

## Child Nutrition and the Wealth of Nations

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The first part of my title "The Wealth of Nations" comes from a book first published in 1776 by Adam Smith, the noted political economist. <sup>1</sup> He believed that the ultimate source of a nation's wealth is the quality of its labor force and that the achievement of an "abundance of the necessities of life," made possible by the "liberal reward of labour" (i.e., fair wages) is both an indicator of national economic development as well as an engine for further growth. He also recognized that there are profound effects of poverty on child health:

"But poverty, though it does not prevent the generation, is extremely unfavourable to the rearing of children. The tender plant is produced, but in so cold a soil and so severe a climate, soon withers and dies. It is not uncommon, I have been frequently told, in the Highlands of Scotland for a mother who has borne twenty children not to have two alive." (pg. 70).

Smith also observed that child mortality responds to "the liberal reward of labour" by 'enabling parents to provide better for their children, and consequently to bring up a greater number...' (pg. 71). Smith, on the other hand, did not speculate on whether poor health and nutrition in childhood might affect labor quality among those individuals fortunate enough to survive, which is what I want to discuss, and hence the title of my talk "Child Nutrition and the Wealth of Nations."

Last October, the population of the world reached 6 billion people, a staggering figure. <sup>2</sup> Many had expected that at this point in time, the world would be faced with widespread famine but this is not happening, except in a few areas of armed conflict and political instability. Quite the contrary, most people today in poor countries are better off than their parents were. This is because of sustained economic growth in most regions. <sup>3, 4, 5</sup> However, it would be premature to claim that poverty has been conquered. Indeed, one of the greatest challenges facing mankind today is the eradication of abject poverty: nearly one billion people remain in absolute, degrading poverty!

There is agreement among development economists that the root cause of poor human development (e.g., poor health and nutritional status, retarded physical growth, deficient learning, low educational achievement, etc.) is poverty and there is also emerging consensus that the relationship between these two aspects is bi-directional. <sup>5, 6</sup> In other words, poor human development is both an outcome as well as a cause of poverty. Interestingly, Adam Smith attacked a

prevailing notion of his time that hunger, poor health and economic necessity makes workers more industrious out of sheer desperation. <sup>1</sup> He proposed the contrary, that poor health and malnutrition lower the productivity of workers. He wrote as follows:

".... that men in general should work better when they are ill fed than when they are well fed, when they are disheartened than when they are in good spirits,

when they are frequently sick than when they are generally in good health, seems

not very probable (page 74)."

Much research has been generated in the last 20 years on the economic returns of investments in human development. <sup>5, 6, 7, 8, 9</sup> There is overwhelming evidence that the returns from education are huge. Similarly, there is strong evidence indicating that the control of infectious diseases more than pays for itself. On the other hand, the evidence documenting that improving nutrition leads to significant economic returns remains weak, but is growing rapidly on account of new research, some of which I will discuss shortly.

Robert Fogel, an economic historian, focused his Nobel lecture in Economics on the relationship between nutrition and productivity. <sup>10</sup> He concluded that improved nutrition accounted for roughly 30% of the growth in per capita income in Britain between 1790 and 1980. This must be taken, as he says, as a very rough estimate. However, Fogel's figure lies within the range of estimates produced by cross-country studies using data from the last 30 or 40 years. <sup>3</sup>

Fogel, as well as most researchers using contemporary data, have focused on the physical size, body composition and diets of adults, and on the importance of these factors for physical work. A recent review of the literature by leading economists suggests that most of the productivity effects of nutrition is through jobs requiring physical strength. These authors speculate that the impact of nutrition on productivity will decline over time with economic development because jobs requiring hard physical labor will tend to disappear. <sup>7</sup> I propose that the effects of nutrition on economic development are not limited to jobs requiring hard physical labor. Instead, I propose that nutrition is likely to be very important in determining productivity across a range of occupations. I also propose that the most important effects of nutrition on economic productivity are due to nutrition in early childhood. It is not that nutrition among adults does not matter for productivity, but that nutrition in early childhood matters more.

The nature of child malnutrition and its causes

It is best to provide some general information about the nature and causes of child malnutrition before discussing its functional consequences. UNICEF has provided a conceptual framework of the causes of child malnutrition (technically undernutrition but "malnutrition" is widely used).<sup>11</sup> Some causes operate at the societal level, such as the quantity, quality and control of human, economic and technological resources (Figure 1). These are the sort of causes that explain differences in levels of malnutrition across countries. Beyond these, UNICEF has identified three clusters of causes that operate at household or family level: insufficient access to food, inadequate childcare practices, and inadequate sanitation and health services. These factors in turn result in the immediate causes of malnutrition at the level of the individual: inadequate dietary intakes and infections. The diets that are commonly offered to young children in developing countries to complement breast milk are of low quality, with poor energy and nutrient concentrations, and multiple nutrient deficiencies are common. Infections are also common, particularly diarrheal and respiratory infections. One key point from the UNICEF conceptual framework is that malnutrition is caused, not only by lack of food and dietary deficiencies, but also by infection. These twin forces — poor diets and infections — are also responsible for the high death rates among children in developing countries, and undoubtedly as well in the U.K. during Adam Smith's lifetime.

Malnutrition is most common and severe during periods of greatest vulnerability.<sup>12</sup> One such period is during pregnancy. About 16% of babies in developing countries are born malnourished, as measured by a birthweight of 2.5 kg or less, and in Bangladesh, this is about 50%.<sup>11</sup> The second most vulnerable period is the first two years of life.<sup>12</sup> Young children have very high nutritional requirements, in part because they are growing fast. They are also very susceptible to infections because their immature immune systems fail to protect them adequately. In poor countries, foods and liquids are often contaminated with fecal matter and are thus the key sources of infections. As a result of infections and poor diets, young children easily succumb to malnutrition. In settings of poverty, the absence of breastfeeding, which takes away a "clean," nutritious food with anti-infective properties, is associated with high rates of malnutrition and mortality.

We are all familiar with images of severely malnourished children, often shown in association with articles or television programs about famines. Often these are pictures of children with marasmus, a form of severe protein-energy malnutrition. We may recall the image of a child with severely emaciated limbs and torso, such that the head and joints seem large in proportion to the body, with the face drawn-in and "old-man" like, the eyes seemingly huge, and the rib cage exposed in exquisite detail due to the excessive loss of fat and muscle, and with the stomach grossly distended due to poor muscle tone. There are haunting images for other severe forms of malnutrition. There is kwashiorkor, also a severe manifestation of protein-energy malnutrition, which generally includes severe and painful edema or swelling due to intracellular fluid retention, hair

discoloration and brittleness, and skin that falls off like old paint in a building, exposing red patches of muscle that later nest foul infections. Or consider Keratomalacia, the end stage of severe vitamin A deficiency, in which the ulcerated cornea eventually melts into a mass of dead-white or dirty yellow gelatin, and the lens and vitreous fluid ooze out. Children with severe forms of malnutrition often die. Those lucky enough to survive suffer irreparable physical and mental harm. For example, severe vitamin A deficiency, despite progress in prevention, is still the leading cause of blindness in very poor countries.

Malnutrition is like an iceberg (Figure 2). The ice above the water, the part that can be seen, represents the severe forms of malnutrition. These severe forms, with their dramatic clinical signs, are relatively rare even in poor countries. The portion of the iceberg below the water represents mild and moderate malnutrition. Children affected with mild and moderate malnutrition lack the visible signs of the severely malnourished. Their malnutrition, like the ice below the water, is invisible. Also, the problem of mild and moderate malnutrition, like the submerged mass of ice, is of massive proportions. According to UNICEF, mild and moderate malnutrition is the "silent emergency."<sup>11</sup> It has extremely important functional implications yet, mild and moderate malnutrition fails to move donors and policy makers to action like famines, the loud emergencies, sometimes do.

The best way of identifying children with mild and moderate forms of malnutrition is by weighing and measuring them. Growth failure is very common in settings of poverty and the proportion of children who are underweight, or below the third percentile of the distribution of weights in normal children of similar age, is accepted as the best general indicator of the state of nutrition in societies.

I would like to give you a sense of the magnitude of the problem of child malnutrition in the world as well as some information about trends.<sup>13</sup> The region of the world with the most child underweight is South-central Asia, a region which includes the Indian subcontinent (Table 1). There has been slow but steady progress in this region and the prevalence of underweight is expected to drop by a third, from 58% in 1980 to 40% in 2005. The region with the next highest proportion of child underweight is sub-Saharan Africa. Here, the picture is bleak; the prevalence will rise from 28% to 38%. In Latin America and the Caribbean, on the other hand, the problem of underweight is disappearing rapidly. However, regional averages hide pockets of malnutrition. Honduras, my own country, has levels of malnutrition similar to those of many countries of Sub-Saharan Africa.

It is also important to track changes in the absolute number of underweight children (Figure 3). The actual number of underweight children in all developing

countries will fall from 175 million in 1980 to 138 million in 2005. Even in India's region, South Central Asia, the number of malnourished children will decline, from 85 million to 74 million. However, South Central Asia will continue to have the largest number of malnourished children, over half the total for all developing countries. On the other hand, the number of affected children in SS Africa will more than double, from 14 to 37 million. This will occur because the prevalence of underweight will increase and because of the fact that this region has the highest rate of population growth in the world. Sub-Saharan Africa and South Central Asia will be the main foci of malnutrition in this new century, with 80% of all the malnourished children in the world. 13

### Early Nutrition and Human Capital

I am now ready to discuss the consequences of poor nutrition. The first point, and one which is not widely appreciated, is the central role that malnutrition plays in explaining the high mortality rates in children in developing countries. The summary finding from many studies of malnutrition (defined in terms of % normal weight for age; 80% WA is roughly equivalent to the third percentile of the weight-for-age distribution) and mortality in children is given in the main panel of Figure 4. Compared to children who are well nourished, children with severe malnutrition have a risk of death more than 8 times as high, moderately malnourished children about 5 times as high, and those with mild malnutrition, over twice as high. 14 The gradient in the relationship between severity of malnutrition and the risk of death is notable.

However, as the pie chart in Figure 4 shows, only about 4 % of children are severely malnourished, even in very poor countries like India. On the other hand, over 60% have mild or moderate malnutrition. For this reason, over 80% of the deaths attributed to malnutrition occur among children with mild and moderate malnutrition. 15 Clearly, public health activities need to focus on the prevention of mild and moderate malnutrition to keep children alive.

Children in developing countries generally die from both malnutrition and infection. It is their combined influence that kills. A good example is measles. Vaccination rates for measles are low in France partly because parents view measles as a natural childhood disease. French children are of course well nourished. Among malnourished children in India and in sub-Saharan Africa, as many as 10% of infected children may die from measles. Therefore, measles becomes a child killer only when superimposed on malnutrition. However, this interaction between poor nutrition and measles is ignored in registering causes of death. Only measles, or other infections such as diarrheal diseases or respiratory infections, are usually recorded as causes of death. Using mortality results from prospective studies and estimates of malnutrition at country level, researchers at Cornell have estimated that about 50 % of all deaths in developing countries

among children less than five years of age are due to the potentiating effects of malnutrition on infection. 15

There is convincing experimental evidence that improving the vitamin A status of children enhances child survival. 16 Vitamin A is needed in very small amounts but is essential for maintaining the integrity of the mucosal barrier of the respiratory and gastrointestinal tracks and also plays many roles in the immune system, making it extremely important for fighting infections. Vitamin A can be given in concentrated capsules that contain the needs for three to 4 months. In the last 15 years, several large trials were carried out to measure the mortality impact of providing vitamin A by comparing death rates in children receiving a capsule of vitamin A every few months to those of children receiving a placebo. Professor Beaton of the University of Toronto and I chaired a committee of the United Nations that was charged with reviewing the evidence from eight studies involving over 160,000 children. Our conclusion was that there was overwhelming evidence that vitamin A supplementation reduced child mortality rates, on average by 23 %. 16 This makes vitamin A programs among the most cost-effective, child survival interventions. Recently, researchers have reported that low doses of vitamin A reduced mortality in Nepalese pregnant women by 40 %. 17 This indicates that the potential benefits of vitamin A supplementation on mortality are not limited to children.

Poor people in developing countries spend a large portion of their incomes seeking treatment for their sick children. They may leave work to take the child to a clinic, they may pay healers or doctors for their services and they may spend money on medicines prescribed by them. Vitamin A supplementation protects children from dying, as we have seen, but surprisingly, it does not prevent diarrheal diseases or pneumonia, the two most commonly reported causes of death. It may be that vitamin A decreases the likelihood of dying from these infections by preventing the progression to very severe disease.

Zinc, also a micronutrient, has recently been found to be a powerful anti-infective nutrient. With Professor Black of the John Hopkins School of Public Health and other colleagues, we have just published the results of a pooled analysis of all available randomized, controlled trials of zinc and infections. 18 We estimate that zinc supplementation reduces the incidence of episodes of diarrhea by 18% and of pneumonia by 41%. These effects are remarkable; the introduction of water, for example, has about the same effect on diarrheal disease rates as supplementation with zinc. Given these effects, zinc status may be as important for survival as vitamin A, if not more so, but no studies of zinc and mortality are yet available. Education to promote consumption of zinc rich foods, the use of foods fortified with zinc and other micronutrients, and direct supplementation of children are some intervention options. Unfortunately, zinc supplementation cannot be achieved through infrequent massive doses (as is the case with vitamin A) but needs to be given daily making this intervention less feasible in resource poor countries. Another problem in that the cereal-based diets of developing countries are very poor sources of available zinc. Meat and

other animal products, on the other hand, are very rich in zinc but these foods are expensive. Also, some societies, Hindu societies for example, are vegetarian. Fortification of toddler foods has worked very well in wealthier countries but is not a good option for delivering nutrients where large proportions of the poor, particularly in rural areas, are not integrated into the market economy. For these reasons, the improvement of zinc status in young children is a difficult matter, prompting some governments, such as Mexico, to design and distribute to poor families high-quality, easily-prepared foods for toddlers.

Adult physical status is compromised among survivors of childhood malnutrition (Figure 5).<sup>12</sup> Some of these effects can be traced directly to the pronounced growth failure that takes place in young children. Very little of the growth retardation in early childhood is made up at later ages and childhood malnutrition is the main factor explaining why adults in poor developing countries are so stunted. In addition to short stature, muscle mass is reduced, as is physical strength. These effects have important functional consequences. First, maternal stunting increases the risk of fetal malnutrition and in this manner, the effects of malnutrition are transmitted across generations. In addition, the danger of delivery complications and death among women of small body size is increased because the size of the pelvic inlet is also reduced. It is this fear of dying in childbirth that drives some women in developing countries to reject nutritional recommendations aimed at improving birth weight. Among men engaged in physical labor, stunting leads to a reduced capacity for work and to reduced earnings. Economists recognize the effects of stunting on productivity but few appreciate that stunting among adults is often due to malnutrition in early childhood.

There are also important consequences on intellectual performance for survivors of child malnutrition.<sup>19</sup> Malnutrition in early childhood is associated with delayed motor development, with IQs that are reduced by 10 or more points, and with behavioral problems and deficient social skills at school age. Child malnutrition is also associated with decreased attention, deficient learning, and lower educational achievement. While there is a large literature on this subject with very consistent results, the interpretation of the findings remain controversial. Poverty causes poor educational achievement as well as growth failure, the indicator of malnutrition most commonly used. Therefore, poverty may account for the relationship between child size and intellectual performance and for this reason, the best studies control for the effects of poverty and for those of other factors such as maternal education. After adjustment for socio-educational factors, these studies consistently demonstrate an independent and robust effect of growth failure on intellectual performance.

There is direct evidence that specific nutritional deficiencies impair mental development.<sup>19</sup> This list includes iodine deficiency. Iodine is needed for making thyroid hormones, which play a central role in the regulation of metabolism, and of growth and maturation. Thyroid hormone deficiency during fetal growth,

therefore, has profound effects on human development. Severe deficiency in utero cause cretinism, a condition associated with severe mental retardation and numerous neurological anomalies. It used to be believed that non-cretins in iodine deficient areas were not affected in their growth and development but this is now known to be incorrect. Cretins are only the tip of the iceberg. A recent meta-analysis focused on 18 studies from 8 countries. 20 These studies included non-experimental comparisons as well as randomized, controlled trials. The authors concluded that on average, IQ is reduced by around 13 points among subjects suffering from mild and moderate iodine deficiency. This is a significant finding since over two billion people are at risk of iodine deficiency. 13 Fortunately this number is lower than in the past because of the successful introduction of iodized salt in many countries. There is hope that iodine deficiency disorders will be virtually eliminated in the near future.

Iron deficiency is another very common problem that impacts on mental development. Iron is needed as a constituent of hemoglobin, the molecule that carries oxygen from the lungs to all tissues. Like zinc, iron is not very available from cereal-based diets. As a result, anemia, or low hemoglobin concentration, is very common in pregnant women and in young children. Anemia affects a large proportion of children in developing countries. Over 60% of children are anemic in South Central Asia, a region dominated in population by India. Almost half of the children in SSA and almost 1 in 5 in Latin America are anemic. Anemia is also common in school-age children and in women. 13

Anemia is a chronic state that causes children to be lethargic and which diminishes their interaction with the environment. Anemia, once established, will persist for years unless it is treated. There are many studies documenting that anemia impairs cognitive functioning and learning. 21 An important question is whether there are lingering effects once anemia is corrected. Evidence from prospective studies from 5 countries indicates that having had anemia in early childhood has long term consequences in the school child. 21 The effects include poor cognitive functioning, poor school functioning and low achievement test scores. One of the studies, from Costa Rica, has detected behavioral problems as well, including greater levels of anxiety and depression, as well as attention problems. 21

There are also results from experimental studies where the diets of children have been improved and the effects on cognition and learning measured. 19 I have been involved with one such study for almost 30 years. 22 Beginning in 1969, children in 2 Guatemalan villages were provided with a highly nutritious beverage, called Atole, while children in two other similar villages received a drink of lower quality called Fresco. The original study ended in 1977. Among the many contributions of this study was documentation that nutrition interventions can reduce the prevalence of low birth weight by 50% and cut infant mortality rates by 30%. The study also showed that the prevalence of severe stunting in children can be reduced by half. This study has been very important for advocacy on behalf of nutrition programs aimed at mothers and children.

The Guatemalan study was funded by the U.S. National Institutes of Health (NIH) to document the effect of improved nutrition on cognitive development. The researchers used an unusually rich battery of preschool tests to unravel these effects but to no avail. It was a great disappointment to all concerned to report to NIH that the effects of improved nutrition on child cognitive development were very modest. Perhaps, it was reasoned, nutrition played only a minor role. I worked in Guatemala on this study, completing my thesis on the effects of diarrheal diseases on child growth and nutrition. I remember the disappointment quite well. While we often say it does not matter what results are found so long as the science is good, in reality, negative findings are often unwelcomed. It is difficult to publish negative findings and these do not often lead to other grants. Later, when I was at Stanford, I managed to obtain funding to study the former subjects in the late 80s when they were adolescents and young adults. My colleagues and I wanted to see if the benefits we had observed in terms of physical growth and body composition were maintained later. They were. We also measured intellectual functioning, placing emphasis on achievement tests of general knowledge, reading and numeracy. To our surprise, we found that the effects of the Atole were much stronger and robust in adolescents than was seen in preschool children. <sup>23</sup> We found effect sizes of the order of half a standard deviation in adolescence compared to effects of around a fifth of a standard deviation in childhood. Also, we found that the effects of the Atole varied with years of primary schooling. There were no differences in performance at low levels of primary schooling. However, as primary schooling increased, the effect of the nutritious Atole was magnified. This interaction suggests that the returns to nutrition improvements can only be realized if children go to school and remain in school.

Our research in these Guatemalan communities continues. We have just completed a longitudinal study of the children of the children that we began studying in 1969. Our interest is in measuring intergenerational effects of malnutrition by tracing the repercussion of the nutrition experiment to the next generation. NIH recently approved funding for the analysis of these data.

We are also embarked on studies of "the fetal origins hypothesis of chronic disease" in these communities. There is some evidence that poor nutrition during pregnancy and infancy increases the risk of "syndrome X", which includes obesity, hypertension, diabetes and cardiovascular disease. <sup>24</sup> If true, malnutrition in pregnancy and early childhood may be one of the forces explaining the dramatic rise in "syndrome x" in developing countries. These are issues currently under study in several countries, including our work in Guatemala.

### Concluding remarks

I would like to return to the main question of my talk: Does improved child nutrition increase the wealth of nations? I propose that there is no question that

improved child nutrition leads to enhanced human development; I also propose that these effects are likely to result in economic returns. Better nutrition in early childhood will enhance survival and make children healthier and reduce health care costs. Also, better nutrition in early childhood will improve physical status in adults and increase productivity in hard physical labor. Another benefit is that better growth in childhood will improve the chances of delivering healthy newborns and decrease the risk of delivery complications and maternal death. Moreover, improving nutrition in early childhood will improve intellectual functioning and school achievement, which are important determinants of choice of occupation and earnings. Because nutrition matters for intellectual functioning, improved nutrition should impact productivity across a range of occupations and not only those requiring brute force. Although the evidence is incomplete and often indirect, I am convinced that nutrition programs aimed at women and young children can increase the wealth of nations, particularly of poor nations.

There is now consensus among economists that development strategies must be aimed at two aspects.<sup>5, 6</sup> First, economic development must be fostered but the wealth generated needs to be shared in order to decrease levels of poverty. Second there must be direct investment in human development, specifically in health, nutrition and education, to build human capital that can take advantage of the opportunities offered by a growing economy. Contrary to views held in the 70s, investing in human development is no longer viewed as drawing away needed resources for economic infrastructure, but is regarded as essential and complementary to these efforts.

We have two reasons for advocating for nutrition programs, particularly those aimed at women and young children. One, the subject of my talk, is that such an investment contributes to building human capital and for this reason should be considered a long-term economic strategy. The second reason is that human beings have a right to be free from hunger and nutritional deficiencies. What is the goal of development if not to satisfy basic human needs? Is it not the role of responsible government to provide for at least the bare minima for human well being?

Adam Smith, the original capitalist, was a really closet liberal with a soft heart for the poor. This is what he had to say:

"No society can surely be flourishing and happy, of which the far greater part of the members are poor and miserable. It is but equity, besides, that they who feed, clothe, and lodge the whole body of the people, should have such a share of the produce of their own labour as to be themselves tolerably well fed, clothed, and lodged." Pg 70.1

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