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# *Social and Economic Equality: A Human Biologist's Perspective on the Developing World Beyond the Limits of Adaptability**

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NATURAL SELECTION is the core principle around which human biology is organized. Darwin's original explanation for the organization of diversity, with the modifications it has undergone in the 139 years since it was first stated, stands firmly as the basis for studying how populations adapt to the environments in which they live. The importance of natural selection has been strengthened even more by the understanding by human biologists – if not evolutionary biologists in general - of selection's role in the physiological, developmental, and behavioral plasticity that characterizes complex organisms, especially humans. Human biologists now accept without question that the relationship between a population and its environment, rather than chaotic, is essentially an adaptive one, mediated through genes, the development, and learning.

Given the above, how can one interpret the situation that exists among those nations of the world that are referred to as developing countries? How is it that among so many groups in so many places, adaptive processes have broken down? How is it that biological and demographic processes have been affected so severely? How is it that so much misery exists in a world which is patterned by adaptation through natural selection? And what is the human biological perspective on these questions and how useful is it?

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The human biological perspective is relevant in three ways:

1. The nature of the environments of groups living in the developing world and the relationships of those environments to biological variation;
2. The functional correlates of biological diversity within and among communities of the developing world;
3. Prospects for alleviating the situation through appropriate interventions.

In bringing the human biological perspective to bear on the problems of the developing world, this paper will focus upon the growth and development of children and youth. The interaction of the environment with the growth process is crucial to the production of mature, functioning adults, and the harsh, stressful nature of the environments of lesser–developed nations is a major retarding force.

## *What is the environment?*

There is by now virtually no disagreement with the premise that the environment exerts a major effect on the course of human development. An impressive accumulation of research has, over decades, focused our attention on the its role in supporting, channeling, and constraining the genetic template of individuals and populations.

The environment may be conceptualized as anything external to the biological conditions set by the genotype of the individual. It may be visualized as layered about a developing child, with the layers moving outward from the immediate and unique to those phenomena encompassing broad aggregate demographic units such as the community, the population, the nation.

Of particular importance in understanding growth and development is the social environment of a child, those components traceable directly to the position of the child in its society. The social environment is, by definition, a broad construct, and variation in social position results from the interaction of a broad set of determinants. These determinants are removed, and are often quite distant, from the biological processes of growth themselves and they exert their influences through

intervening, more immediate, and often interactive factors. By doing so they are no less important and often provide more powerful explanations of growth variation than those gathered from fine-grained observation and measurement.

## *Evolutionary Considerations*

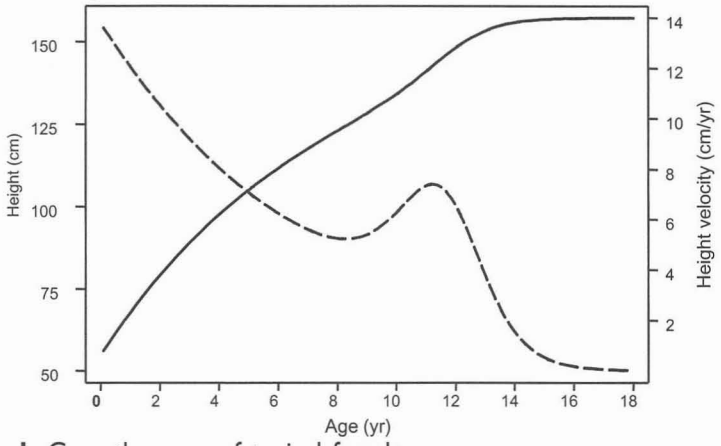


**Figure 1**. Growth curve of typical female

Figure 1 shows the form of the human growth curve for height, expressed both as the attained height and the velocity of growth by age. Relative to other species, human growth is characterized by an attenuated period of childhood followed by a marked increase in velocity, the adolescent spurt. Evolutionary biologists have emphasized the importance of the lengthened childhood years (lasting from approximately 2 to 10 years of age), when the rate of growth is rather slow and constant and when the developing child becomes acculturated and socialized through the process of social learning. It is a time of increased sensitivity to the environment.

While the heightened sensitivity of the individual during childhood to external stimuli is a crucial aspect of social learning, it also increases the impact of the environment upon both physical and behavioral development. When the environment is one that supports the genetic template that regulates development, the resulting interaction is a positive one.

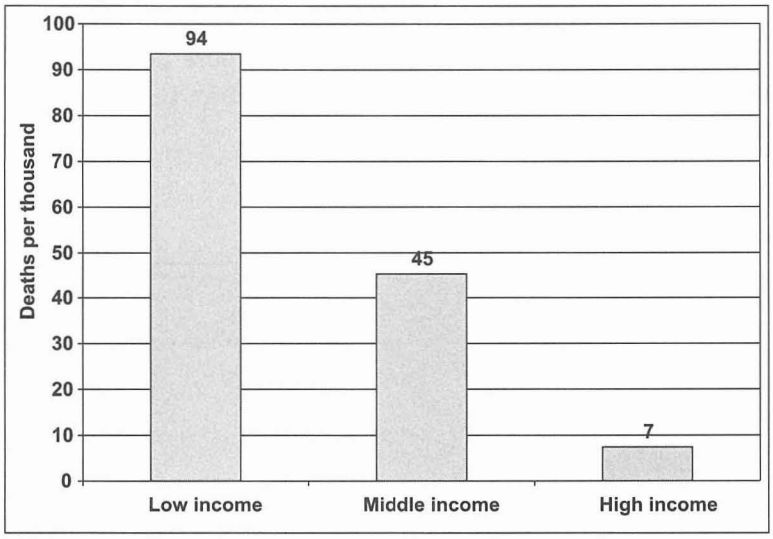


**Figure 2.** Mortality rate per thousand of children <5 years by income level of country – 1996 (World Bank)

However many communities and groups exist under conditions of great social and economic disadvantage, with poverty, malnutrition, disease, and overcrowding indicative of a spectrum of misery comprising the environment within which millions of children grow to adulthood. As examples, Figure 2 shows the infant mortality rate by national income level, and Table 1 gives the estimated proportion of children under 5 years of age in the world, by region, who are underweight, stunted, or wasted in their growth.

**Table 1.** Estimated prevalence of malnutrition in developing countries, by region

| Region | Low Weight | Stunting | Wasting |
|---|---|---|---|
| Africa | 27.4 | 38.6 | 7.2 |
| Asia | 42 | 47.1 | 10.8 |
| Latin America | 11.9 | 22.2 | 2.7 |
| Oceania | 29.1 | 41.9 | 5.6 |
| All developing countries | 35.8 | 42.7 | 9.2 |

(M. de Onis, C. Monteiro, J. Akré and G. Clugston.Bull. WHO, 71:703-712, 1993)

How can we interpret the devastating impact of the environment on the inhabitants of developing nations in an evolutionary context that has adopted adaptation as its main focus? We can only conclude that the sensitivity to the environment represented by an attenuated childhood has become, among disadvantaged communities of the developing world, a burden. Rather than shaping the pattern of growth as part of the process of adaptation, the environment becomes a threat to normal existence by preventing the achievement of human potential, and by significant negative effects on physical health and well-being, on cognition, and on economic productivity.

## *The Environment as Constraint*

Figure 3 presents a model of the effects of environmental constraints on growth. In general terms, the environment may be thought

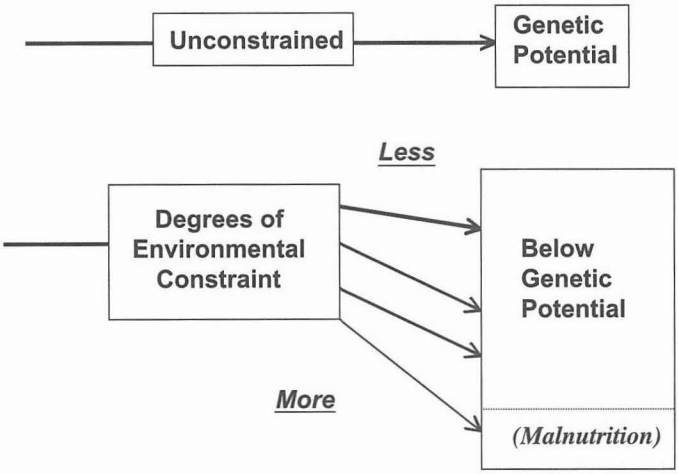


**Figure 3.** Model of environmental constraints on growth

of as presenting two modes of interaction with the developmental process. In the first mode the course of growth and development is *unconstrained,* in that the impact of the environment does not inter-

fere with the biological determinants of growth and the individual develops to genetic potential. This is what is meant when we speak of a "good" environment, i.e., one in which development is not limited by surrounding conditions. In such a case a major proportion of the variability among individuals, as well as the populations they comprise, reflects their genetic variability, individualized environmental experiences, and gene/environment interaction. Where the environment affects the growth process, it does so in ways that are beneficial to the organism, which has been called "developmental adaptation".

The second mode of interaction is one in which the environment *constrains* the developmental process. The results are distributed along a spectrum of outcomes. Any particular outcome depends upon the intensity and persistence of the constraint. In many instances the impact will be minor and such outcomes as growth, mental performance, and work capacity may compromised by only a small amount. However, in many other instances, growth may not just falter, but will fail. Not only will the environment leave its mark upon the individual, it may have serious consequences in functional capacity and ability, as well as nutrition and health status.

## *Characteristics of Developing Countries*

The most striking characteristics of developing countries are those associated with the extent and distribution of poverty, the disadvantaged lifestyles of many of their inhabitants, and the widespread occurrence of inadequate nutritional and health status among the population. Taken collectively, these characteristics form what Benjamin Bloom, in 1964, called "deprived" environments. He described these deprived environments as powerful and extreme. Individuals subjected to powerful environments will tend to change in uniform ways and directions, such that an entire distribution will be shifted downward. Although a few individuals may escape partially from extreme environments, the proportion of individuals affected in similar ways is likely to be as high as 90-95%.

## *Environmental effects on the development of children from developing countries*

The action of a powerful environment can be seen in our study of El Progreso, a poor community (*colonia*) located on the urban periphery of Guatemala City, where my colleagues and I have conducted a 10-year longitudinal study of the effects of the social and economic environment on the physical growth, mental development, and academic achievement of its children. Three cohorts of children were followed, with complete longitudinal data on a sample of 318, seen initially at either 3, 5, or 7 years of age (Johnston and Low, 1995).

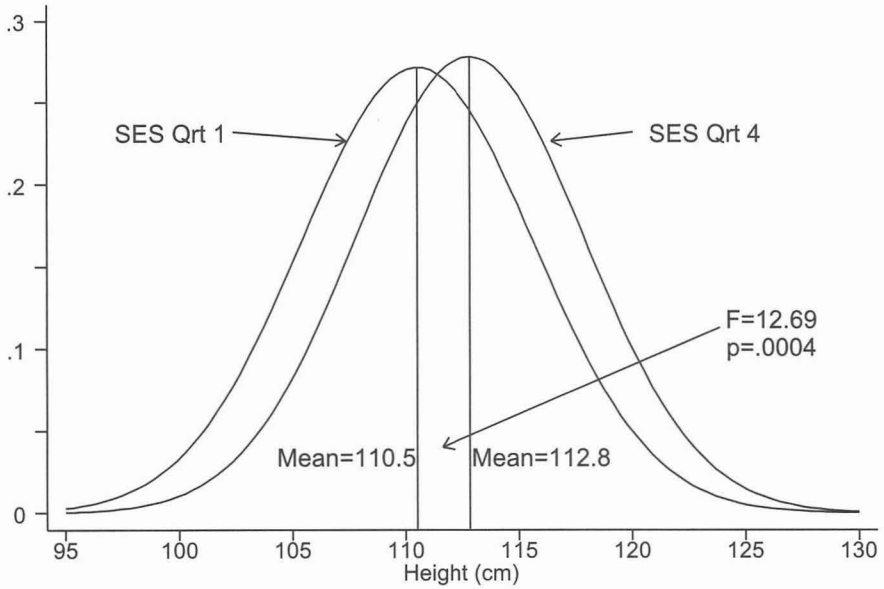


**Figure 4.** Distribution of height of Guatemalan children from the highest and lowest quartile of socioeconomic status of a disadvantaged peri-urban community.

Figure 4, presents the distribution of height at age 7 of the highest and lowest quartiles of socioeconomic status of the children.

Even though extreme poverty and social disadvantage characterizes the total community, contrasting those from the economically better-off and the worst-off quartiles demonstrates the systematic nature of environmental effects on growth. As the figure shows, the only difference between the two distributions is in the mean (F-12.69, p=.0004). There is no difference in either the variance or the skewness. In other words, the environment has exerted a downward pressure on the growth of these children, shifting the distribution among the poorest quartile to the left, but retaining a normal distribution.

The data from this study provide us with more insights into the effects of the environment on children from developing countries, and of the potential for correcting these effects. Figure 5 presents the mean height of the sample from 3 through 14 years of age. The data of this figure are pure longitudinal and collected on 318 children, each of whom was seen every year for the duration of the study. Those of cohorts 3 and 5 were each measured over 10 years, and those of cohort 7 over 8 years. The heights have been converted to z-scores relative to the WHO/USNCHS reference standards. The families of each child was assigned a socioeconomic score at each annual examination based on the following indicators:

- Number of electrical appliances in the home
- Type of fuel used for cooking
- Number of years of schooling of the mother
- Number of years of schooling of the father (Johnston and Low, 1995)

The three groupings are by socioeconomic status at the initial visit. While all are poor, those in the figure of group 1 represent the lowest third, group 2 the middle third, and group 3 the highest third.

The curves demonstrate two things. First is the very low scores at all ages. Relative to the standards, the children of El Progreso fall some 1/2 to 2 standard deviations below the mean. At age 7, only 7 of 318 children were at or above the reference mean. Clearly the environment has imposed a heavy cost on physical growth.

The second observation from this graph is the consistency of the growth patterns for each of the socioeconomic categories. Children who, the first time they were examined, came from the poorest homes were

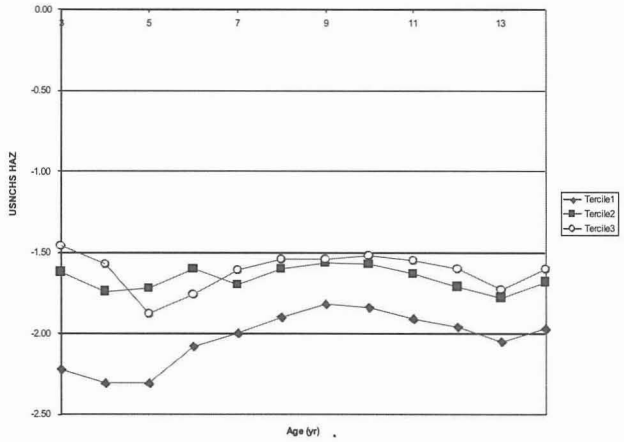


**Figure 5**. Mean USNCHS z-scores of a longitudinal sample of Guatemalan children of a disadvantaged peri-urban community, grouped by socioeconomic status.

more than 1/2 standard deviation smaller than there peers from better off households. This difference was maintained throughout the age period, becoming only slightly smaller by age 14.

**El Amparo, n-257**

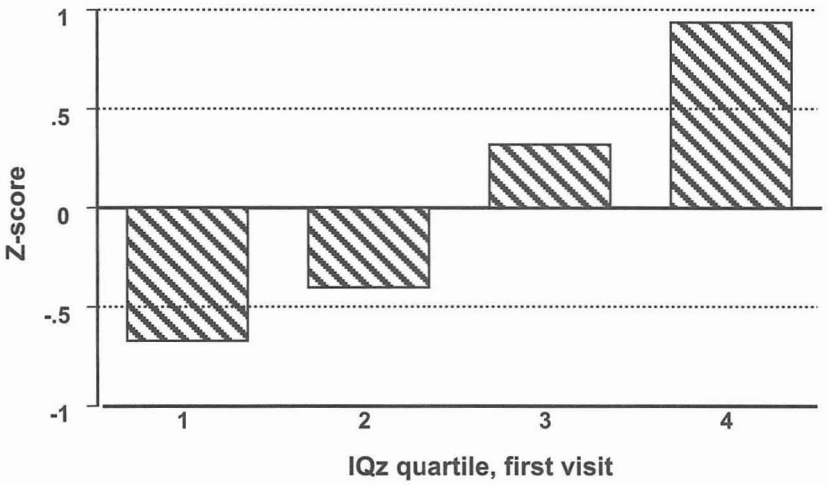


**Figure 6**. Cohort-specific Wechsler IQ z-scores of El Progreso children at the last examination grouped by IQ quartile at the first examination

The long term effects of the early socioeconomic environment on mental development may also seen in the data from El Progreso. Figure 6 shows the relationship between the Wechsler IQ scores of 257 children of the study at the last visit (age=14 years), grouped by the quartile of their IQ at the first visit. The IQ's were standardized to z-scores by cohort and grouped into quartiles. The difference between the mean IQ at the last visit of those in the first and fourth quartile of IQ at the first visit (7-10 years earlier), was greater than 1/2 standard deviations. As with height there is a remarkable consistency of mental development.

## *Is small body size an adaptation?*

This presentation began with a discussion of adaptation as an organizing principle of human biology, and adaptability as an essential attribute of humanity. But it was also suggested that, in the developing world, the limits of human adaptability had been exceeded by the forces of extreme, powerful environments. The argument made is that human growth and development is sensitive to the environment and that differences among populations reflect, to a large degree, differences in the degree of constraints exerted by the different environments.

At the same time there are some that have suggested that the small body size of children and adults from regions of the developing world where there is malnutrition is an adaptation to the environment, conferring upon individuals a reduced nutritional requirement. A parallel argument is represented by the small-but-healthy hypothesis. This interpretation holds that the small body size of adults from such populations is, in fact, irrelevant. They are healthy and functional regardless of their size. In short body size is not a functional indicator of status.

Such explanations of body size differences are of enormous import, not just as interpretations of human variability but in their impact on public health programs designed to improve the human condition. What conclusions can we reach regarding the significance of reduced body size among the poor and the disadvantaged of the developing world? While it is true that, in any setting, smaller individuals have reduced energy requirements compared to their larger peers. But it is also true that the small average body size of individuals of such communities is an indi-

cation of an earlier insult that has impaired the developmental process (Figure 4). In other words, when interpreting the variation among means, small body size reflects an environmental insult that has prevented the attainment of genetic potential (Figure 3). That is, it is an indicator of the environmental deprivation experienced during childhood. But small body size is more than an indicator.

A number of studies have measured the work capacity of the small adults of deprived environments of developing countries. In a recent publication, Spurr has analyzed the result of undernutrition during childhood on the work capacity of adult Colombians. His conclusions are clear:

> "...the conclusion is inescapable that undernourished children become smaller adults who will have lower Vo2 max and therefore, reduced productivity in heavy physical work" (Spurr, 1998)

What, then is the significance of small body size in populations? It is those factors associated with the process of becoming small, not the state of being small, that is the real concern. Being - as opposed to becoming - small is in itself harmful only in the case of the relationship between body size and work capacity and in the relationship between maternal size and infant birth weight. Limitations on productivity are an important constraint among the economies of developing countries and a reduction in the ability to perform manual labor associated with small body size is one contributing factor. And small mothers are more likely to have a low birth weight infant.

On a broader level, the small body size of disadvantaged communities and sectors of society is clear and indisputable evidence of something badly wrong. It is powerful evidence of a normal developmental process that has gone adrift because of the inequities of an environmental interaction that was designed by evolution to be supportive and adaptive. And it is evidence of the utility of human biological data in evaluating the state of human health and well-being.

## *Are biological indicators reversible?*

The data presented here indicate clearly that the effects in childhood of extreme and powerful environments carry through into the later

years, and in fact to the next generation. This has been suggested by three points:

1. Our data on peri-urban Guatemalan children indicate that those from the most deprived levels of the community had not, 10 years later, caught up to their better off peers either in physical growth or mental performance;
2. Undernourished children become small adults with diminished work capacity and economic productivity.
3. Small mothers are at greater risk of giving birth weight to children of low birth weight.

But can these biological indicators be reversed? Can interventions designed to enhance the quality of life be carried out successfully, and can this success be measured by the indicators used by human biologists?

Bringing about positive changes in communities beset by complex social problems is a challenging task. The challenge results from the multicausality of the problems, reflecting geopolitical forces, ideology, the ability to control one's life, knowledge, attitudes, and behavior. A powerful, extreme environment is just that: powerful and extreme. And there is ample evidence that the success of interventions is severely limited by internal and external factors. For example, in the 1960's and 70's the Nutrition Institute of Central America and Panama (INCAP) carried out a carefully designed program in which the diets of pregnant women and children were supplemented, the children up to 7 years. In a series of analyses carried out in the past several years, a team has evaluated the long term results of the intervention (Martorell, 1992). They have concluded that intervention after 3 years of age had no effect on growth, mental performance, or work capacity some 20 years later.

However the situation may not be as bleak as their analysis would indicate. Figure 7 presents the changes in the height (HAZ) and weight (WAZ) USNCHS z-scores of the children according to the changes in their socioeconomic levels over 10 years. As expected the social and economic well being of some families worsened (about 10%). About 50% showed none or only a small change, and about 40% improved their status. For this analysis they were grouped into quartiles of change as shown in the figure.

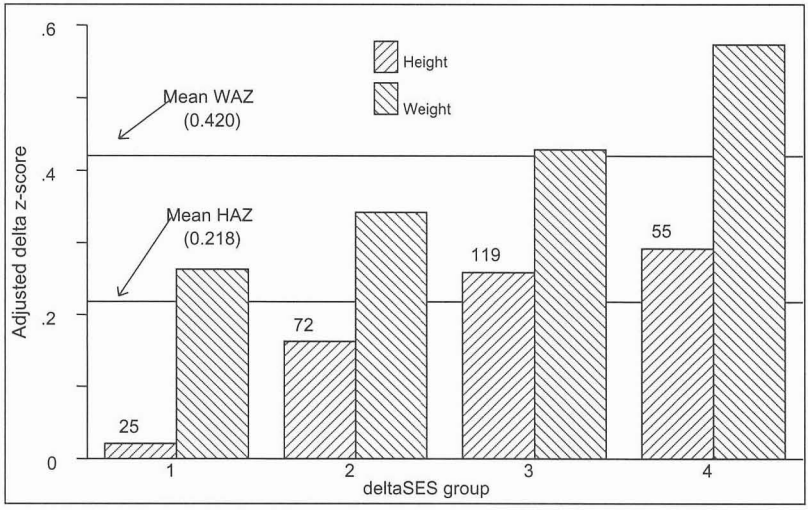


**Figure 7**. Mean USNCHS height (HAZ) and weight (WAZ) of children from El Progreso at the last examination, grouped according to the change in socioeconomic status of their families from the first to the last visit.

The figure shows clearly that the greater the improvement in socioeconomic status a positive direction of, the greater the improvement in growth status. The difference was slightly than 1/2 standard deviation, and was greater for weight than for height. In other words, improved conditions in the home were reflected in a better growth status over a 10-year period. This finding is of even greater interest because in Guatemala, the 1980's were a time of great social unrest, a major devaluation of the currency, and a marked increase in the cost of living. In spite of that, in homes where improvement occurred, growth status improved.

The data from El Progreso suggest that the negative effects on cognition of the powerful socioeconomic environment in the early years can be lessened by parental characteristics. Figure 8 shows the relationship between the years of schooling of a child's mother and the child's IQ at the last examination. The IQ's are expressed as z-scores to correct for differences in the particular test that was applied. They are also adjusted for a number of other variables.

- sex of the child.
- material well-being of the household

- years of schooling of the father education.
- IQ at the first visit,

Thus this analysis presents, about as accurately as can be done in a non-experimental study, the effects of mother's education on changes in her child's IQ over 10 years.

The sample size is 257. The regression of mother's education on the change in child's IQ is significant at a probability of .029. In other words, holding other social variables and the initial IQ of her child constant, the IQ's of children of mothers with more schooling improved over 10 years more than half a standard deviation over children of mothers with less education. Even in the face of a degradation of the environment at the national level, the educational attainment of individual parents is a positive factor in mental development.

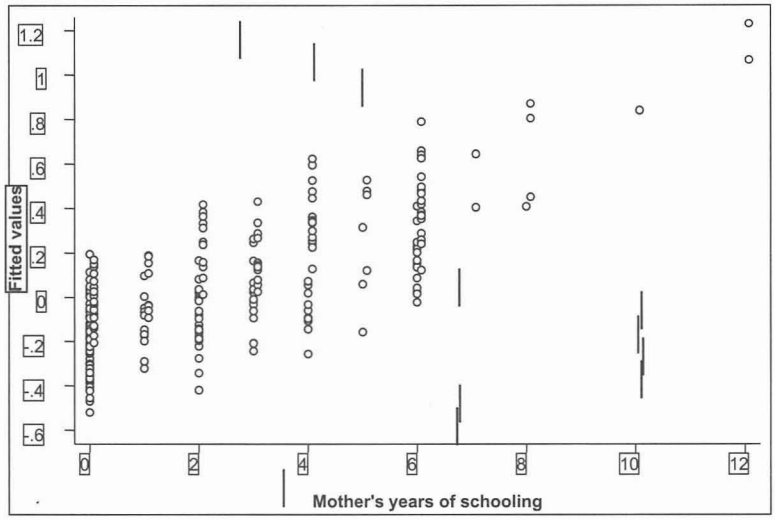


**Figure 8.** IQ z-score at last visit of children, by years of mother's education, adjusted for cohort, sex and IQ at last visit, El Amparo study

## *Human biology and human welfare - concluding thoughts*

My view - as a human biologist - of the developing world can be summed up in three statements:

1. There is great inequality in the world, in every region. There is a depressing persistence of this inequality despite the efforts of

many to enhance the situation. Among the most disadvantaged, the impact of their extreme, powerful environments on their biology has surpassed the limits of the human adaptability so much a part of our evolutionary heritage.

2. Despite the many problems, available data indicate that individual families are capable of responding positively and their responses may be seen in biological indicators of well-being.
3. Human biologists and anthropologists can no longer justify the detachment from the real world that became a hallmark of science in the last century. Value-free research is a delusion. We have the tools and the background to contribute significantly to the problems of inequality and disadvantage that beset the developing world. Now is the time for us to become full participants in helping peoples achieve their own potential.

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