonstrate the importance of visual acuity of the student. The achievement models also highlight the role of good nutrition. While cost data are not available, a *prima facie* case can be made for a number of policy options. [*JEL* I2] ©1997 Elsevier Science Ltd

1. INTRODUCTION

HEALTH AND EDUCATION are typically viewed as distinct topics from both a research and a policy perspective. As a result, health research says much more about the health of preschool children and adults than the health of school-aged children (World Bank, 1993); and, not unexpected, health interventions are typically skewed toward the nonschool population. Similarly, education research says little about the educational consequences of poor health or nutrition; and, as Leslie and Jamison (1990) point out, "Educational planners have paid relatively little attention to children's health and nutritional status despite the everyday observations of many teachers and parents about the importance of ill health and malnutrition for absenteeism and inattention." This paper focuses on just such complementarities of health and school performance.

To the extent that research has considered the interaction of health and education it has been primarily concentrated on the study of how increased education leads to better health. This line of inquiry is essentially a branch of the study of adult schooling outcomes that has taken the perspective that improved health is another part of the return to schooling, similar to the conventional study of earnings. From the policy side, some attempts, particularly in the United States, have developed "integrated services" in schools where separate agencies delivering a variety of children's services are located within the school. This model, however, is based more on arguments of efficiency in delivery of services than on interest in the complementarities of different programs. In short, the production interactions of health and schooling have received little research or policy attention.

The independent treatment of health and education can lead to a variety of distortions. From a policy perspective, ignoring any complementarities between health and education moves policies toward underinvestment in the health of school-aged children and toward educational interventions that might be less efficient than health related investments. From a research perspective, educational analyses might be biased by neglecting key, but unmeasured, health and nutrition impacts.

Here, we pursue the nature and importance of complementarities between health and school performance of children. The empirical work relies upon a unique panel data set that includes information about both health and primary school performance of students in the rural parts of Northeast Brazil. The main empirical result is that nutritional and health status strongly affects both student grade attainment and student achievement. More specifically, vision impairment appears to be a barrier for learning as well for progression in school, and students with poor vision have higher probabilities of dropping out of primary school altogether. The student's short-term nutritional status also plays a important role in cognitive learning but does not appear to have the same strong influence on their grade attainment patterns.

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These findings have obvious policy relevance, suggesting that nutrition and health programs might be efficacious educational devices in addition to being important in pure health terms. While detailed consideration of costs and policy implementation are beyond the scope of this paper, it appears likely that a variety of low-cost screening and feeding programs might be appropriate.

The following section provides an overview of existing research and the difficulties of providing reliable information about health–education complementarities. After that, we provide direct empirical evidence about the effects of health and nutrition on both school attainment and school achievement.

2. SHORTCOMINGS OF EXISTING RESEARCH

Reviews of the educational consequences of nutritional and health status can be found in Leslie and Jamison (1990) and Lockheed and Verspoor (1991).[1] While documenting many general patterns, they also demonstrate the paucity of specific and generalizable results.[2] Most typically, inferences about health and nutrition effects come from combining the results of standard health inquiries (e.g. the effects of infectious diseases on sick days) with (reasonable) hypotheses about how the measured outcomes affect school attainment and cognitive learning. Thus, while suggestive, there is a shortage of direct investigations into educational outcomes of interest. Moock and Leslie (1986) and Jamison (1986) provide early exceptions in their investigations into how nutrition and health status affect grade attainment and achievement, but such modeling efforts have not been widely developed.[3]

The lack of direct research is explicable. Health studies and educational studies are both difficult to do because of the extensive (and expensive) data requirements. There is not an overabundance of either health or education studies that support policy making in developing countries. Combined, however, the difficulties multiply.

Educational analyses in developing countries, even ignoring health and nutrition issues, have faced a series of difficult analytical problems. The relevant dimensions of education are grade attainment and educational quality, and the analytical problems in each dimension have been important, if not fatal, in most past work. For example, investigation of promotion and drop-out behavior (which jointly determine grade attainment) has seldom provided appropriate evidence about the underlying causal determinants relevant for individual students (see Gomes-Neto and Hanushek, 1994). To ascertain the determinants of grade attainment, it is necessary to combine panel information about student progression through school with detailed information about the student's background and achievement. Such data have only rarely been available. Similarly, to investigate the determinants of student achievement or cognitive development the most appropriate modeling approach again calls for panel data in order to estimate models of achievement growth.[4] Analyses of education in developing countries have seldom had such data available, but without this type of data the analytical problems are truly enormous.

Layering the analysis of health issues on top of the general analysis of education implies data requirements that rarely have been met. Data on health status itself are very difficult and expensive to collect, ideally requiring expensive individual measurements and testing. Where available in the past, such data have not been found with suitable information about student characteristics and their school progression or achievement. The unique panel data used here allow a direct investigation of the complementarities of health and education—an issue which, while constantly described by policy makers as being important, has generally eluded researchers in the past. Individual student measurement of both measures of health and nutrition status were combined with data on student performance.

As discussed below, even with the superior data from the extensive panel data employed here, estimation and interpretive difficulties remain. Specifically, disentangling the causal influences of health status from general investment behavior of parents is difficult (see, for example, the discussion in Behrman and Lavy, 1995). Nonetheless, the models here provide direct evidence on potential health impacts and confirm general but untested presumptions of policy makers. They thus provide the basis both for refining further research and experimentation and for helping to guide policy development.

3. DATA BASE AND MODELS

During the 1980s, a unique set of surveys of students was conducted in three northeast states of Brazil—Piaui, Ceará and Pernambuco—as part of the evaluation of a major educational intervention program, EDURURAL. The EDURURAL program involved a broad attack at low achievement and high drop-out rates in rural areas. Both the intervention program and the accompanying evaluation project were unique.[5]

This work, however, is not directly related to the EDURURAL project evaluation. Instead, it utilized data collected for that project to investigate a series of fundamental educational relationships. The overall evaluation effort involved a series of surveys of students and primary schools in rural areas, but our efforts are concentrated on the special attempts to measure the health conditions of the student populations. The data collection relevant to health and nutrition was confined to the final phase of the eight-year survey effort. This special survey involved measurement of each student's health attributes, a very expensive undertaking. To compensate for the expense of the data collection, a targeted sampling of a more limited set of schools was used as contrasted to the earlier sampling that was designed to support more general analyses of educational efficiency.

The 1985 EDURURAL survey collected information about over 4000 second grade students in the three survey states. This information included data about them, their families, teachers and schools, along with their performance on specially constructed Portuguese and mathematics tests.[6] These tests, given near the end of the second grade, provide a baseline of the knowledge and cognitive abilities of students who were resampled in 1987 and who form the data base for this analysis.

In 1987 a specialized survey was conducted in Ceará schools. This survey was designed explicitly to be a panel of students, and only second grade students present in larger schools in the 1985 sample were targeted.[7] In 1985, 1516 second grade students in Ceará were surveyed; the 1987 design targeted 735 of these students, and 395 were found. For these analyses a few cases were dropped because of questionable data.[8] Table 1 summarizes the analytical sample.

The same tests given to second graders in 1985 were again given to the matched students in 1987, thus providing a measure of achievement that can be linked to the 1985 starting position of students. In addition, certain anthropometric and other health information about students was obtained. Evidence of the nutritional and health status of the students is derived from these data.

Better nutrition and improved overall health are expected to improve the academic performance of children. Several mechanisms drive this hypothesis. Past research demonstrates that malnourished children are less resistant to disease than their adequately nourished peers. Similarly, children with a variety of infectious diseases (such as parasites) will become malnourished. Whichever relationship governs the situation, because of greater absences from school, adversely affected students are likely to have more limited exposure to the learning opportunities of the school. Even in school, malnourished children are likely to have lower attention spans, energy levels, and motivation; all of these have negative impacts on mental development and ability to learn. Finally, children with a history of severe malnutrition from birth (or before) may have suffered lasting, even irremediable, brain lesions which impair ability to learn.[9]

Table 1. Sample counts for Ceará sample—1987

Counties	11
Schools	79
Students	
2nd grade	31
3rd grade	111
4th grade	212
Out of schools	24
Total	378

Each child's height, weight, age, and triceps skinfold thickness were measured and expressed as percentages of commonly used norms.[10] Chronic or persistent malnutrition, sometimes called stunting, is reflected in substandard height-for-age. Current or acute malnutrition, often termed wasting, is reflected in substandard weight-for-height; this indicator has the advantage of being independent of age, which may suffer from greater measurement error than the anthropometric characteristics. An alternative indicator of current nutritional status, more sensitive to sudden change in food intake, is triceps skinfold thickness-for-age. Weight-for-age is an overall indicator of nutritional status reflecting stunting, wasting, or both. Visual acuity, as measured using the Sneller Chart, was also obtained for each student. We hypothesize that students with uncorrected visual deficiency would be at a learning disadvantage.

Table 2 displays the overall picture. 15% of these students are stunted (below 90% of reference median height-for-age), 32% are severely malnourished (below 60% of the reference median skinfold thickness-for-age) and 45% have some visual deficiency.[11]

The table also points to one of the important aspects of Brazilian education. All students were attending the second grade in 1985, implying that, with normal age of entry and steady promotion, the aged distribution should be tightly bunched around ages 10 and 11. Yet, 40% of the students are older than age 14. While repetition is a generally important issue in Brazil, a central issue to be considered here is whether or not repetition is directly related to health status.

The focus of our analysis is what happens to students between 1985 and 1987. We are interested in how health status and other factors affect student performance. Health, family background, and individual characteristics are, however, thoroughly intertwined. Moreover, some factors such as individual ability are never satisfactorily measured. Therefore, an important task is separating the factors of interest from other influences, both measured and unmeasured.

In this analysis we concentrate on three measures of performance: drop-out probability, on-time promotion probability, and achievement in 1987. For the first two measures, we use observations about those who dropped out or about those who were promoted to infer how various factors affect the underlying probabilities. Dropouts are simply those who are no longer enrolled in school in 1987; promoted students are those found in the fourth grade in 1987 (having started in the second grade two years prior). Probit models are estimated to relate these outcomes to student characteristics and health status. The achievement measure is the sum of the students' Portuguese and mathematics test scores in 1987, and, as described below, the determinants are analyzed in value-added models of cognitive development.

Table 2. Descriptive statistics of the anthropometric indicators by age

Age in years	Number of cases	Below 90% NCHS median height-for-age (%)	Below 60% NCHS median skinfold thickness-for-age (%)	Some visual deficiency* (%)
9	6	0	33	33
10	9	0	56	56
11	27	4	26	52
12	58	19	36	36
13	69	12	30	49
14	56	16	25	43
15	63	14	37	45
16	45	13	22	39
17	32	28	38	56
18	13	23	38	46
Total	378	15	32	45

Note: *Eight observations are missing visual acuity data; percentages refer to complete observations.

For the regression models we use two groups of variables: a set of control variables and the anthropometric indicators. The control variables are students' characteristics and socioeconomic status, and the anthropometric variables are proxies for the students' nutritional and health status. To examine the general impact of nutritional and health status on grade pattern and achievement, we employed regression models designed to take advantage of the unique character of the 1985/1987 matched Ceará sample. By using the previous achievement and by accounting for the variation of probabilities of dropping out of schools in the estimated regression equations, we have set a quite stringent test of the independent impact of the health and nutritional variable.[12]

The measures of Portuguese and mathematics achievement were scored on specially-constructed criterion referenced tests. The *Fundação Carlos Chagas* (FCC), a leading Brazilian educational research organization, developed these tests in conjunction with educators in the northeast. They were designed to capture achievement of the curricular goals of the region's schools.[13]

The statistical analysis employs transformations of the three measures of the students' nutritional and health status previously described: visual acuity, height-for-age and skinfold thickness-for-age. To these was added the Sounis index, a measure designed to summarize the student's vital capacity. It is defined as *Height (cm) − [Weight (kg) + Thorax Circumference (cm)]*, and employs Brazilian norms which, according to Sounis (no date), provide well defined vital capacity levels. Here the Sounis index is used as a dummy variable, in which 1 means good vital capacity or better.[14] The visual acuity scores, measured using the Sneller Chart, range from 10 to 100% of expected visual acuity. Fifty-five percent of the students did not show any visual problem. An additional 24% of the students, while having some problems, got within 90% of normal visual acuity on this test. For this latter group, although they should see a doctor, visual problems were not yet serious enough to affect them in any activity. For analysis, we again aggregated across the top categories by creating a dummy variable, defined to equal 1 when the student was at or above 90% of normal. Height-for-age, our indicator of persistent malnutrition, is measured as the percentage of the students' height to the normal median height-for-age according to the National Center for Health Statistics (NCHS). Finally, the skinfold thickness-for-age, our indicator of current nutritional status, is compared to the normal median thickness-for-age according to Frisancho (1981) and converted into a dummy variable where 1 implies a skinfold thickness 60% or more of the standard.

The transformation of the anthropometric variables into categorical variables reflects an underlying concern about the accuracy and meaningfulness of the precise individual measures. Even though this study develops one of the most detailed pictures of child health available for poor rural children, the difficulties of measurement in these circumstances suggest the possibility of important measurement error. The aggregation of the anthropometric measures to broad categories, while potentially sacrificing some detail, lessens the impact of any measurement errors and concentrates attention on the large potential effects at the ends of the distribution.

These combined measures are designed to give a broad picture of each student's actual health status and lead to a distinct difference from most past studies which attempt to infer health from less satisfactory information. Table 3 has the descriptive statistics of the variables used here. While we return to individual characteristics and performance below, it is important to emphasize again that there is considerable variation in the health status of the sampled students. Only 15% are "good" or better in vital capacity, 21% have noticeable vision problems, and 32% show substantial nutritional problems.

One concern in the analysis of health and school performance is the possibility that families simul-

Table 3. Descriptive statistics for key variables ($N = 378$)

Variable	Mean	S.D.
Dropout	0.06	0.24
On-time promoted	0.56	0.50
1987 achievement	159.60	27.14
1985 achievement	128.84	36.37
Female	0.63	0.48
Age (yrs)	13.92	2.04
Student's motivation*	0.48	0.50
Years of father's education	1.32	1.79
Years of mother's education	2.10	2.25
Father is not farmer	0.14	0.35
Sounis index	0.15	0.35
Visual acuity†	0.79	0.40
Height-per-age	94.72	4.62
Skinfold thickness-per-age	0.68	0.47

Notes: *Motivation is a dummy variable = 1 if student wants to continue until grade 8 (in 1985); = 0 otherwise.
†Only 370 cases are available for the visual acuity measure.

taneously make investments in both the health and schooling of children and that these family inputs are imperfectly measured in the statistical models (see, for example, Behrman and Lavy, 1995). Unmeasured family inputs would then tend to be correlated with the health status of the student, implying in general that the independent effects of health status on scholastic performance would be overstated. This would result, for example, if a linear "taste for human capital" term affected both health and achievement directly. It could also happen if, for example, some of the health measures—such as corrected visual acuity—were merely proxies for poorly measured family income or other variables. On the other hand, in all of the statistical models, attention is concentrated on the performance in 1987 given achievement and school enrollment in 1985. This inclusion of prior achievement will lessen any potential problems by effectively including the impact of the level of family investments prior to 1985. In essence, the inclusion of prior achievement measures extracts any fixed components of family inputs, thus considerably lessening any concerns about simultaneity with health status. An alternative approach would be to find measures that might influence health status but be independent of the level of family investment. Such measures could be used in an instrumental variable approach to estimation. Finding such measures is generally quite difficult, however. Even such exogenous factors as the availability of health care facilities or differences in the cost of medical care presents difficulties, because families—by the same logic that leads to the initial concern—would be expected to modify their own investment in response to such attributes of the health care system. In any event, the Brazilian sample employed here offers little hope for developing suitable instruments for the estimation of health effects.

4. DROP-OUT AND ON-TIME PROMOTION PROBABILITIES

Many students in Brazil, especially in the rural northeast of Brazil, never finish the first four grades. High drop-out and high repetition rates combine to produce very low levels of school attainment in the Brazilian education system (see Gomes-Neto and Hanushek, 1994). While about 90% of the Brazilian population enters the first grade, only 56% go as far as the fifth grade. For the rural northeast of Brazil, these figures go from bad to catastrophic: 68% ever attend first grade, and only 29% persevere to the fifth grade. For the low-income population in this area, only 9% of the population ever enter the fifth grade.

A variety of factors interact to produce these educational outcomes. The rural parts of the northeast of Brazil are among the poorest in the world. Family survival in the agricultural areas places demands for work on children of all ages. Poor schools do not appear to the uneducated parent to provide a reasonable investment. In addition, there is the more direct feedback of the poverty on schooling that is investigated here. Anecdotal stories of hunger, especially among children, are reinforced by the data showing the tenuous situation with respect to students' nutritional and health status. There is, as indicated previously, some evidence that malnutrition can hurt student learning capacity, which clearly can lead to more repetition and dropouts. This section considers the independent effects of nutritional and health status on grade pattern and learning ability. Specifically, we examine the effect of the students' nutritional and health status on the drop-out and promotion probabilities. In both analyses we are concerned with separating the effects of health status from other influences, for which we employ multivariate probit techniques.

4.1. Drop-Out Probabilities

While the sample of dropouts is relatively small—24 students out of 378—it provides a virtually unique opportunity to investigate health influences. The simple question asked here is whether there are systematic differences between students who drop out and those who stay in school.

Before looking at the multivariate analysis, it is useful to understand the overall pattern of school attendance and health status. The percentage of dropouts in each group defined by the four anthropometric indicators is displayed in Table 4. Clearly, students in each lower health status category display a higher drop-out probability, with the largest discrepancy appearing in the case of visual acuity. The samples of dropouts are small, however, and there is the possibility of confusing differences caused by other factors with the anthropometric classifications.

The probit analysis, which is designed to separate students' characteristics from nutritional and health status, compare dropouts to those continuing in

Table 4. Percentage of dropouts by anthropometric category

	Percentage
The Sounis index	
Below good vital capacity	6.5
Good vital capacity or more	5.5
Visual acuity	
Below 90% of normal	14.5
90–100% of normal	4.4
Height-per-age	
Below 90% of normal	7.1
90% of normal or more	6.2
Skinfold thickness-per-age	
Below 60% of normal	7.5
60% of normal or more	5.8

school. Table 5 shows the estimates of the probit models along with estimates of marginal drop-out probabilities evaluated at the sample means.[15]

The main result is that students facing visual problems are more likely to drop out of school. At the sample means, students having less than 90% of normal visual acuity are 8.6% more likely to drop out of school than those without visual problem. Since the overall mean probability of dropping out is 6.5% (Table 3), this effect is substantial.

It is an interesting result that a student's previous achievement does not appear to affect the student's drop-out propensity.[16] Except for student's age, all other student characteristics are not statistically significant in the model. A year added to the student's age increases the drop-out probabilities by 2%. Motivation toward schooling, measured in 1985, is included to control partially for any heterogeneous family attitudes toward human capital investment.[17] While subject to concerns about endogeneity, its inclusion has little effect on the other parameter estimates. It does have the correct direction of effect but is statistically insignificant.

The results from this regression give us little general guidance about the other underlying factors affecting drop-out probabilities. Most of the (nonhealth) variables used in the model are not statistically significant at 5% level,[18] but our sample is missing key information relevant for school attendance. As we know from our prior research, the two most important general factors affecting school drop-out behavior are the opportunity costs of work outside of school and the existence of a school with advanced learning opportunities (see Gomes-Neto and Hanushek, 1994; Harbison and Hanushek, 1992).[19] While we have imperfect information about these general factors, we do not believe that this biases the results. We find little reason to believe that individual student health status is systematically related to the availability of local employment opportunities for the student or to the availability of advanced schooling.[20] Thus, we do not believe that the estimates of the independent effects of health status are affected by lack of this more general information.

4.2. On-Time Promotion Probabilities

We now turn to the probability that a student is promoted to the fourth grade, given that he or she stayed at school. Identification of grade level, which relies on teacher reports, has subjective aspects since the standards for grade level performance may vary across teachers and schools. While the subjective nature of promotion is common to schools around the world, it is more central here because individual classrooms frequently serve multiple grades simultaneously. Because the grade levels observed are effectively restricted to lie between grade 2 and grade 4 by the sampling design, assessments of grade levels for individual students probably underestimate true performance. On the other hand, grade levels are closely linked to independent performance measures in Portuguese and mathematics in both multiple grade and single grade classrooms, so teachers tend to make

Table 5. Probit estimates of drop-out behavior

	Coefficient	t-statistics	Marginal probability
1985 achievement	0.0004	0.126	0.0001
Female	−0.0438	−0.171	−0.0056
Age (yrs)	0.1675	2.567	0.0212
Student's motivation	−0.3136	−1.318	−0.0398
Father's education	−0.0124	−0.160	−0.0016
Mother's education	−0.1339	−1.845	−0.0170
Father is not farmer	−0.4137	−0.894	−0.0525
Sounis index	−0.2959	−0.852	−0.0375
Visual acuity	−0.6816	−2.778	−0.0865
Height-per-age	−0.0185	−0.629	−0.0023
Skinfold thickness-per-age	0.0811	0.317	0.0103
Constant	−0.3849	−0.459	
N	369		
Mean of the dependent variable	0.0650		
Log-likelihood	−73.845		

Table 6. Percentage promoted on-time by anthropometric category

	Mean percentage
Sounis index	
Below good vital capacity	58.8
Good vital capacity or more	65.3
Visual acuity	
Below 90% of normal	44.6
90–100% of normal	62.6
Height-per-age	
Below 90% or normal	57.7
90% of normal or more	60.3
Skinfold thickness-per-age	
Below 60% of normal	52.3
60% of normal or more	63.4

consistent performance decisions even in the absence of readily available test information (Harbison and Hanushek, 1992). None of the available information suggests significant biases in the investigation of promotions because of errors in grade identification.

Table 6 displays the overall pattern of promotion by health status. A total of 204 out of the sample of 345 students still in school (59%) was promoted to the fourth grade over the period. Looking at the percentage of students promoted on-time in each group defined by the four anthropometric indicators, we again note that students with better nutritional and health status are more likely to be promoted on-time. The largest discrepancy in mean promotion probabilities is again related to visual acuity, but other differences are also substantial.

To estimate the underlying effects on on-time promotion probabilities, we again use probit techniques. The estimates of the probit model, along with the calculated effects at the sample means, are shown in Table 7.

Of the anthropometric indicators, again, visual acuity is statistically significant (at the 5% level) and appears to be the most important health factor. All other things equal, those without a visual problem are 21 percentage points more likely to be promoted on-time. Combined with the previous finding of how vision affects a student's drop-out probability, the apparent importance of having routine eye examinations for all students is highlighted. While these results do not take costs into account, the dramatic effects on school attainment, coming from both drop-out and promotion behavior, suggest the distinct possibility of cost-effective approaches to the educational problems of the poor in this region.

The skinfold thickness-per-age, reflecting the effects of current nutrition, is the other significant anthropometric indicator. Although only significant at the 10% level, the estimates show that well-nourished students are on average 12% more likely to be promoted on-time. This finding provides some support for a school lunch program which is designed to improve directly the student's diet and nutrition. At the same time, Harbison and Hanushek (1992) found little direct effect of school lunches on promotion or achievement in their analysis of schooling in the same region for earlier years. It is not possible, however, to distinguish between insufficient nutritional effects of school meal programs and spurious effects, say through unmeasured family tastes for general investment in children. The remaining two anthropometric indicators have no statistically significant effect on promotion possibilities. This provides an interesting contrast with Moock and Leslie (1986) who highlighted the importance of height-for-age in determining school attendance and grade attainment.

The other student characteristics included are both plausible and supportive of previous findings about promotion probabilities (Gomes-Neto and Hanushek, 1994; Harbison and Hanushek, 1992). The most interesting part is the relationship between second grade test scores and promotion probabilities. Higher test scores consistently lead to greater promotion prob-

Table 7. Probit estimates of on-time promotion probabilities

	Coefficient	*t*-statistics	Marginal probability
1985 achievement	0.0156	6.738	0.0061
Female	0.0311	0.191	0.0121
Age (yrs)	−0.1589	−3.802	−0.0617
Student's motivation	0.2541	1.652	0.0987
Father's education	−0.0392	−0.894	−0.0152
Mother's education	0.0901	2.416	0.0350
Father is not farmer	0.1382	0.645	0.0537
Sounis index	0.1746	0.799	0.0678
Visual acuity	0.5521	2.835	0.2145
Height-per-age	−0.0225	−1.249	−0.0087
Skinfold thickness-per-age	0.3097	1.810	0.1203
Constant	1.5693	0.825	
N	345		
Mean of the dependent variable	0.5913		
Log-likelihood	−192.67		

abilities. In other words, factors that raise a student's achievement systematically lead to higher promotion probabilities. While this might not seem very startling in general, it has been the subject of some controversy given that there is no general examination system and given that there is wildly different school quality in the region.[21] Not surprisingly, after considering actual cognitive achievement, promotion probabilities dip with age. Education level of the student's mother is positively related to promotion probabilities, indicating the lasting, intergenerational impacts of educational attainment (cf. Lillard and Willis, 1994).

5. SCHOLASTIC ACHIEVEMENT

The final place where health can have its impact is the learning, or achievement, of the student. To address this issue, we estimate a standard value-added achievement model with multiple regression techniques. The general approach, described in detail elsewhere (Hanushek, 1979, 1986), is to look at achievement growth over a limited period of time. Thus, we look at achievement in 1987 as a function of achievement in 1985 and other intervening factors such as family and student's characteristics and, importantly for this investigation, the health status of the student.

The performance measure is the student's combined achievement in 1987, i.e. the sum of the student's Portuguese and mathematics scores in 1987.[22] The separate tests were intended to measure the percentage of the minimal second grade curricular requirements that the student had acquired. Thus, a student meeting the minimum in both mathematics and Portuguese would attain a score of 200. The mean of students' achievement in 1987 for each group defined by the four anthropometric categories is displayed in Table 8. It is clear that the average student, regardless of health status, is considerably below these minimum standards (of 200 points) that were devised *for the second grade*. Even though students have spent two years in school since being previously observed in the second grade, they on average achieve less than 80% of the expected second grade score.[23]

Table 8. Mean 1987 achievement by anthropometric category

	Mean
The Sounis index	
Below good vital capacity	160.37
Good vital capacity or more	164.37
Visual acuity	
Below 90% of normal	154.69
90–100% of normal	163.09
Height-per-age	
Below 90% of normal	158.75
90% of normal or more	161.26
Skinfold thickness-per-age	
Below 60% of normal	157.35
60% of normal or more	162.51

Again the student's nutritional and health status appears to affect the student's performance. For all anthropometric indicators, raw performance is higher for students with better nutritional and health status. Well-nourished students and those without visual problems do especially better than those with problems.

Now we turn to the estimated independent effects of health status provided by the value-added achievement models. We report in Table 9 on the three variants of estimation of this model. The first one includes only the student's characteristics and ignores the health status measures. The second variant includes all of the explanatory variables including health characteristics. The final variant corrects for bias that might result from using the sample of just students who remained in school.

In all the estimated regressions, previous achievement, age, and student's motivation appear to influence 1985 achievement. Higher achievement in previous years leads to better current achievement. Not surprisingly, holding constant earlier performance of the student, achievement diminishes with age and increases with motivation. The other variables (sex, father and mother's education, and father's occupation) do not appear to have a strong effect on student achievement, although there is an indication that females may do somewhat worse than males.

The second variant demonstrates that health status has an important effect on achievement. Again visual acuity stands out as the most important variable health related factor influencing student achievement. Good vision on average accounts for 8 points of student achievement growth over the two years, a time when the average performance increase is 30 points. Combined with the two previous results about attainment, this new finding underscores the importance of visual acuity. In all the three models (drop-out probability, on-time promotion probability, and achievement), students not suffering serious visual problems are shown to be much better off.

The proxy for the current nutritional status of the students, skinfold thickness-for-age, also shows a statistically significant impact on achievement. A current nutritional status placing the student within 60% of normal on skinfold thickness is worth almost 6 points in achievement growth (compared to those who are more deficient). This again provides support for a school lunch program designed to improve current nutrition, although with the previous caution about lack of observed direct effects of lunch programs in Harbison and Hanushek (1992). The other two anthropometric indicators (the Sounis index, and the height-per-age) are not statistically significant.

Finally, other variants of the estimation were considered. The final columns in Table 9 adjust for sample peculiarities. Specifically, since children drop out of school as time goes on, the models estimated for only children who stayed in school could be biased by nonrandomness of the sample. Therefore, we also

Table 9. Achievement models

	Only students' characteristics		All variables		With sample selection	
	Coefficient	*t*-statistics	Coefficient	*t*-statistics	Coefficient	*t*-statistics
1985 achievement	0.319	9.24	0.326	9.43	0.325	9.31
Female	−4.361	−1.72	−3.801	−1.45	−3.955	−1.49
Age (yrs)	−2.712	−4.30	−2.792	−4.19	−2.378	−2.39
Student's motivation	7.974	3.21	7.978	3.25	7.210	2.54
Father's education	−0.556	−0.77	−0.330	−0.46	−0.330	−0.46
Mother's education	−0.270	−0.47	−0.303	−0.53	−0.562	−0.76
Father is not farmer	0.764	0.22	0.075	0.02	−0.693	−0.19
Sounis index			3.501	0.98	2.673	0.69
Visual acuity			8.066	2.56	6.066	1.27
Height-per-age			−0.014	−0.05	−0.036	−0.12
Skinfold thickness-per-age			5.746	2.07	5.881	2.09
Lambda*					13.941	0.57
Constant	157.707	15.57	147.826	4.86	148.674	4.83
N	345		345		345	
R^2		0.237		0.272		0.273
Adjusted R^2		0.221		0.248		0.247
F statistics		14.977		11.320		10.381

Note: *The inverse Mill's ratio from drop-out probability model in Table 5 used to correct for sample selection.

estimated a regression including sample selection probabilities (derived from Table 5). As shown, the sample selection correction (labeled lambda in the table) has no effect. This estimation is not entirely persuasive, however, because identification comes essentially from the functional form of the probit models. Further, because so few drop out from the sample, concern about selection biases is not very great—implying that attention should be directed at the second column.

Alternative estimates (not shown) investigated whether or not the effects of health status varied by achievement level. In particular, since low achieving students may find the impact of poor health even greater than high achievers, the models were reestimated separately for students below the mean and for students above the mean in 1985 performance. These estimates did not provide qualitatively different estimates of the effects of health status (although there was mild support of the hypothesis of differential impact on low achievers).

6. CONCLUSIONS

The main conclusion is that a student's nutritional and health status affects both expected attainment and performance in school. While school policy makers have long suspected such a relationship, there has been little previously available evidence either confirming it or indicating the magnitude of any effects.

Perhaps the most startling conclusion is the importance of visual acuity in the schooling of children. Poor vision systematically leads to higher drop-out rates, to more grade repetition, and to lower achievement. The pervasiveness and strength of this finding suggests a new focus for policy. This work has not considered the costs of testing or correcting visual problems. Nonetheless, the importance of this to the schooling of children suggests that programs in this area are likely to be very productive. Routine provision of eye examinations—for example, through simple eye chart testing by teachers—could identify where problems were important at a very low cost. While any programs for correction of problems would need further analysis, this should unquestionably be an important concern for policy makers. The prevalence of visual problems combined with substantial impacts on both grade attainment and achievement suggest that this should be a priority consideration.

The results also provide some direct support for school feeding programs. While some type of school feeding program is quite common in this area (and in other poor regions of the world), the justification frequently comes through its hypothesized effect on attendance.[24] In other words, by promising a meal to students, students can be "bribed" to attend school. The evidence here is different. It suggests that well-nourished children indeed learn more. Therefore, to the extent that the school feeding program improves student nutrition, there is a direct effect on both progress through school and on achievement.

The results presented here are not conclusive and may not be fully generalizable. They rely on relatively small samples of students in a particularly poor environment. They also rely on a limited set of health measures (even though the measures go far beyond other commonly observed health factors). The results suggest considerable potential for policies operating on the intersection between health and schooling of students, but they need to be confirmed in other settings. The concerns about endogeneity of health outcomes that have been raised elsewhere suggest added caution even if prior investigations have found it difficult to identify satisfactorily the impact of such a possibility.

Further, the precise policies that might be employed to address the problems need development, including the careful consideration of the costs of alternatives. Because of the analytical questions and of uncertainties about optimal policy design, the use of random-assignment experimentation appears especially appropriate in this situation. (For a similar argument in the developed country context, see Hanushek *et al.*, 1994.)

Policy has proceeded, but it has not been fully informed by evidence. For example, suspecting health–schooling linkages, Brazil has a school lunch program as one of the main policies in public schools. Yet there is little evidence on the effects of such a program, on its costs, or on its efficacy compared to alternative approaches. The results here suggest much more consideration for such programs and for policy expansions such as entering more actively into the diagnosis and correction of vision problems.

NOTES

1. The review and synthesis in Leslie and Jamison (1990) and Jamison and Leslie (1990) are designed to push health issues to the forefront of educational planning considerations. An attempt to study cost-effectiveness of school-based interventions to enhance students' nutritional and health status is made in Jamison and Leslie (1990). Although their study lacks precise information on the cost of such interventions, they conclude that it is almost certainly cost-effective to implement some simple policies (for example, teachers could be trained to screen visual or hearing problems among their students).
2. While more limited, there are also a few studies specifically for Brazil (see Victora *et al.*, 1982; Colares, 1986).
3. See also Balderston *et al.* (1981), Sabogal *et al.* (1981), and Popkin and Lin-Ybanez (1982).
4. See Harbison and Hanushek (1992) for a detailed discussion of the effects of alternative model specifications and estimation approaches.
5. For more information about the EDURURAL project, see Armitage *et al.* (1986), and Harbison and Hanushek (1992). The program involved a broad-based attempt to improve rural schools through provision, as needed, of such things as books and writing materials, teacher training, curricular guidance and the like. The evaluation effort included both schools covered by the project and schools outside of the project. It is this general data set that is employed. In this work, there is no specific attempt to evaluate the program efficacy; for that, see Harbison and Hanushek (1992).
6. The tests were constructed by the Carlos Chagas Foundation and were designed to measure key elements of the second grade curriculum employed in the northeast region. These tests were constructed for the project because no suitable tests for this rural population previously existed.
7. The survey design was as follows: (1) 11 counties out of 20 previously sampled counties in Ceará were visited; (2) only schools with more than 5 second grade students sampled in 1985 were visited; (3) all students [identified in (1) and (2), above] who could be located in 1987 were sampled, regardless of whether they were in second, third or fourth grade or even out of school.
8. The largest reason for sample attrition (24%) was students moving away from their second grade school, thus precluding their being tested or conducting anthropometric measurement. While there were substantial sample losses, direct analysis does not suggest significant biases are introduced (Harbison and Hanushek, 1992). Seventeen observed cases were dropped. Only students 18-yrs-old or younger were kept. Further, because of concern about the accuracy of student matching, those who showed either very low achievement in 1985 and very high achievement in 1987 or, conversely, very high achievement in 1985 and very low achievement in 1987 were dropped.
9. For reviews of evidence on the relation between malnutrition and mental development, see World Bank (1993).
10. Special measuring devices for height, weight, and skinfold thickness were supplied to the teams of interviewers, who were trained specifically in their use. The norms are the median values for a large population of U.S. children surveyed for the purposes of developing standards by the U.S. National Center for Health Statistics (NCHS). Separate norms are used for males and females.
11. Norms were based on the U.S. National Center for Health Statistics standards.
12. We could not use schools' characteristics in the models since information about schools as well about teachers in 1987 is not available. Note, however, that these omissions are a serious problem only if changes in school inputs are correlated with the health status of the individual students after conditioning on individual achievement in 1985. We have no reason to believe that there is any particular pattern to input changes that would suggest a particular direction of bias in the estimated effects of health factors.
13. The FCC constructed several parallel forms of its basic criterion referenced test, and these alternate versions were applied in different years of the overall project. This analysis, however, relies on the same form used in both 1985 and 1987. The test construction involved extensive research into content validation by specialists in tests and measurement. An analysis of both content and item validity is found in Harbison and Hanushek (1992).
14. Vital capacity usually refers directly to lung capacity, and the anthropometric measures here are aggregated to proxy this. Sounis (no date) defines seven distinct categories: bad, very weak, weak, fair, good, strong, and very strong. Because of concern about the precision of these, we aggregate into the dichotomous measure.
15. The probit models provide nonlinear estimates of how the various explanatory variables affect drop-out probabilities. Here we evaluate the probit function at the means for each of the variables. In this estimation, nine observations from the analytical sample had to be eliminated from the analytical samples because of missing data. These arose primarily because of inability to give the eye examination at one school where the light was too low.
16. A simple investment model with Ben-Porath neutrality (Ben-Porath, 1970) provides ambiguous predictions about the effects of early achievement, depending in part on how early achievement is inter-

preted. If human capital is equally productive in producing further human capital in the market, one might expect small effects of measured achievement on the choice of quantity of schooling attained. Nevertheless, given the young ages where any work is almost certainly manual labor, achievement would seem to have higher pay-offs in school than at work. Additionally, it is necessary to separate human capital skills and innate ability in the Ben-Porath model.

17. Motivation is a categorical variable which equals 1 if the student expressed a desire in the early sample (1985) to remain in school until at least the eighth grade and equals 0 otherwise.
18. As we know from our prior research (see Gomes-Neto and Hanushek, 1994; Harbison and Hanushek, 1992) information on provision of school (with advanced grades) is very important for such models. Unfortunately, we also lack this information.
19. The sampling design employed here collected data only in places where a fourth grade was known to exist. The other analysis considers the more general situation that school went out of existence between sample years, a factor having obvious implications for individual schooling decisions. The previous work attempted to assess the strength of the local economy to measure the pull of alternative employment, but that could not be done here.
20. We have information about whether or not the student's father is in farming (which has a negligible effect on dropping out), but we lack information about the overall viability of the local economy.
21. The analysis in Harbison and Hanushek (1992) exploits this general finding in the context of the costs of providing alternative quality improving programs. This stands in contrast to alternative ways of dealing with grade repetition through mandatory promotion and the like.
22. While the achievement models could have been estimated separately for mathematics and Portuguese performance, there seemed to be little cost in simplifying the estimation of the achievement component by aggregating across dimensions.
23. The estimates here all apply only to those students still in school. "Expected" score refers to the judgments of the educators who devised the tests specifically for the rural northeast region.
24. Such policies are widely pursued in developing countries and even in more advanced countries such as the United States. The arguments for them, however, are seldom based on any direct evidence. The arguments also include other (equally untested) ideas such as that school lunch programs offer an inducement to students to attend school regularly.

REFERENCES

Armitage, J., Gomes-Neto, J. B., Harbison, R. W., Holsinger, D. B. and Leite, R. H. (1986) *School Quality and Achievement in Rural Brazil.* World Bank, Washington, DC.

Balderston, J. B., Wilson, A. B., Freire, M. E. and Simonen, M. S. (1981) *Malnourished Children of the Rural Poor: The Web of Food, Health, Education, Fertility, and Agricultural Production.* Auburn House, Boston, MA.

Behrman, J. R. and Lavy, V. (1995) Production functions, input allocations and unobservables: The case of child health and schooling success. (Mimeo).

Ben-Porath, Y. (1970) The production of human capital over time. In *Education, Income and Human Capital*, ed. W. L. Hansen, pp. 129–147. National Bureau of Economic Research, New York.

Colares, C. A. L. (1986) Programa de merenda escolar. *Cadernos Cedes* **4**, 48–54.

Frisancho, A. R. (1981) New norms of upper limb fat and muscle areas for assessment of nutritional status. *American Journal of Clinical Nutrition* **34**, 2540–2545.

Gomes-Neto, J. B. and Hanushek, E. A. (1994) Causes and consequences of grade repetition: Evidence from Brazil. *Economic Development and Cultural Change* **43**, 117–148.

Hanushek, E. A. (1979) Conceptual and empirical issues in the estimation of educational production functions. *Journal of Human Resources* **14**, 351–388.

Hanushek, E. A. (1986) The economics of schooling: Production and efficiency in public schools. *Journal of Economic Literature* **24**, 1141–1177.

Hanushek, E. A., Benson, C. S., Freeman, R. B., Jamison, D. T., Levin, H. M., Maynard, R. A., Murnane, R. J., Rivkin, S. G., Sabot, R. H., Solmon, L. C., Summers, A. A., Welch, F. and Wolfe, B. L. (1994) *Making Schools Work: Improving Performance and Controlling Costs.* Brookings Institution, Washington, DC.

Harbison, R. W. and Hanushek, E. A. (1992) *Educational Performance of the Poor: Lessons from Rural Northeast Brazil.* Oxford University Press, New York.

Jamison, D. T. (1986) Child malnutrition and school performance in China. *Journal of Development Economics* **20**, 299–309.

Jamison, D. T. and Leslie, J. (1990) Health and nutrition considerations in education planning: 2. The cost and effectiveness of school-based interventions. *Food and Nutrition Bulletin* **12**, 204–214.

Leslie, J. and Jamison, D. T. (1990) Health and nutrition considerations in education planning: 1. Educational consequences of health problems among school-age children. *Food and Nutrition Bulletin* **12**, 191–204.

Lillard, L. A. and Willis, R. J. (1994) Intergenerational educational mobility: Effects of family and state in Malaysia. *Journal of Human Resources* **24**, 1126–1166.

Lockheed, M. E. and Verspoor, A. (1991) *Improving Primary Education in Developing Countries.* Oxford University Press, New York.

Moock, P. R. and Leslie, J. (1986) Childhood malnutrition and schooling in the Terai region of Nepal. *Journal of Development Economics* **20**, 33–52.

Popkin, B. M. and Lin-Ybanez, M. (1982) Nutrition and school achievement. *Social Science and Medicine* **16**, 53–61.

Sabogal, C. G., Molina, S. and MacVean, R. (1981) Variables educativas, socioeconomicas y de crecimi-

ento fisico del nino, en relacion con el rendimento intelectual y la lectura. *Latinoamericana de Psicologia* **13**, 433–445.
Sounis, E. (no date). Manual de higiene e medicina do trabalho. (Mimeo) Brazil.
Victora, C. G., Estanislau, J. S. D. and Da Costa, J. S. D. (1982) Estado nutritional e rendimento escolar. *Jornal de Pediatria* **52**, 115–117.
World Bank (1993) *World Development Report 1993: Investing in Health.* Oxford University Press, New York.