E C O N O M I C S   B U L L E T I N

# The impact of child health status on learning ability and school entrance age

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## *Abstract*

A growing number of papers demonstrate that child health/nutritional status is likely to affect learning ability. Provided that both cognitive development and the capacity to respond to educational stimuli also depend on age, parents might rationally choose to postpone school entrance age of unhealthy children in order to increase their probability of success at school. This note explores this channel of influence, through which a child initial health stock affects school entrance age. To this end, a simple theoretical model is presented here in order to offer a rationale for school postponement, and new empirical evidence is provided for supporting the main conclusion. The empirical analysis carried out, which uses data from a Brazilian household survey, shows that improved health has a negative impact on entrance age. In other words, it is shown that healthier children enter the school earlier.

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## 1. Introduction

The age at which children enter school is likely to influence school performance (e.g. Langer, Kalk and Searls, 1984; Bisanz, Dunn and Morrison, 1995; Datar, 2006). Datar (2006), for instance, estimates the effect of delaying kindergarten entrance on children's academic achievement, and conclude that a one-year delay significantly boosts test scores and implies a steeper test score trajectory during the first two years. This result is consistent with findings of child development researchers, who have argued that children's "readiness" is a key factor that determines school performance. However, the definition of "readiness" is somewhat ambiguous and difficult to measure. In this paper, we relate this concept to child nutritional status, and it is shown that poor nutritional levels result in postponed school entrance.

Child ability to learn depends on a number of individual characteristics, from genetics to health status and intellectual development, as well as family and environmental factors. Aylward et al. (1989), Martorell (1995), Grantham-McGregor et al. (1999), the Micronutrient Initiative and United Nations' Children's Fund (2004), Miguel (2005) and Alderman et al. (2006), among others, find a positive correlation between health status and cognitive capacity. Aylward et al. (1989), for instance, review 80 studies on the consequences of low birth-weight and conclude that IQ tends to be higher in children who were heavier at birth. In addition, neurological, behavioural and intellectual impairments at school age have been observed in children who were born low birth-weight (e.g. Hille et al., 1994; Hille et al., 2001; Saigal et al., 2003). Unfavourable health/nutritional status, therefore, may delay intellectual child development and hence, a child's capacity to respond to educational *stimuli*. When unfavourable health status results in delayed cognitive development, parents might rationally postpone school entrance of children in order to increase the probability of academic success.

Some researchers have analysed the effect of poor health on school absenteeism and school entrance age. Glewwe et al. (2001), for instance, estimate the impact of nutrition on learning using a longitudinal dataset collected in Cebu, Philippines over a period of 12 years, and they find that improved child nutrition raises academic achievements; increases in test scores are partially due to the fact that well-nourished children enter the school earlier, while the rest arises from a direct impact on learning productivity. Alderman et al. (2006), using longitudinal data from rural Zimbabwe, show that improved health (measured as height-for-age) during early childhood results in increased height as young adult, higher educational attainment, and an earlier age of school entrance. This paper explains the negative relationship between improved nutritional status and entrance age by means of a parents' rational decision making approach, and new empirical evidence is provided in order to support the main conclusions.

The rest of the paper is organized as follows. Section 2 presents the basic theoretical model, which is aimed at explaining the rationale behind the negative correlation between health/nutritional status and entrance age. Section 3 provides empirical evidence in favour of the theoretical results. Main conclusions are summarized in Section 4.

## 2. The basic model

A representative parent has to decide the age at which her child will enter school. For the sake of simplicity, it is assumed that the parent is only worried about child "readiness", $R$, which determines the probability of success during the first year of schooling, and the cost of education, $C$, which is equal to the cost of not working, excluding thus direct costs. Focusing only on the first school year simplifies the analysis, but it does not affect main conclusions. For instance, it might be considered that school achievement during the first year is an indicator of the subsequent academic performance. Child readiness depends on child health/nutritional status $(H)$, age $(age)$, other individual characteristics $(Z)$, and family or environmental conditions $(F)$,

$$R = f(H, age, Z, F),\ \ R_H^{'} > 0,\ \ R_{age}^{'} > 0 \tag{1}$$

Child "readiness" affects the probability of completing the first school year with success and hence, it influences the expected level of human capital that a child is able to accumulate during that period. Enhanced capacity to face a school year results then in improved performance and higher expected monetary benefit. It is assumed that altruistic parents care about child human capital accumulation and future income or, equivalently in the model considered here, that they simply enjoy having their child as ready as possible for school. Thus, child readiness positively affects parents' utility $U$, where $U_R^{'} > 0$ and $U_R^{''} < 0$.

Schooling also implies a cost $C$, which is equal to the potential remuneration of child labour. It is assumed that very young children (i.e. $age < \underline{age},\ \underline{age} > 0$) are not able (or not allowed) to work and thus,

$$age < \underline{age} \Rightarrow C = 0\,. \tag{2}$$

When $age$ is above $\underline{age}$ however, the remuneration of child labour increases with $age$ due to enhanced working capacity, for example,

$$C = h(age),\ \ C_{age}^{'} \geq 0, \tag{3}$$

It should be observed that parents decide if and when their children have to accumulate human capital and hence, assuming that the opportunity cost $C$ only depends on $age$ as in (3) is not an especially restricting hypothesis: when individuals do not accumulate human capital, their wage is likely to increase with experience only. The opportunity cost of schooling has a negative impact on parents' utility, $U_C^{'} < 0,$ provided that children may contribute to increase family budget, for example.

Hence, focusing only on school entrance age, parents choose the level of $age$ in order to maximize their utility,

$$\underset{age}{Max}\left[U = u(R, C)\right], \tag{4}$$

where $U$ is continuous in each factor.

**Assumption 1.**

$$\lim_{age \to 0} \left( \frac{dR}{dage} \right) > 0, \tag{A1}$$

A1 states that child ability to learn (cognitive development) increases with age since the very beginning of life.

**Assumption 2.**

$$\lim_{age \to \overline{age}} \frac{dR}{dage} < 0 \leq \lim_{age \to \overline{age}} \frac{dC}{dage}, \tag{A2}$$

where $\overline{age}$ represents a theoretical maximum length of human life.

From A2 follows that there is a level of individual age starting from which time has a negative effect on "readiness" and the expected benefits of schooling. That is, the ability to face the educational process decreases starting from a certain age. In addition, A2 states that the opportunity cost of schooling is non-decreasing in age.

The following proposition summarizes the result of the parent's maximization problem (4).

**Proposition 1 (Existence and uniqueness of the optimal school entrance age)**. Under A1 and A2, there exists a unique level of individual age, $age^* = age(H, F, Z)$, which maximizes parents' utility.

***Proof.*** Under A1 and provided that $C = 0$ for $age < \underline{age}$, $\lim_{age \to 0} \Omega \equiv \frac{dU}{dage} > 0$; under A2, $\lim_{age \to \overline{age}} \Omega < 0$. Hence, $\Omega$ takes positive values for $age \to 0$ and negative values for $age \to \overline{age}$. Since $U$ is continuous in $age$, $\Omega = 0$ for a unique value of $age$, $age^*$. Moreover, the slope of $\Omega$ ensures that the level $age^* \big| \Omega = 0$ is a maximum of the objective function.

■

The simple maximization problem presented above provides a rationale for delaying entrance age, which is consistent with the literature presented in the introduction. In particular, parents postpone school entrance in order to increase child readiness and child ability to face schooling. However, postponement has a cost (expressed here as the opportunity cost of schooling, which increases with age) and hence, it is not optimal to delay school entrance indefinitely. Proposition 1 implies an interesting corollary to our end, which is concerned with the effects of child health on the optimal school entrance age.

**Corollary 1 (Effect of improved health on entrance age).** The optimal age of school entrance decreases with child health/nutritional status.

In fact, it should be noted that $age^*$ is defined by the first order condition $\Omega = 0$; see Proposition 1. Provided that $\Omega = \frac{\partial U}{\partial R}\cdot\frac{dR}{dage} - \frac{dC}{dage}$ and $\frac{d^2U}{dR^2} < 0$, improved health, which boosts child readiness, results in a lower level of $\Omega$ for each value of $age$. Therefore,

$$age^* = age(H, F, Z),\ \frac{dage}{dH} < 0. \tag{5}$$

By linearizing (8) we obtain the equation that will be estimated in the empirical exercise,

$$age_i^* = \alpha + \beta H_i + \gamma Z_i + \delta F_i + \varepsilon_i\,, \tag{6}$$

where $age_i^*$ is the age of school entrance of individual $i$, which is supposed to be the optimal entrance age and $\varepsilon_i$ is the error term. Consistently with the theoretical conclusions, we expect the sign of $\beta$ to be negative. Provided that the health proxy in (6) is likely to be correlated with the error term because child health and educational investments might reflect related household decisions regarding investments in children's human capital, the model will be estimated by 2SLS (e.g. Beherman, 1996). The empirical analysis also considers two binary variables related to $age^*$, which are aimed at analysing the impact of health status on the probability of beginning school either early (i.e. entrance age below the median entrance age) or late (i.e. entrance age above the median). The same problem of endogeneity mentioned above arises when estimating the probit model and hence, instrumental variables have been used in the second exercise, too.

## 3. Empirical analysis

The analysis makes use of data from a Brazilian survey, the Living Standards Measurement Survey (Pesquisa sobre Padrões de Vida - PPV), a household survey conducted by the Brazilian Institute of Geography and Statistics in association with the World Bank (IBGE, 2003). The survey collected data from 19,409 individuals in 4,800 households that were representative of the northeast and southeast regions of Brazil.[1] The Brazilian dataset being considered includes a very heterogeneous population in terms of health status, income and socio-economic conditions. In particular, about 25% of children suffer from the consequences of poor nutrition (measured as low BMI-for-age, for example), which is an interesting characteristic in order to analyse its impact on entrance age. In addition, the Gini index for income per capita is about 0.56, underlining a soaring level of inequality.

In order to obtain a useful dataset in our purpose, individuals of the same family have been linked using children as reference point. As a result, a total number of 4187 children have been extracted from the original dataset, in which full information about parents is available for each child. In other words, the 4187 observations used in the analysis include children that have been surveyed and whose parents have been surveyed, too.

[1] The metropolitan regions of Recife and Salvador, the rest of the urban area of the northeast, the rest of the rural area of the northeast, metropolitan regions of Belo Horizonte, Rio de Janeiro and Sao Paulo, the rest of the urban area of the southeast and the rest of the rural area of the southeast.

*Variables*

Variables used in the empirical analysis and main descriptive statistics are presented in Table 1. The dependent variable being considered is the age of school entry, AGE. It should be noted that considering a developing country has the advantage of a greater variability in entrance age, provided that the enforcement of compulsory entrance age is weak. In addition, pre-mandatory education has been taken into account and hence, AGE measures individual age at the very first approach to schooling. In addition, binary variables related to AGE have been constructed in order to distinguish individuals who started school either early (E-ENT) or at later ages (L-ENT).

Health status has been measured by objective indicators related to nutritional status, namely BMI-for-age and weight-for-age (WFA). BMI-for-age is defined as the ratio between individual BMI and the median BMI of the age and sex group (2007 WHO standards). Provided that WHO standards are referred to individuals aged up to 20 years, the sample is restricted to this group of children when the health proxy being considered is BMI-for-age. WFA is defined as the ratio between individual weight (in kilograms) and the median weight of the age and sex in the sample. Parents' health is measured by individual BMI. Other individual characteristics used in the analysis are individual age (YEARS) and sex (MALE). Parents' education (EDUM, EDUF), family income (LOGFI) and geographical localization (NORTH, URBAN) characterize the household.

**Table 1. Variables and sample means**

| Variable | Description | Mean (sd) |
|---|---|---|
| **BMI-for-age** | BMI for median BMI of the age and Sex group (2007 WHO standards) | 1.015 (.175) |
| **WFA** | Weight for median weight of the age and sex group | 1.041 (.225) |
| **YEARS** | Age (completed years) | 14.635 (7.204) |
| **MALE** | 1 = if the individual is male; 0 = otherwise | 53.37% |
| **AGE** | Entrance age at school | 5.248 (1.632) |
| **E-ENT** | 1 = if AGE below than median AGE; 0 = otherwise | 31.76% |
| **L-ENT** | 1 = if AGE above median AGE; 0 = otherwise | 46.38% |
| **EDUM** | Completed school years - mother | 7.574 (4.687) |
| **EDUF** | Completed school years - father | 7.595 (5.144) |
| **BMIM** | BMI - mother | 25.205 (4.879) |
| **BMIF** | BMI - father | 24.883 (3.887) |
| **LOGFI** | Log of family income | 7.077 (1.029) |
| **URBAN** | 1 = if the individual lives in a urban area; 0 = otherwise. | 80.70% |
| **NORTH** | 1 = if the individual lives in the North-East area; 0 = otherwise | 51.44% |

### *Estimates and results*

Columns 1 and 2 of Table 2 present the results of the estimation of model (9); columns 3 and 4 consider a model in which the dependent variable is E-ENT, whereas in the last two columns the dependent variable is L-ENT. Regarding methodology, it should be noted that exogeneity tests point at the endogeneity of the health proxies and thus, instrumental variables have been used in all situations. On considering the dependent variable AGE, it can be observed that the coefficients of both health proxies are negative and significantly different from zero. In other words, children endowed with favourable health status begin school at lower ages, consistently with the theoretical analysis presented above. Results are confirmed by the estimations of (IV)probit models, see Columns 3-6. In particular, improved health has a significant and positive effect on the probability of starting school before the median entrance age, whereas it has a negative impact on the probability of commencing above the median entrance age. It should be observed that the median age corresponds to the age of mandatory school start. Therefore, healthy and rich children begin the educational process before compulsory schooling, whereas poor and unhealthy children tend to postpone education (obviously, it would be difficult to obtain this conclusion if law enforcement was more effective).

**Table 2. Effects of health status on entrance age**

| **Dependent variable** | **AGE** | **AGE** | **E-ENT** | **E-ENT** | **L-ENT** | **L-ENT** |
|---|---|---|---|---|---|---|
| **Variables** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| **BMI-FOR-AGE** | **-2.225*** | | **2.077*** | | **-1.468^** | |
| | (-2.43) | | (2.60) | | (-1.72) | |
| **WFA** | | **-2.184*** | | **2.003*** | | **-1.595*** |
| | | (-3.07) | | (3.52) | | (-2.72) |
| **Control variables** | | | | | | |
| **EDUM** | **-.065*** | **-.065*** | **.050*** | **.048*** | **-.061*** | **-.060*** |
| | (-5.92) | (-6.31) | (4.50) | (4.55) | (-5.30) | (-5.49) |
| **EDUF** | **-.042*** | **-.039*** | **.036*** | **.031*** | **-.030*** | **-.028*** |
| | (-4.11) | (-4.17) | (3.48) | (3.34) | (-2.74) | (-2.87) |
| **LOGFI** | **-.200*** | **-.177*** | **.143*** | **.112*** | **-.150*** | **-.117*** |
| | (-4.35) | (-3.78) | (2.81) | (2.19) | (-3.08) | (-2.47) |
| **URBAN** | **-.428*** | **-.386*** | **.396*** | **.305*** | **-.349*** | **-.314*** |
| | (-4.62) | (-4.26) | (3.59) | (2.97) | (-3.70) | (-3.49) |
| **NORTH** | **-.645*** | **-.585*** | **.634*** | **.593*** | **-.690*** | **-.662*** |
| | (-6.49) | (-6.12) | (7.09) | (7.40) | (-7.83) | (-8.74) |
| **MALE** | **.098^** | **.253*** | **-.054** | **-.171*** | **.012** | **.131*** |
| | (1.81) | (3.98) | (-.96) | (-2.96) | (0.21) | (2.27) |
| **YEARS** | **.062*** | **.058*** | **-.023*** | **-.037*** | **.072*** | **.051*** |
| | (6.52) | (12.96) | (-2.25) | (-6.19) | (6.62) | (8.42) |
| **Hansen J stat** | 1.002 | 1.95 | | | | |
| **Wu-Hausman F stat / Wald test** | 10.09* | 18.01* | 4.69* | 8.31* | 3.16* | 6.12* |
| **Model statistic** | 81.66* | 95.36* | 329.67* | 447.85 | 401.45 | 475.04 |
| **centered R2** | 0.26 | 0.25 | | | | |
| **Observations** | 2363 | 3057 | 2365 | 3059 | 2365 | 3059 |

**Note.** Methodology: columns 1 and 2, 2SLS estimates (instruments for both dependent variables: BMIM, BMIF); standard errors adjusted for clusters (households). Columns 3 to 6: instrumental variables probit estimates (instruments for both dependent variables: BMIM, BMIF); standard errors adjusted for clusters (households). * = significant at 95%; ^ = significant at 90%; standard errors in parenthesis.

Concerning control variables, more educated parents tend to school their children at earlier ages and, in addition, mothers' education has a larger effect respect to fathers' education. This is an interesting prediction, which should be interpreted with caution. On the one hand, it might suggest that mothers have a greater influence on schooling decisions of children. On the other hand, this result might follow from the relationship across women's education, participation in the labour market and available time for childcare. In fact, when it is assumed that mothers dedicate more time to child care respect to fathers, children of more educated mothers are more likely to start school earlier due to lacking family care. Other control variables have the expected sign. For instance, entrance age decreases with household income. Individual age (YEARS) is highly significant and it has a positive effect on entrance age. This variable reflects an historic negative trend in entrance age that is important to take into account when considering students of different ages.

## 4. Conclusions

This paper treats about the effects of child health/nutritional status on the age at which children enter school. Provided that child readiness to face the educational process increases with both age and child health, due to a correlation between health status and cognitive ability, parents might rationally choose to postpone school entrance age in order to ensure a better school performance. However, a positive opportunity cost of schooling, which increases with age, makes the indefinite postponement of entrance age suboptimal and hence, an optimal age of school start can be defined. Explicitly, the optimal entrance age is the age of children that maximizes the net benefit of schooling, which is equal to the monetary benefit that improved education implies in terms of higher wages, minus the opportunity cost of education.

In the empirical analysis, entrance age and two additional derived binary variables have been considered. All estimations point at a negative effect of improved health on entrance age, consistently with the theory. In other words, it is shown that healthier children enter the school earlier. Therefore, differences in the initial health stock of children result in different schooling decisions and contribute thus to generate differentials in human capital formation. Though mandatory school age might eliminate the problem related to this particular human capital decision, it may be detrimental to school performance of unhealthy children. The lack of strict restrictions might thus enhance human capital formation and reduce disparities in child readiness.

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