The Economic Impact of Micronutrient Deficiencies

Susan Horton

Munk Centre for International Studies, University of Toronto, Toronto, Ont., Canada

Micronutrient deficiencies have significant adverse consequences on key aspects of body functioning, such as on immune systems and hence resistance to infection, on hearing, cognition, endurance and peak work capacity. The impacts are particularly significant at vulnerable times (pregnancy, the perinatal period, infancy, and likely in old age). Micronutrient deficiencies therefore have important effects on the global burden of disease, with important outcomes on morbidity and mortality. They also have direct economic effects on work productivity and, via morbidity and premature mortality, on work output, as well as more indirect ones on the costs of health system usage, via cognition on the success of the education system, on the incentives to save and invest in children.

Although the human costs alone (burden of disease) justify interventions to alleviate micronutrient malnutrition, efforts have also been made to quantify the economic costs. Information on the burden of disease attributable to micronutrient deficiencies can help to persuade Ministers of Health to devote additional resources within the health budget to micronutrients. But information on the economic consequences of deficiencies may help to persuade Ministers of Finance to allot more resources to health, and away from other competing economic priorities.

Hence, advocacy for increased investment in micronutrient interventions has followed two different approaches. One has been the approach preferred by the World Health Organization, namely to estimate the cost-effectiveness of micronutrient interventions – the currently preferred metric being cost per disability-adjusted life-year (DALY) saved. The other approach has been to estimate economic costs of micronutrient deficiencies as a first step towards undertaking a cost-benefit analysis of micronutrient interventions, an approach that development banks have been willing to take. The approaches are complementary but cannot readily be combined in a single metric. Saving
lives of small children (or preventing stillbirths) has enormous human benefits, but these typically do not show up as large economic benefits. Likewise, some micronutrients may have large effects on cognition or productivity, but relatively modest benefits in terms of saving lives. In some cases, the approaches may overlap: some micronutrient interventions may improve health as well as avert important costs to the health care system.

In this article we focus on the economic benefits. The World Health Organization (WHO) [1] has already done important work on the relative cost-effectiveness of micronutrient supplementation/fortification for vitamin A, iodine and iron. (The WHO website has more extensive discussion on their website, as part of the CHOICE project – CHOosing Interventions that are Cost-Effective.) The literature discussed in here does indeed suggest that micronutrient interventions are highly worthwhile investments, and also a fruitful area for public-private partnership [2].

In this short survey, we first examine in more detail the mechanisms through which micronutrient deficiencies can have economic impacts. We then use some specific micronutrients as examples to give estimates of the magnitude of the economic effects. The four mechanisms elaborated upon in the next section are the effects of micronutrients on productivity (generally of adults, in market work), on cognition, on morbidity, and on mortality, and we trace possible economic impacts through each route. In the following sections we survey numerical estimates for three specific nutrients, namely folate, iodine and iron. Again, this is not exhaustive. This survey does not go as far as comparing the economic costs of micronutrient malnutrition, with the economic costs of micronutrient interventions (cost-benefit) [for explicit cost-benefit, see for example, 3, 4]. The final section provides some policy suggestions and recommendations for future work.

Selected Mechanisms by Which Micronutrient Deficiency Can Adversely Affect Economic Outcomes

Here some of the key effects on productivity, cognition, morbidity and mortality, and their corresponding economic impacts are catalogued in turn. While this is not necessarily an exhaustive list, it represents some of the major mechanisms, beginning with those with the strongest empirical documentation of impact.

Productivity

Some micronutrients have well-documented effects on adult productivity. A large number of laboratory and field studies document the adverse effects of anemia on performance in laboratory tests and in the field [for summaries see, 3, 5]. Intervention studies, for example providing iron convincingly demonstrate that these productivity effects can be reduced/reversed by
reducing the level of deficiency. Biological studies provide the underpinning mechanisms for the underlying causes (reduced maximal work capacity; reduced endurance). The largest body of work exists for iron, but other micronutrient deficiencies such as zinc and iodine may directly affect productivity. The zinc results are more speculative, but productivity is known to be associated in some occupations with height, and zinc has effects on growth and stature.

**Cognition**

There is evidence that some micronutrients have effects on cognitive outcomes, both from studies correlating cognitive performance and deficiency, and from studies of interventions which find performance improvements. The most intriguing studies are those which follow up nutritional interventions over the long run, for example the INCAP supplementation studies in Guatemala, where participants received supplements both of energy and micronutrients [6]. There are relatively few such longitudinal studies, but they have the potential to find the broadest range of impacts. These studies of effect are supported by biological studies of the mechanisms. Evidence of cognitive outcomes exists for iron, iodine, and vitamin B$_{12}$, and is also hypothesized for zinc.

**Morbidity**

Some micronutrients are associated with impaired immune function and hence increased morbidity. Morbidity is most evident at vulnerable stages of life, for example in young children. There may also be effects in the elderly, but few such studies exist in developing countries. Morbidity in infants and children involves costs, such as costs of health care (visits to health practitioners, purchase of medicine) and costs of taking care of sick children and transporting them to hospital. These costs are hard to document in developing countries. Several micronutrient deficiencies are also associated with increased risk of premature birth (iodine, iron, folate for example). In developing countries the primary outcome may be increased neonatal mortality and stillbirth, whereas in developed countries with more developed health systems there are increased health care costs for the care of premature babies. Some deficiencies may lead to birth outcomes with implications for expensive long-term care, e.g. folate deficiencies which lead to neural tube defects.

**Mortality**

In the extreme, micronutrient deficiencies can lead to increased mortality. This has been documented for iron deficiency in both maternal mortality as well as perinatal mortality; for iodine deficiency in stillbirths and perinatal mortality, and for vitamin A in infant and child mortality. The WHO [1] attributes 0.8 million deaths worldwide to iron deficiency, 1.5% of the annual total,
0.8 million to vitamin A, 1.4% of the annual total, and 0.8 million to zinc deficiency, 1.4% of the annual total. One area not much examined is the effect of micronutrient deficiency in the elderly, where increased mortality may also plausibly be observed. One could make the case that calcium deficiency (via increased bone loss and falls) contributes to mortality in elderly women.

It is difficult to quantify the economic impact of stillbirths and deaths of infants and young children. The direct economic effect of these deaths in developing countries is likely more modest than for example the death of working-age adults from cardiovascular disease and stroke. The economic effect of the death of mothers in childbirth may be hard to demonstrate in countries where the assumption is that the man will simply take another wife, although the human costs are considerable. There are for example studies documenting the increased mortality rate for other children, if the mother dies.

However, there may be other important, but more subtle, effects. In societies with elevated infant and child mortality rates, there may be adverse effects on investments in children, affecting learning and education and hence long-run productivity. Savings depend on life expectancy since one important motive for saving is provision for one’s old age, hence shorter life expectancy may reduce savings, with impacts on economic growth. Individuals who are malnourished are less likely to play an active role in the community, possibly impacting social capital. All these effects are speculative and difficult to quantify.

The next three sections in turn examine the economic impacts of three nutrients, namely folate, iodine and iron (in alphabetical order). Readers will notice that vitamin A, one of the ‘big three’ micronutrients in recent policy, is not included. This does not imply that there are no economic consequences of vitamin A deficiency, rather that its major effects show up in health outcomes, and its effects on morbidity and mortality are the primary rationale for intervention. There are economic consequences of other micronutrient deficiencies which are not covered in this brief survey (the effects of zinc, calcium, and vitamin B₁₂ have all been mentioned above).

**Economic Impact of Folate Deficiency**

A number of recent studies have modeled the economic and health impacts of folate deficiency. One key area is in plasma homocysteine and the incidence of coronary heart disease, as well as stroke and peripheral vascular disease [7]. Another is in peri-conceptional supplementation and the prevention of birth defects, especially neural tube defects (spina bifida being an extreme case) [8], as cleft lip/palate, conotruncal (heart) defects, and limb defects.

Studies of birth defects suggest that based on recall data, there was a 30% reduction in the risk of heart defects and a 36% reduction in the risk of limb
defects if mothers had taken folic acid-containing multivitamins during the month before conception or the first 2 months of pregnancy [9]. In families at high risk of oral clefts because of a parent or previous child with the condition, there was a 65% reduction in risk in an intervention study if women received multivitamins and high-dose folic acid beginning 2 months before conception [9, 10]. The risk reduction for spina bifida with folic acid supplementation from at least 4 weeks before until at least 8 weeks after conception is 50% [8].

Table 1. Estimated costs associated with birth defects, potentially avertable with periconceptional supplementation with folic acid (in USD for 1992)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cost/case USD (millions)</th>
<th>Medical costs USD (millions)</th>
<th>Total costs USD (millions)</th>
<th>Possibly avertable medical costs USD (millions)</th>
<th>Possibly avertable total costs USD (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spina bifida</td>
<td>294,000</td>
<td>205</td>
<td>489</td>
<td>102.5</td>
<td>244.5</td>
</tr>
<tr>
<td>Cleft lip/palate</td>
<td>101,000</td>
<td>97</td>
<td>696</td>
<td>63</td>
<td>466</td>
</tr>
<tr>
<td>Tetralogy of Fallot</td>
<td>262,000</td>
<td>185</td>
<td>360</td>
<td>56</td>
<td>108</td>
</tr>
<tr>
<td>Truncus arteriosus</td>
<td>505,000</td>
<td>108</td>
<td>209</td>
<td>32</td>
<td>63</td>
</tr>
<tr>
<td>Single ventricle</td>
<td>344,000</td>
<td>62</td>
<td>172</td>
<td>19</td>
<td>52</td>
</tr>
<tr>
<td>Upper limb reduction</td>
<td>99,000</td>
<td>11</td>
<td>170</td>
<td>4</td>
<td>61</td>
</tr>
<tr>
<td>Lower limb reduction</td>
<td>199,000</td>
<td>17</td>
<td>167</td>
<td>6</td>
<td>60</td>
</tr>
</tbody>
</table>

Columns 1–4 are based on data from the California Birth Defects Monitoring Program [9]; columns 5 and 6 were calculated by the present author assuming the following relative risk reduction with periconceptional folic acid supplementation: 50% (spina bifida); 65% (oral clefts); 30% (heart defects including tetralogy of Fallot, truncus arteriosus and single ventricle), and 36% (upper and lower limb reduction defects). See references in text for sources for relative risk data.

defects if mothers had taken folic acid-containing multivitamins during the month before conception or the first 2 months of pregnancy [9]. In families at high risk of oral clefts because of a parent or previous child with the condition, there was a 65% reduction in risk in an intervention study if women received multivitamins and high-dose folic acid beginning 2 months before conception [9, 10]. The risk reduction for spina bifida with folic acid supplementation from at least 4 weeks before until at least 8 weeks after conception is 50% [8].

There are approximately USD 8 billion lifetime costs associated with birth defects related to births in a single year in the US. USD 2 billion of these are direct medical costs, and USD 6 billion are other direct costs such as special education and lost productivity due to premature death and occupational limitations; costs of caregiving are not included [9]. Table 1 (summarized from the California Birth Defects Monitoring Program [9], with additional calculations by the author) shows that, by applying the risk reductions associated with folic acid supplementation, about one quarter of these could potentially be averted by peri-conceptional supplementation of folic acid (about USD 1 billion total costs, including about USD 0.25 million in direct medical costs).
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This type of data has contributed to the implementation of flour fortification with folic acid in the US and efforts to encourage supplementation for pregnant women as well as women seeking to become pregnant.

There are additionally billions of dollars in annual medical costs that are potentially avertable with folic acid supplementation in the area of cardiovascular disease [for cost-effectiveness analysis and some data on medical costs see, 7]. It seems likely that more economic work will be done in this area to encourage other developed countries to adopt folic acid fortification and supplementation programs, in some cases linked to efforts to deal with deficiencies in vitamin B₁₂.

**Economic Impact of Iodine Deficiency**

Iodine is an excellent example of a case where data on the size of the economic costs of deficiency were used effectively to help mobilize support for international action to reduce deficiency. Iodine's role in thyroid hormones and hence regulation of metabolic activities of all cells throughout the life cycle means that severe deficiency can lead to lower metabolic rates, growth retardation and brain damage. The success of international efforts to intervene are summarized in the WHO's Third Nutrition Report [11]. Based on Clugston et al. [12] and Bleichrodt and Born [13], it can be estimated that there is an average 10.27% productivity loss per birth to a mother with goiter: 3.4% of such births are cretins with an assumed zero market productivity in adult life; 10.2% are severely mentally impaired with 25% lower productivity, and the remainder are 5% less productive than normal, using the estimate from Bleichrodt and Born [13] that IQ is 13.5 points lower.

This can be used to generate a crude estimate of economic losses by region, utilizing data on the prevalence of goiter from the WHO [14]. The dates of the goiter data are not specified but are likely from the mid 1990s. When these are combined with data on the gross domestic product (GDP) and per capita GDP by WHO regions (calculated by the author from data from the World Bank [15]), and assuming (to be conservative) that all the goiter is concentrated in the areas of poorer health and hence lower GDP within each region (i.e. that none exists in the ‘A’ regions categorized by health), table 2 provides estimates of economic losses by region. The estimates suggest that worldwide economic losses around 1994 (before salt iodization began to be rapidly expanded) could have exceeded USD 36 billion annually, exceeding USD 6 billion in each of three regions, namely the Americas (Latin America and the Caribbean), lower income Europe (Eastern Europe particularly Turkey, former Soviet Union), and Western Pacific (particularly China, parts of Southeast Asia). The losses were proportionately largest in the Eastern Mediterranean region where soils are particularly deficient and the prevalence of goiter was the highest.
Since widespread salt iodization has occurred, the predicted economic losses will decline dramatically. In the future, new methods to calculate losses will need to be developed, using urinary iodine as a measure of iodine status and relating functional impairments of children to the urinary iodine status of pregnant women (goiter rates only respond to improved iodine status with a long lag, and become a much less useful indicator).

Economic Impact of Iron Deficiency

Much work has been done on the economic impact of iron deficiency (although the success of interventions to reduce iron deficiency has proven more elusive). We summarize here the main effects directly on adult productivity, indirectly via cognitive development in childhood, and some illustrative dollar estimates for selected countries, based on Horton and Ross [3].
The effects of iron supplementation on adult productivity have been convincingly demonstrated both in the field and in the laboratory. There are some limitations, for example the studies demonstrate impacts within narrowly defined occupations where productivity can be readily measured, and omit more subtle effects (such as in white collar occupations where productivity is hard to measure, or effects causing workers to choose less demanding and lower productivity occupations, or even to drop out of the labor force entirely).

Two frequently cited studies give estimates of the order of magnitude of the productivity impact.

The first study of male rubber plantation workers in Indonesia [16] showed that iron supplementation of anemic workers (undertaken in a placebo-controlled, double-blind trial) was associated with a 17% increase in the weight of latex collected. This suggests that large increases in productivity can be associated with iron supplementation in very heavy manual labor, where maximal work capacity is a factor. The second study, [17] of female textile factory workers found that iron supplementation (again in a placebo-controlled double-blind trial) was associated with a 5% increase in productivity. This study suggests that even in occupations involving light manual labor, there are effects of iron deficiency on productivity likely via endurance. Although the productivity effects are more modest than in heavy manual labor, they occur over a broader range of occupations.

The effects of iron supplementation on cognition are somewhat speculative since there are as yet no long-term studies of interventions, although the INCAP studies may capture the effects of iron supplementation as well as supplementation of calories [6]. Our earlier work [3] relies on a series of inferences. We surveyed 11 studies of interventions for children below 2 years of age, which found evidence of effects on motor skills as well as mental skills, which tend to be more significant when children are initially anemic and when the intervention has a longer duration. The effects on motor skills are of more interest, since these are correlated with mental tests on older children (whereas mental skills below the age of 2 years do not correlate well with mental tests on older children). In 4 supplementation studies in developing countries on children over 2 years old, 3 studies found improvements on cognitive tests. The one with a quantitative measure of effect [18] found this to be about 0.5 SD, similar to the difference between anemic and non-anemic children in observational studies. Suppose there is some attenuation of effect over time (the intercorrelation between IQ scores of children ages 6–8 years, with those of the same children age 17 years, is about 0.62–0.65 [19]. Finally, 5 studies we surveyed for developing countries suggested that a 1 SD increase in cognitive achievement, was associated with an 8% increase in adult wages. Accordingly, a plausible estimate is that iron interventions in children in childhood could result in a 2.5% productivity impact in the labor market (8% × 0.5 × 0.65). This is conservative, since it does not include the
well-documented effects of improved cognitive performance on higher schooling, and of schooling on wages (and hence implied productivity).

When these effects (17% impact on heavy manual labor, 4% impact on light manual labor, and 2.5% effect on other labor) are combined, along with information about the level of anemia in men and women, women’s share of the labor force, and the relative importance of heavy manual and light manual labor in total work, one can make estimates as to the US dollar value of economic losses associated with insufficient iron intake.

Figure 1 presents these estimates in USD per capita for 9 countries, showing the contribution of losses in different kinds of work. Table 3 provides similar

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Table 3. Economic losses expected due to iron deficiency, as % GDP and in absolute USD for 1994

<table>
<thead>
<tr>
<th>Country</th>
<th>Loss 1994 (USD millions)</th>
<th>% GDP 1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanzania</td>
<td>24</td>
<td>0.59</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>451</td>
<td>1.74</td>
</tr>
<tr>
<td>Mali</td>
<td>21</td>
<td>0.84</td>
</tr>
<tr>
<td>India</td>
<td>4,294</td>
<td>1.47</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>11</td>
<td>0.81</td>
</tr>
<tr>
<td>Pakistan</td>
<td>501</td>
<td>0.92</td>
</tr>
<tr>
<td>Honduras</td>
<td>16</td>
<td>0.33</td>
</tr>
<tr>
<td>Egypt</td>
<td>180</td>
<td>0.42</td>
</tr>
<tr>
<td>Bolivia</td>
<td>29</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Source: updated calculations based on Horton and Ross [3].

Fig. 1. Per capita loss due to iron deficiency.
information as to the absolute dollar value of losses and the loss as percent of the GDP for the same countries. A couple of things stand out. Broadly speaking, the share of the loss associated with cognitive effects increases with the level of development (figure 1 and table 3 are arranged in order of ascending GDP per capita). Losses tend to go up absolutely with the level of development (the exception is that the level of anemia is much higher in the South Asian countries showing correspondingly higher losses). Losses as a percentage of the GDP tend to be highest in the poorest countries, particularly the South Asian poor countries which have the highest levels of anemia. Table 2 also points out that the annual losses in South Asia exceed USD 5 billion. The losses in sub-Saharan Africa would also be substantial.

**Policy Implications, and Areas for Future Research**

This brief survey shows that the economic costs of micronutrient deficiency are substantial, and provide a compelling rationale (in addition to the health consequences) for intervention. The results need to be interpreted cautiously. The economic costs estimated here are generally costs existing in cross-section at the current point in time and accumulated due to past deficiencies (deficiencies in utero or during childhood, with the exception of the immediate effects of iron on adult productivity). Hence programs of intervention will not have dramatic effects instantaneously, but will take time to show economic gains. One way to see this is to undertake a formal cost-benefit of interventions, appropriately discounting future gains, and using an 'incidence methodology'.

The three micronutrients examined here are of interest, being at different stages in the policy lifecycle. The adverse effects of iodine deficiency were recognized and quantified during the 1980s, and led to a policy thrust to iodize salt broadly throughout the developing world in the 1990s. Although the productivity effects of iron were well known in the 1980s, the technical issues to reduce deficiency had not been solved. Quantifying the economic costs in the late 1990s has underpinned current ongoing efforts for widespread iron fortification. Finally, the economic impact of folate deficiency has only been more recently calculated: countries with existing fortification are very few (the US has fortification, but Netherlands which has calculated the costs, has not yet opted to fortify), but it is likely that efforts to fortify and supplement will become more widespread.

Some of the nutrients not covered in detail in this survey are at too early a stage in the policy lifecycle to include. It is likely that there are economic impacts of zinc deficiency, but the relative lack of studies of impact and the difficulties in measuring zinc status mean that little progress has been made. The economic effects of vitamin $B_{12}$ deficiency are likewise understudied.

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Some useful areas for future research would include: the effects of micronutrient deficiency in the elderly; those micronutrients for which the evidence base is not as strong (such as zinc, vitamin B₁₂), and micronutrients for which policy implementation has as yet occurred in only a few countries (folic acid).

References

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Discussion

Dr. Endres: I think physicians don’t very much like to compare cost versus treatment, but if we have to convince policy makers then it must be done. Only in one small case did you mention how much we save if we spend money, for example, to fortify flour
with folic acid or salt with iodine. I could imagine that in countries where unemployment is very high, policy makers don’t pay much attention to these benefits because they believe there are enough people to compensate for the loss of productivity due to illness. Do you have any figures proving that a non-reaction by policy makers has happened? In the past 20 years we have seen how difficult it is to add iodine to salt in many countries. For example in Germany it was extremely difficult to convince people, and it is the same and still true for folic acid fortification of flour in some countries.

Dr. Horton: I think you are absolutely right. It is very difficult to do a case-control study because you either fortify for the whole country or you don’t. And if you fortify you don’t have case controls; you don’t have groups that are not receiving the flour. It is much less good quality evidence than nutritionists would like to work with. Many times also you are working with the counterfactual of what would have happened if we didn’t do this. I think now we will begin to see problems if countries like New Zealand and Switzerland start to slip back and get iodine deficiency because they let up on the effort on salt. But unfortunately, because we are doing this counterfactually it involves modeling and it involves making assumptions. You also made a very good point about unemployment. People won’t care so much about adult productivity if unemployment is high, and how I would counter that is to say that cognitive effects are really important. No developing country can argue that they have an excess of cognitive skill. Clearly to succeed in the world economy, education and cognition are increasingly important, and I think this is a really important area for more work.

Dr. Tolboom: I have a question about the mortality you mentioned in adults which is clearly a great loss economically. But I would like to have your ideas as a professional on infant and child mortality. As doctors we do our best and try to save life, but if I were an economist I would perhaps say, so what? So I would like to have your ideas on that one.

Dr. Horton: That is why I carefully avoided doing any estimates on the cost-benefit of vitamin A. As an economist I am very uncomfortable with attaching low values to lives of children and infants, but unfortunately that is what convention and economic assumptions will do. So I think to some extent you have to use both techniques. The global burden of a disease is one calculation, as the economic loss is another, and for certain nutrients the economic losses matter more than for others. For iodine the economic case is much more important than the global burden of disease, but it is the reverse for vitamin A. So in my own work I have always refused to make that trade off.

Dr. Bhutta: Thank you for these very interesting economic arguments. I just want to support the need for them in countries where health budgets are very low and where not enough priority and attention have been paid to health and nutrition issues. It is very important that we further develop and expand on these economic arguments if policy makers, who are driven a lot by economic arguments, are asked to increase their investment in this very critical area of human development.

Dr. Gebre-Medhin: I very much enjoyed listening to you and I think this is a very important component of our deliberations. Dr. Tolboom partly took up my question and the issue of calculating the impact on mortality. Many years ago, when I worked as a pediatrician in Ethiopia, we tried to calculate the impact of death in families from a cultural perspective. Every family is culturally bound to perform in a certain way and this may go over a period of several years, having to invite the community, not working for periods of time, coming back again and celebrating the death of children, for example. We came up with horrendous figures on loss of work and productivity because of this cultural impact. Have you done any work on that? Working in Sweden we are now worried about initiating a folic acid-supplementation program in Sweden because side supplementation may lead to an increase in twin births, and the calculations for Sweden seem to point in the direction that the benefits are balanced off. I would like to hear your comments on that.
**Dr. Horton:** On the first question, on the cost of mortality, let me give you one example. I was in Pakistan doing work on the high level of maternal anemia and maternal mortality rates, which were shockingly high. But then my collaborator, who is a nutritionist from Pakistan, asked me the ‘so what?’ question. He said ‘so what, these people will just take another wife’. So it was hard in that context to attach a value to it. There are studies showing that the death of the mother has significant effects on death of other small children in the household, so that there are social consequences that are perhaps hard to capture economically. As to your second question about the down side, sometimes in addition to benefits from the intervention there are down sides as well, and the same is true for the fluorination of water that has been strongly resisted in some countries because people perceive a negative effect of adding substances to food you can’t avoid consuming. As an economist I would just take the cold-hearted approach that you calculate the value of the benefits and those of the additional costs, but one thing you have to take into account is that different people will bear the benefits and the costs, and that is a very hard value judgment to make.

**Dr. Semba:** You talked about applying these analyses to older adults, and there is this idea with the compression of morbidity hypothesis that you would keep older adults healthier longer. We can compress all their morbidity and all the cost of the health care into a very short period of their life. I am just wondering if these types of analyses have been applied to something like vitamin D deficiency and hip fracture in older adults?

**Dr. Horton:** Probably there are people here who would know more about this than I do. Since I primarily work in developing countries I haven’t surveyed the literature on older adults; it has been less relevant for developing countries. But clearly with the increase in life expectancy in countries like China, I think there would be increased interest in this for developing countries as well, and I think we should encourage much more work on this. In the developed countries older adults have effects on the economy, not primarily through their work output because often they are retired, but through huge costs to the health system from health effects such as fractures.

**Dr. Pettifor:** I wish to discuss the issue of child mortality and, as Dr. Tolboom brought up, that mortality has very little cost on productivity. In fact it may have a benefit as one is removing a child from the family and the cost of feeding that child. So a much bigger problem is in fact morbidity rather than mortality during childhood. Have you studied that?

**Dr. Horton:** It tends to be very specific to the country. I mentioned birth defects. These have huge costs in the US but I would expect much lower costs in developing countries. I think even if you did the work very carefully, and often we are hampered by the lack of data from doing it, the costs for morbidity in children still would not bear up against the costs of morbidity in adults, even though for families they may be quite significant. Sometimes a severe illness in a child could be the thing that pushes a family into poverty, so I think we shouldn’t neglect that.

**Mr. Parvanta:** I guess you are really a very good economist because you certainly have learned the value of nutrition or micronutrients. In the United States, for example, there has been a very successful nutrition program for women and children, the Women, Infants, Children (WIC) program has lasted now for about 30 years. A number of evaluations have been done, and as I recall the last time I looked some years ago, they came out with an estimate that for every dollar spent on the program there was a savings of USD 3–4 on future health care cost. I am wondering whether you have used this kind of information in some of the calculations you have made?

**Dr. Horton:** Yes, I am familiar with them. For example vitamin A in WIC products, there have been studies associating this with less otitis media and ear infections, and showing that there are net economic savings. 20 years ago I also did work on the food stamp program in the US, and you know the economic benefits associated with that.
Yes, definitely you can make an economic case associated with these kinds of social and health interventions in developed countries; in the Head Start program (an education intervention), people have done the cost-benefit of that. These studies tend to be better than for the developed countries because we have more data, we have more panel studies, we can control for things better, we have much better cost data for the health system.

Mr. Parvanta: I am not an economist and certainly I have a lot of trouble saving money. But the question I have is the issue of cost, if you could perhaps help me understand this a little better. Often when I am speaking with colleagues and governments and public agencies, development agencies, when we talk about cost it almost seems as though we are approaching them with the perception that the government has to pay, to cover the cost, or the development agency has to cover the cost. Yet in a lot of these programs, especially the fortification of salt or flour, the idea is essentially that the cost will be passed on to the consumer. Are those costs the same kinds of costs? I guess in terms of fund money it is, but can you give us an idea of how we might use that to help convince certain governments or public agencies how to deal or how to think about those costs?

Dr. Horton: I should mention that economists don’t have the monopoly on doing savings; I also do not balance my check book very well. But the ‘who pays?’ perspective is really important and if you read a cost-benefit study it often tells you from whose perspective it has been written. Sometimes for the US, the study is done from the point of view of the government as payer or the health system, and then the government makes the decision. If it is going to save the government money then it will implement the project. But economists would advocate that you should take a more general perspective and you should be concerned about social costs. The social costs may not even be monetary costs, sometimes there are resources which appear to be free because there are no charges but that doesn’t mean that there is no social cost. For example, suppose you make a nutrition intervention that takes a lot of the mother’s time. Many mothers are not working in developing countries or in developed countries, or they are not working in the market and not being paid. Does that mean we can freely use their time in a project at zero cost? No, of course not, there are opportunity costs, there are costs of the things that they are not doing. A part of the methodology of doing cost-benefit studies appropriately is to think of the payer perspective, and also attaching true economic societal costs to resources.

Dr. Lozoff: I am curious, when you present this kind of economic analysis, what sort of attacks do you get? What criticisms come up?

Dr. Horton: Perhaps I have been lucky, I have had good experiences. I remember being in Vietnam where UNICEF has been trying to convince the government to do investment planning and the government was really more interested in economics, trying to get the economy to grow, and perhaps let the social consequences take care of themselves. The minute they started hearing rates of return on iron investments, it had an effect on the Minister of Finance, the financial people’s discussions. There are a couple of organizations, the Micronutrient Initiative and the Food and Agriculture Association of the UN have been developing tools in which you can plug into economic models’ data for your own country, and come out with the results for the economic costs of iron deficiency in your own country, and the rates of return. From what I understand these are quite convincing for policy makers. But on the other hand people do raise doubts about the assumptions, for example the issue that many people are unemployed. Actually you could quite validly criticize the results, the assumptions I have made on the cognitive effects of iron saying we don’t have longitudinal data to support that, you are making a big assumption. That plus the general dislike of economists’ ideas about assumption, the idea that you should be able to put a value on human life is very distasteful to many people, so not everyone is convinced.
Dr. Zlotkin: One of the problems I think with iron is that as you describe the costs, you list four costs in the area of productivity, cognitive cost, morbidity cost and mortality cost. But unlike the example for vitamin A deficiency or iodine deficiency where for vitamin A you have something that population people can understand, they understand blind, what it means to be blind, and with iodine deficiency people understand what it means to have a big lump in their throat. What you are doing in terms of the economic advocacy is really important but part of our overall problem is finding the right hook for physicians to advocate their governments to do something about anemia, teachers to advocate their ministry of education to do something about anemia, and the economic ministry to do something because I think the argument you make whether it is owed by 1 or 2 degrees is a very powerful argument. Most of us would say that if we were to invest USD 2 and get a return of USD 10 or 20 everyone in this room would do it. So the question is why haven’t we done it? I think one of the reasons we haven’t done it is that we do need popular support for this type of advocacy and we lack this blindness when we are talking about anemia. So I think what you are doing is extremely important and the information you provide is important, but I really do think it is up to all of us in the room to be the advocates for this particular health issue.

Dr. Horton: I think you are right and zinc is an even more extreme example. It is difficult to measure zinc status, we don’t have good estimates of prevalence of zinc deficiency and it is going to be even harder with zinc than with iron.

Mr. Parvanta: I would like to follow up on Dr. Zlotkin’s comment as far as the delivery of the message or the hook that you mentioned. Dr. Galar told me about the work he tried to do in Egypt. When he made appointments with the Minister of Education of Egypt to explain the issue of anemia and how the children were sick and anemic and not feeling well, and to talk about iron deficiency anemia. He said that the minister was very kind and gracious but told him to go and see the Minister of Health. He had two visits like this. On the third visit, he became wiser and did not talk about iron deficiency to the Minister of Health; he said nothing about anemia, he talked about the cognitive and education skills of the students and the fact that they were not learning as well at school. This time, on the third visit, the minister not only listened but he actually got out from behind his desk, came around, put his arms around Dr. Galan’s shoulders and asked him to sit on the couch and talk about iron deficiency once again. So the type of message that we give is very important. One final observation I made in China. As I understand, and I suppose our colleagues from China can verify this, micronutrients and nutrition interventions are components of the national development plans, the economic plans of the country, and part of the reason why that came about, as I understand from the stories I was told by colleagues there, is that there was a meeting in 2000 in Manila on fortification and micronutrients actually had a lot to do with it. The meeting was sponsored by the Asian Development Bank and so the report of the meeting was put together in English and was sent to the various countries. The copy that went to China went routinely to the Ministry of Economy to be translated. It was sent to the group that handles the economy or finance, and so the economists could actually read this entire document in order to translate it into Chinese. As a result they actually paid attention to essentially every sentence and that is when they became aware: ‘Oh, we didn’t realize that nutrition had so much to do with economic development’, and that lead to the next steps. So it is a coincidence that the report went there. What we have to do is give this type of information to the right source with the right hook.

Dr. Semba: I understand why you are avoiding the cost of the child or infant dying. I think it has much broader implications for society. There was a book published years ago by Scheper-Hughes [1] who is an anthropologist working in Bahia who wrote about the high mortality rates, and how it just was accepted. A child dies and the mother has another child, and I think when it gets to a point where society comes to accept this, then we have all failed.

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**Dr. Sablan:** The real issue with food fortification is that the economic burden has actually shifted to the industry. In our country we have a food fortification program which has actually been shown to be more cost-effective than actual supplementation, and the Ministry of Health agrees that it is a good program and it will actually address a lot of vitamin and mineral deficiencies. As an economist, is it not a little hard to convince the industry that they will actually be carrying the cost of fortification? In the long run they will probably look at the long-term effects and realize that it is probably very good to fortify and will improve the economy. But what would be your answer to their question on the short-term so that they will fortify?

**Dr. Horton:** I think there are several things that you can do. Firstly industries may bear the costs of the initial investment but typically they will pass the costs on to the consumer, the recurrent cost of the fortificant. So in those cases it is really important to do social marketing. It is really important to make the consumers aware that what they are consuming is a better quality product, that they should be willing to pay these few cents additional cost because of the benefits that will accrue to them and their children, and that may be something where assistance is required for social marketing. So that is one thing that is really important. Another thing that is really important is legislation. There have been some attempts in small African countries to go for fortification of sugar, for example, but if you are acting in isolation without all the countries surrounding also acting in this legislation you run into problems of cheaper unfortified supplies coming in. So this is not a problem in big countries like the Philippines or India, but in Africa it indicates that it is going to be more difficult to fortify because we will have to get regional groups of countries to act in concert.

**Reference**