

Original Article

The potential impact of reducing global malnutrition on poverty reduction and economic development

Joseph M Hunt PhD

John Simon Guggenheim Memorial Foundation Fellow (Nutrition and Economics)

This review is premised on the importance of reducing both underweight prevalence of children, as the key policy variable for hunger reduction, but also reducing “hidden hunger” - the micronutrient deficiencies that rob life, health, ability and productivity. The role of nutrition in development is discussed, balancing the importance of broad infrastructure policies and nutrition-relevant actions in health services and in community development. Convergent approaches to eliminating micronutrient deficiencies include supplementation, fortification and biofortification. Relative costs drive a reordering of the mix. Next, community-based health and nutrition programs in South Asia and Sub Saharan Africa could be the focus of a global strategy to reduce underweight prevalence among under-fives, and resource needs are discussed. An approximation of resources needed to meet the first Millennium Development Goal (halving global hunger), with side benefits to MDG # 4 on child mortality) is offered. The author draws upon his recent paper on costs and benefits of hunger alleviation prepared for the United Nations Hunger Task Force (Hunt 2004).

Key words: global malnutrition , poverty, economic development, underweight children, hidden hunger, food fortification, Asia, Africa, United Nations Hunger Task Force

I. Nutrition and economic development

This paper addresses the micronutrient deficiencies, the clinical and food-based interventions that work well when they are combined to reach target populations; the community actions that promote growth and mental development of young children before death or the crippling effects of being underweight or stunted intervene; and the innovative approaches of public nutrition programs that cross health, agricultural and industrial boundaries to promote health and wealth. The role of environmental prudence in preventing ill health and poor nutrition is mentioned, as a counter-weight to the peculiarly modern notion that health services are the cornerstone of good health.

Improvement of human health at the population level is largely determined by good policies that protect the environment and people, that raise the quality of the working and living environments, and that assure the permanence and safety of life's necessities—air, water, food, and shelter—as widely as possible. The advent of health services and modern medicines as a response of the State to demands for health care by the public occurred late in the mortality transition of the industrializing West, as Thomas McKeown (1976) famously showed. Health services are a 20th century concept and practice, but the secular decline in mortality in northern Europe occurred long before. McKeown showed that between 1700 and the 1970s, the American standardized death rate declined by 35 points and the British rate by 21 points. About 70% of the American decline and about 50% of the British decline took place before 1911. Modern medicine (e.g. antibiotics) is a 20th century intervention and access to health services of

life-saving potential was remote for most people during this rapid mortality decline.¹

According to the World Health Organization (WHO), almost one third of the global disease burden can be attributed to environmental risk factors. That means that preventive strategies can be deployed by many sectors in society to avert harm in the forms of death, disability, and illness. The point is that just as health services are viewed as the provision of the right to health, regardless of the political influence of the sufferer, improvement of the natural and human environments for life and work address mortality and disability arguably as profoundly as the cumulative impact of health services.

Health, wealth, and equity

Human resources economics have demonstrated the positive correlation between income per capita and health, but

Correspondence address: Dr Hunt, John Simon Guggenheim Foundation Fellow (Nutrition and Economics)

Tel: 011-617-822-9474

Email: josephhunt4@hotmail.com

Accepted 1 October 2004

¹ This observation is in keeping with the history of health in the developed world, where life expectancy increased from about 50 years to 75-80 years during the 20th century. Of the 25-30 years of increased life expectancy seen in that century, about 80% can be attributed to public health measures (improved water sanitation, nutrition, immunizations, decreased environmental pollution, reductions in major injuries, and healthier, safer work places) and only about 20% to technical advances in health care.

only recently has the literature recognized that health is fundamental to sustained economic growth. Healthier populations have lower mortality and fertility rates, higher labor productivity, are more inclined to invest in higher levels of skills training for themselves and education for their children, leading to higher permanent incomes, savings rates, and national investment over time. Improvements in population health set in motion a virtuous cycle of rising incomes and poverty reduction (Bloom and Canning, 2000).

Health equity, normally relegated to abstract reflections on social justice, has concrete influence on sustained economic growth. According to Sen (2002), countries that pursue “growth-mediated” processes often find that inequalities in income persist or exacerbate inequalities in health, and reduction of income poverty alone does not necessarily catalyze health equity. Given the acceptance that health is a universal human right, inequalities in health can be seen as a transitional state of affairs in developing societies struggling to raise incomes, and are viewed as inequities only when they are avoidable, unnecessary, and unfair. Sen argues that countries adopting “support-led” processes are more likely to address the socially controllable determinants of health that include establishing levels of basic human needs by essential services for all and by pro-health policies assuring education and health care for all, food and nutrition security, water supply, and public sanitation at a minimum.

II. Rationale for investment in public nutrition to alleviate global hunger and malnutrition among poor women and children

Without concerted action, 140 million under-five children will be underweight in the year 2020. (Smith and Haddad, 2000). More than 180 million children under age five – nearly one in three – are stunted. 40% of the developing world’s people suffer from iron deficiency - 1.6 billion people are anemic. Nearly one fourth of the half million women who die in childbirth or its tragic aftermath are severely anemic, the cause of those deaths. Probably 15% in the developing world lack adequate iodine, half the rate a decade ago because of the rapid expansion in coverage of iodized salt. Up to 40% of under-five children are growing up with insufficient Vitamin A.

The economic and mortality consequences of malnutrition in developing countries are staggering, and must be addressed if sustained and equitable economic growth will convert most countries to a “developed” state. The separation of underweight and micronutrient deficiencies is a programmatic decision for governments and agencies, but they are interrelated dimensions of the pathology of malnutrition. Programs that address the improved height, weight and micronutrient status of children and women of reproductive age are more likely to contribute to sustained human and economic development. More narrowly bounded programs must coordinate better with other sectors that attack other parts of the malnutrition equation.

According to Pelletier *et al.*, (1994), 54% of child deaths in developing countries are attributable to malnutrition, the single greatest cause of child mortality. Most of these preventable deaths are located in South

Asia and about a dozen countries in Sub-Saharan Africa. Most of these deaths hit mild and moderate underweight children, not the visually decimated victims of famine. Children under five with mild, moderate, or severe malnutrition under five years are respectively 2.5, 4.6 or 8.4 times more likely to die than children whose weight-for-age is within the normal range. MDG#1 (halving number of under-weight children between 1990 and 2015) and MDG#4 (two-thirds reduction in under-five mortality rate between 1990 and 2015) are obviously inter-related.

Further evidence suggests that thin children are usually the issue of thin mothers, and both are caught up in an intergenerational cycle of poverty and malnutrition. Underweight or very thin children, suffering from macro and micro deficiencies, are much more susceptible to chronic diseases in midlife, including cardiovascular diseases, hypertension, and diabetes, which combined with poor adult diets predispose for adult obesity. Thus, poor children risk a ‘double burden of disease’ through fetal risks (Barker 1998). Proper nutrition for the mother and young infant will avert a substantial disease burden across the life cycle of the next generation. The same causes that lead to underweight (low maternal height and weight, low social status of women, poverty, lack of access to micronutrient-enriched foods, lack of community resources to support optimal child growth) lead often to stunting by age 3, rarely reversible. Stunted children suffer IQ loss, a higher likelihood of entering school and not completing basic education, as well as later onset of nutrition-related chronic diseases (diabetes, hypertension, heart disease among others) that lead to early death, diminished quality of life without needed health care services because of income constraints. Stunting impacts negatively on the future productivity of children (Haddad and Bouis, 1991): reduced adult height for childhood stunting is associated with a 1.4% loss in productivity for each 1% loss in adult height.

Micronutrient deficiencies reduce children’s learning ability, school performance and retention rates (Jukes *et al.*, 2002). Iodine deficiency disorders (IDD) are implicated. Based in research findings by Clugston *et al.*, (1987), it is estimated that 3% of babies born to iodine-deficient women suffer from cretinism and 10% suffer from severe mental retardation. A meta-analysis of 20 studies demonstrated that in endemic iodine-deficient communities, the IQ of children is reduced by about 13 points. Bleichrodt *et al.*, (1994). Vitamin A Deficiency (VAD) causes many child deaths, and Vitamin A capsule (VAC) distribution programs have demonstrably reduced under-five child mortality by a range of 20-26% in the developing world, based on a synthesis of eight country trials by Beaton *et al.*, (1993). VAD is a risk factor for mortality from measles, diarrhea and dysentery, and this likely explains the strong effect (Arthur *et al.*, 1992).

Maternal anemia is responsible for 20-22% of maternal deaths due to complications of pregnancy and unsafe birthing situations (Ross and Thomas 1996; Allen and Gillespie 2001). Productivity effects for adult anemic agricultural workers (or other heavy manual labor) are reduced by 1.5% for every 1% decrease in hemoglobin (Hb) concentration below the established threshold for safe health (Levin *et al.*, 1993 in Jamison 1993).

II A. Productivity gains

Millions of lives and billions of dollars of missed productivity (direct wages and indirect gains through advanced schooling) are at stake every year, and yet there are both established and emerging technologies that can reverse the downward spiral of malnutrition, diminished mental and physical performance, and perpetuated poverty.

The direct productivity effects of malnutrition are on the capacity to perform physical work and on earning ability. Protein-energy malnutrition (PEM), stunting, and iron-deficiency anemia (IDA) reduce both. Improvements in PEM improve wages through increases in weight-for-height, while improvements in iron increase the capacity to perform moderate to hard labor with related increases in wages. These effects have been demonstrated in India, Indonesia, Philippines, and other countries (Haddad and Bouis, 1991; Basta *et al.*, 1979; Deolalikar, 1988; Spurr *et al.*, 1977; consolidated in Behrman, 1992).

II. B Cognitive gains

The indirect productivity effects are on cognitive ability and achievement, through impact on psychomotor skills, development quotients (DQs) for infants, and intelligence quotients for both pre-school and school-age children. IDD, PEM, and IDA have substantial negative impact on developmental capacities of children, probably in that order of significance. As noted, in high-risk populations with a large incidence of goiter, IDD depresses average intelligence by 13 IQ points. Salt iodization programs throughout the world are helping to eliminate this problem, but much work remains to be done in terms of program coverage and product quality. IDA depresses psychomotor skills and intelligence, but the effects are reversible if the intervention is early enough (Brown and Pollitt, 1996; United Nations Subcommittee on Nutrition, 1991). PEM depresses DQs and Bayley scores in 12-month-old children in a controlled study have shown that psychomotor and mental development indices correlate with birth weight groups. On the other hand, appropriate complementary feeding for under-twos has a remarkable effect on stunted children of impoverished background, especially when combined with early cognitive stimulation (Grantham-McGregor, 1995).

Macroeconomic impact: raising growth rates

A regional Asian effort to impress governments on the urgency of taking action has yielded estimates of the growth-reducing impact of malnutrition in a number of low-income Asian nations (Mason *et al.*, 1990,2001). Asian Development Bank and UNICEF worked with seven countries² to develop 10-year investment programs that would achieve the International Conference Nutrition (ICN) and World Summit for Children (WSC) goals somewhat belatedly. The general conclusion was that malnutrition, with its insidious effects over the life span of the child, will cost the economies of developing Asia at least 3% of gross domestic product, based on conservative assumptions (a 'low scenario' built into the model). India, for example, loses growth from two directions: adult

productivity (3%) from PEM, iodine deficiency, and iron deficiency; and from IDA-induced cognitive impairment (about 1%). The study estimated that productivity losses for manual laborers are up to 9% for severely stunted workers; losses from IDA are 17% for workers engaged in heavy physical labor and 5% for moderate labor. Losses due to cognitive deficits for malnourished children were 10 % for stunted individuals, 4% for IDA, and 10 % for IDD (from Horton, 1999). This translates into a staggering sequence of losses in growth and human potential for the region as a whole.

Horton and Ross (2003) show that IDA has substantial impacts on both physical and cognitive ability, but the cognitive effects on earning and national economic growth are dominant, and these impacts increase proportionately to average wage and per capita income in developing countries. The estimates, drawn from a ten country sample in all developing regions, demonstrate the huge losses to personal income and national economic growth imposed by poor cognitive development in early childhood with lifelong consequences. Among the ten countries, average annual productivity losses are estimated at 0.57% of GDP, but when cognitive losses are added, the total is 4.05%. Losses in absolute terms rise with level of per capita income by country; for example, the annual losses to anemic South Asians is \$ 2.04-\$ 4.53, or \$5 billion for the sub-region; for richer Latin America, the range is \$ 4.03 - \$8.53 (Fig. 1).

II.C Malnutrition's contribution to global disease burden

In the 90s, the WHO provided the best known estimate of nutrition's contribution to the global burden of disease, about 16% (Murray and Lopez, 1996). This is certainly an underestimate, because malnutrition's contribution to mortality from communicable diseases is not factored into the model, and the recently discovered links between fetal malnutrition, low birth weight, and chronic disease risks in mid-life are ignored as well. Mason *et al.*, (1999,2001) estimated the contribution is about one-fourth. Nutrition's contribution may increase in the next century, even if underweight under-fives decline, according to Murray and Lopez (1996). The projected shift in disease burden towards cardiovascular diseases, diabetes and cancer, with persisting problems among the infectious, parasitic and respiratory diseases, have an underlying theme: nutrition as a shared risk factor.

According to Ezzati *et al.*, (2002, 2003), about 15% of the global disease burden can be attributed to the joint effects of "under nutrition" - child and maternal underweight and micronutrient deficiencies. However, the latest estimate shows this is considerably understated. As part of the Disease Priorities Control Project (DCPP), Mason, Musgrove and Habicht (2003) have recalculated malnutrition's contribution to be one-third of global disease burden. The WHO estimate of 16% was based on Pinstrip-Anderson *et al's* emphasis on protein-energy malnutrition. The new estimate under the DCPP takes into account more recent knowledge about micronutrient deficiencies and mortality, morbidity, and disability. Mason,

2. Bangladesh, Cambodia, India, People's Republic of China, Pakistan and Viet Nam

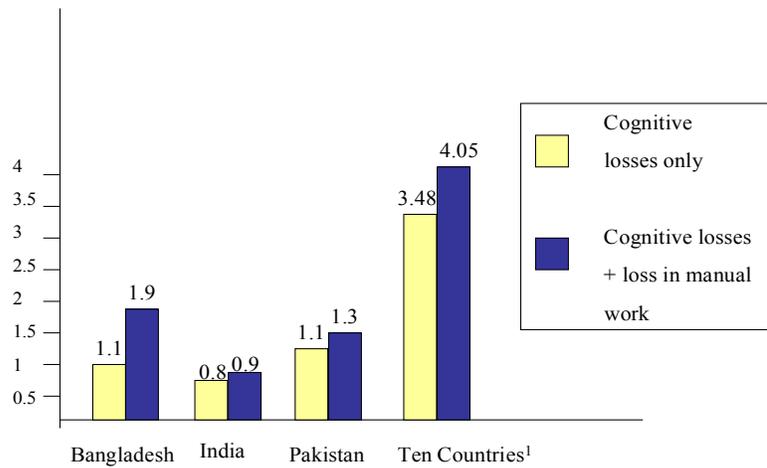


Figure 1. Percentage loss in GDP due to iron deficiency; *Source: Horton 1999, Horton and Ross 2001*
¹Bangladesh, India, Pakistan, Mali, Tanzania, Egypt, Oman, Bolivia, Honduras, Nicaragua

Table 1. Estimated reductions in the disease burden (% DALYs lost) in developing countries (all population groups, all causes), from general malnutrition (as underweight) or micronutrient deficiencies (vitamin A, iodine, and iron); from the direct effect (the deficiency considered as a disease itself) and as a risk factor for other diseases (infectious diseases only included in estimating reduction).

	Direct effect	As risk factor	Total
General malnutrition	1.0%	14.0%	15.0%
Micronutrient deficiencies	9.0%	8.5%	17.5%
Total	10.0%	22.5%	32.5%

Source: Mason, Musgrove & Habicht, (2003), table 10

Musgrove and Habicht (2003), summarize their findings:

“ The portion of the global burden of disease (mortality and morbidity, 1990 figures) in developing countries that would be removed by eliminating malnutrition is estimated as 32%. This includes the effects of malnutrition of the most vulnerable groups’ burden of mortality and morbidity from infectious diseases only. This is therefore a conservative figure, but nonetheless much higher than previous estimates, mainly due to now including micronutrient malnutrition. The larger part (20%) is from malnutrition acting as a risk factor, in synergy with infectious diseases, modifying their effect on health and survival. About 10% of the burden is the direct effect of deficiencies with very high prevalences, primarily iron (e.g. anemia affects 40-55% of women, non-pregnant and pregnant) and iodine (over 600 million people with goiter) causing disability. In children 0-4 years, reducing underweight (an index of general malnutrition) would lower their disease burden by 35%, mostly by reducing mortality. Vitamin A deficiency also primarily acts as a risk factor in infant and child mortality, and eliminating it would save 16% of the burden in children. The mortality risk associated with iodine deficiency is the least well known; a few results indicate a possible 8% benefit in child mortality reduction. Eliminating severe anemia in pregnancy is estimated to reduce maternal disease burden by some 13%. The countries with the worst health and nutrition conditions – Asia and Sub Saharan Africa – would gain most from the broad public health benefits of better nutrition. Seen in relation to the overall burden (all population groups, all causes, developing countries), eliminating child underweight

would save 15%, and eliminating micronutrient malnutrition (in children plus anemia in reproductive age women) an additional 18%“

The breakdown for direct and indirect effects is in Table 1.

III. Convergent approaches to eliminating micronutrient deficiencies in developing countries

Economists have reflexively ignored the claims of public nutrition on public finance, arguing the normal patterns of agricultural and economic growth will both solve hunger and malnutrition and restructure the healthier labor force into the industrial world consonant with the natural history of political economy. Recently, the view has changed as indicated by the conclusions of the Copenhagen Consensus earlier this year. The goal of the Copenhagen Consensus project was to set priorities among a series of proposals for confronting ten great global challenges, including hunger and malnutrition, education, communicable diseases and climate change, among others. A distinguished panel of international economists was asked to rank proposals they would prioritize in using a hypothetical \$50 billion made available to governments in developing countries. Providing micronutrients through a combination of public health, agriculture and industrial programs was ranked second, after control of HIV/AIDS, thus reflecting both the economic and mortality losses that micronutrient deficiencies pose to the global community, as well as their centrality to reaching global poverty reduction targets. The Consensus Statement noted that

reducing the prevalence of iron deficiency anemia (IDA) by means of food supplements has an exceptionally high ratio of benefits to costs, and recommended that \$12 billion be allocated to public health and food fortification programs for reducing IDA substantially.

The review addresses three strategies to eliminate micronutrient deficiencies: supplementation; fortification; and biofortification through nutrition-enhancing plant breeding. All can play an effective role, based on calibrated costs and benefits.

III A. Damage assessments

Until recently, assessments of the harm done by micronutrient malnutrition were based on selective country and field studies that lacked a common methodology and policy thrust. Now, thanks to a comprehensive “damage assessment” completed by the United Nations Children’s Fund and the Micronutrient Initiative, a global take on the preventable human and economic harm is provided in the Vitamin and Mineral Deficiency (VMD) Report (2004). The Report, available at www.micronutrient.org, provides a summary of the findings for 80 countries (80% of the world’s population). Two sets of data are presented: Damage assessments that estimate the number of women and children dying with a deficiency as a prime cause or principal risk factor, or suffering mental impairment from a deficiency; and National Protection Audits that estimate the population covered by supplements of micronutrient-enriched salt and flour, staples with nearly global reach. It is an enlightening and disturbing overview, hinting strongly that a job only half done deserves faint praise. As described below, the countries’ Damage Assessment Reports (DARs) provide a unique opportunity to model the benefits from population-wide provision of micronutrients through health care or food technology. Staples’ fortification on a global scale is presented later. The methodology for estimating prevalence for each deficiency is described in Ross and Steifel (2004). Costs of micronutrient supplementation and fortification follow, with estimated benefits as available. Then the new plant breeding initiative – biofortification – is discussed in terms of approximated costs and benefits.

III B. Supplementation Costs

III B1. Vitamin A

Status

Vitamin A deficiency (VAD) increases the severity and case fatality of diarrhea and measles, and contributes between 20 and 30% of under-5 year old mortality (Beaton *et al.*, 1992). 1-2 million children die each year from VAD. Vitamin A supplementation programs have been proven, in a review of gold standard studies, to reduce under-five child mortality by 23% on average, a bit higher in Asia where the prevalence of the deficiency (VAD) is higher. Where Vitamin A capsule (VAC) programs have been used widely, clinical blindness and night blindness have virtually disappeared as public health problems. Impacts of successful programs on sub-clinical status of children are less clear. In many countries, 30-40% sub-clinical VAD persists even when VAC program coverage is high. Food-based strategies are essential to remove the sub-clinical problem. Fortification and

agricultural strategies promoting dietary diversity are well known and not applied as widely as they should be.

There are substantial deaths of mothers and preschoolers from sub clinical VAD. A USAID study (1998) estimated that the lives of some 714,000 children less than five-years old have been saved annually in 12 low-to middle-income Asian and Pacific countries from steady improvement of vitamin A status, with an additional 211,000 occurrences of child blindness avoided. Estimates of health care costs averted were \$93-126 million annually.

Vitamin A supplementation has been a successful global campaign, linked generally to national immunization days in recent years: piggybacking on a major health initiative and addressing two major risks of child mortality are its distinct program achievement. But the program only covers half the 500 million preschool children in developing countries and the program is driven by one major donor, CIDA that has sustained its commitment admirably. CIDA provides a half billion capsules annually. With the phasing out of the Vitamin A supplements in the immunization program as the polio campaign approaches completion, the Vitamin A program needs a new “home” in primary health care systems and a broader base for financial support, with governments and donors other than CIDA the target for financial commitment.

As part of this dialogue on investment needs, it is important to acknowledge that the cost of supplementation has been considerably under-estimated until recently. Levin (1993) reported an annual cost of \$0.10 per child. A series of careful country studies, synthesized by Neidecker-Gonzales *et al.*, (2004), reveal that the unit cost of the supplement (\$.04 per child for two doses) represents only 5 % of the delivery costs when the full program is costed. The authors constructed a strong model that allows for cross-comparability by standardizing costs into 2004 dollars, standardizing maturity of programs by distributing start-up costs across the life of the program, comparing urban versus rural components, stand alone vs. National Immunization Day (NID) programs, volunteer vs. child-to-child strategies, and proposing a predictive model to estimate costs using low, mid and high estimates for all developing countries. Costs were disaggregated for labor, capital, administration, communications/promotion, and training. The key findings synthesized from the six country studies were:

- The distribution of costs are 75% to labor costs for transporting and delivering the capsules to the target population; 5% for the capsules; and 20% goes to administration, marketing, planning, organization and training.
- The worldwide average is estimated to be \$0.75 per pill, or \$1.50 for two doses per child per year. The global cost (lower-bound estimate) is \$375 million for one dose for 500 million under-five children, and \$750 million for two doses. The higher (upper-bound) estimate would double the cost.
- The costly parts of the program are in the rural areas (in Philippines the rural –urban cost ratio is 3.7:1, in the other countries about 2:1) and stand-alone programs are twice as costly as integration with NIDs.

- Foreign aid is a major contributor and most countries are not prepared to go it alone.
- Systems of volunteers drive the Vitamin A campaigns, but now that the NIDs are disappearing, it's not clear whether volunteers will stay the course on a routine basis.
- 1-2 million children's lives could be saved by full coverage, at a cost of \$750 million to \$1.5 billion. But earlier estimates (e.g. Levin *et al.*, 1993) projected that \$100 million would cover the under-fives.

Program implications include:

- A greater awareness by governments of the recurrent cost commitments that official personnel and volunteers pose for sustainability.
- Replacement of NIDs is likely to drive program costs up, and it's not clear who will pay.
- Extending coverage to rural areas will be resisted when local governments have to pay the recurrent cost bill. There is a risk that, absent NIDs, VAC programs will focus on urban areas. This is particularly true in Sub-Saharan Africa where fewer than half the children are fully immunized, and costs of EPI and VAC programs are higher generally, and much higher in the rural areas.
- Planners should examine how VAC distribution can be included in community health worker essential health packages to sustain the momentum and also broaden coverage.
- Whether the donor community is willing to pay the major share of the true costs of service delivery (7-15 times higher than reported earlier) remains to be seen but is unlikely.
- The contributions of food science and technology (fortification and biofortification) can complement the VAC program, probably at much lower cost.

III B2. Iron/Folate

Status/Trends

Global anemia prevalence has barely improved in the last decade due to poor program implementation and under-funding. Funding of iron supplementation programs covers about one-fourth of the women in need, and much less than that for infants 6-24 months old. According to the INACG Secretariat, both groups require supplementation for the foreseeable future. The sources of funding for existing programs are not easy to find. There has been no recent or concerted effort to organize donors' thinking about scaling up the funding to meet global requirements. The assessments by the Tulane group for the Micronutrient Initiative are the best sources on coverage and factors that contribute to successful programs, whether programs have plateaued or need to be scaled back. (Mason *et al.*, 2004). The question is whether the evidence on program effectiveness really commands a lion's share of international public finance, since the dwindling donor resources committed to health are dwindling.

Programs

Daily supplementation trials (Indonesia, Malawi, China, and Korea) have shown that anemia prevalence can be

reduced by 20 percentage points. Efficacy is of course linked to compliance, best assured under a controlled trial but difficult to maintain when projects are scaled up to national programs.

The best approach is to integrate (i) increased iron intake (from supplementation and fortification, and potentially biofortification), (ii) infection control (public health measures to control hookworm infections, malaria and schistosomiasis), and (iii) improved nutritional status (control of major deficiencies like Vitamin A to enhance iron absorption), and dietary diversification. Iron supplementation has been the main strategy to date, but rarely are programs integrated with infection control. Moreover, the espoused goal is universal coverage for pregnant women without benefit of nutrition surveillance to target women at-risk. There may be good reasons for this approach, but the inability to distinguish nutrition-based anemia from other causes and the passive detection approach consistent with antenatal care services can easily lead to over supply of iron supplements and inefficient wastage, on the one hand, and misdirected consumption on the other. Weak nutrition surveillance systems compound the problem.

Compliance by women with the supplements is a major problem. The reasons for non-compliance with iron deficiency treatment are summarized by Galloway and McGuire (1994): inadequate program support (financial, managerial, logistical – procurement, distribution and storage); insufficient service delivery (especially supply shortages); poor communications by health care workers regarding the benefits to mother and child so that the mother can make an informed choice; and patient factors (such as misunderstanding instructions, side effects, or frustration about the frequency and number of pills taken).

Pessimism abounds regarding future prospects. The British Medical Journal stated that "implementation strategies have not kept pace with the better scientific understanding of the disorder, and the gap between the necessary and the practical remains unbridged. There is no real prospect of a new generation of smarter, stronger children replete with iron." Few programs for women cover both pregnancy and lactation (a full nine month period of daily supplementation, as WHO recommends). By analogy, if recent country estimates of delivering Vitamin A supplements to under-fives are indicative, the cost of supplements may represent a small portion of total program costs to reach clientele. This must be factored into any proposal to sustain or scale up investment commitment to iron supplementation. Expansion to under-twos is a strategic choice endorsed by the responsible agencies that, in most resource constrained environments in Asia and Africa, are being postponed until the needs of women, protecting their lives, are fulfilled. Even there, scaling up appears problematic.

Low compliance and logistics problems are correctible as an 8-country review of clients' views and constraints shows (Galloway *et al.*, 2002), with successful examples of program management and communications campaigns in the program literature. Side effects, suspicion of program "agenda", and poor supervision are common obstacles to program success, and may be overcome. But as

the recent UNICEF-MI report on Vitamin & Mineral Deficiency notes the UN's population target to reduce iron deficiency by 30% by 2010 is admirable but: "...there is little to indicate that the new target will be achieved. The issue does not yet seem to have engaged the energies of national political leaderships or of the international community."

Effectiveness of iron supplementation programs (both daily and weekly) to raise hemoglobin and serum ferritin levels has been demonstrated (Institute of Medicine 1998; Beaton and McCabe 1999; Allen and Gillespie 2001). There are obvious synergies in promoting joint health and nutrition interventions for iron improvement in mothers and their young children in the form of family-based packages of services. Unquestionably, iron supplementation is competitive with other cost-effective options available to primary health care, as long as effective management and supervision systems are in place and education supports informed consent and voluntary compliance. The only caveat is that the cost/DALY saved in the literature should be modified to reflect the much higher cost of delivery reported in this paper.

Program Costs

There are only two published studies with a third to be published shortly. WHO's primer (Iron Deficiency Anemia: Assessment, Prevention and Control- a Guide for Programme Managers, 2001) indicates (without detailed explanation) that the cost of the iron folate supplement in programs for pregnant women average 7% of total delivery cost to clients. WHO recommends nine months of daily supplements for at-risk pregnant women, the second and third trimesters of pregnancy and three months during lactation. UNICEF purchases supplements for \$2.80 per box of one thousand tablets, plus 10% for shipping charges, total \$3.08. One box supports about 4 pregnancies at a supplement cost of \$0.83 per pregnancy. That would project delivery cost per pregnancy as greater than \$10.00, using WHO's 7% platform for capsule cost, even though the standard cost is reported as \$1.70 per pregnancy (Allen, Benoist *et al.*, 2004; Horton 1999) or earlier as \$1.89-\$3.17 (Levin 1993).

A recent review (Baltussen *et al.*, 2004), pending publication, confirms the relative magnitude of the full program delivery costs with non-capsule costs over 90% of total costs. Using cost-effectiveness estimates for several of WHO's 14 sub-regions drawn from the WHO-CHOICE project's updated databases on the costs and effects of health interventions, Baltussen *et al.*, simulated the costs of delivering iron supplements to pregnant women using two impacts: reduction of maternal and neonatal mortality for assumed rates of coverage (for sensitivity analysis, modelled at 50%, 80%, and 95%) and compliance (67%), as well as cost per Disability-adjusted Life Year (DALY). Cognitive outcomes were not addressed, in part to support conservative, base case conclusions. The simulation used WHO databases on iron supplement programs for 26 countries in sub-Saharan Africa (WHO's AfrD sub-region) and 7 countries in South Asia (WHO's SearD sub-region), where high anemia numbers are concentrated. Most women receive iron supplements through antenatal care programs, if at all, so

WHO's database for developing regions is one of the most reliable sources of information. For costing purposes, 95% coverage was assumed to produce a least cost estimation. The main findings of the study were:

- Program delivery costs were more than ten times the cost of the supplement. In the Sub-Saharan group, the cost was \$16.59 per pregnant woman, and for the South Asia group the cost per pregnancy was \$10.42.
- The WHO-CHOICE cost methodology included three types of costs: (i) additional staff time for 4 antenatal visits; (ii) program-level activities to support local intervention, such as training, health and nutrition education, and supervision; (iii) long-term capacity strengthening resources to maintain iron nutrition interventions at all levels, including shared personnel, materials and supplies, media, transport, maintenance, utilities, and capital costs.
- With high coverage and compliance, reduction of maternal mortality by 22% among women ages 30-44 is feasible in Sub-Saharan Africa, with proportionate drops in mortality impact as coverage and/or compliance decline.
- The authors conclude that all the tested interventions are cost-effective, using the standard recommended by the Commission on Macroeconomics and Health, i.e. interventions that have a cost-effectiveness of less than 3 times GDP/capita.

The second published study looked at the cost-effectiveness of joint iron supplementation and malaria chemoprophylaxis among Tanzanian infants (Gonzalez *et al.*, 2000). In a complex environment where both iron deficiency and malaria were major contributors to anemia and severe child illness, the study tested three control strategies for iron, chemoprophylaxis and a combination. The combined intervention was most cost-effective: \$8/DALY saved compared to \$9/DALY for malaria prophylaxis and \$21/DALY for iron supplementation alone. All three interventions meet the World Bank's cost-effectiveness test of delivering a DALY at less than \$25. This provides a little perspective on the conventional linking of iron supplements to antenatal care in the literature, because the links between iron deficiency and infectious diseases is strong, and is best addressed aggressively by joint health interventions, recognizing that half of anemia is attributable to nutritional and non-nutritional causes each. There are no studies on the distribution of iron program cost sharing between governments and donors, all the more urgent given the much higher delivery costs noted above compared to previous estimates. The absorptive capacity of governments (national and local) for these costs, and sustainability of the service, is at least questionable.

Program Implications

Mason *et al.*, (2001) reported the disturbing trend that global coverage of pregnant women in iron supplementation programs was only about one-fourth of targeted clients, and that the adequacy of the tablet supply was much less than that. Most country reporting systems are spotty, unlikely to report coverage and adequacy. Some examples from high anemia settings:

Many countries failed to report their coverage rates and have yet to establish monitoring systems that will

justify continued investment in iron supplements as part of a business plan to improve women's health. Mason *et al.*, (2004) provide the best current assessment of iron program effectiveness and impact, based on an eight country study of micronutrient control programs (7 Asian countries and South Africa). The results are discouraging for iron compared to Vitamin A and iodine deficiency. Iron programs for women perform with less intensity, lower coverage and acceptance, in part because iron supplementation is not linked to standard, well-supported programs (as Vitamin A tablets are with EPI), and the antenatal programs to which they are attached are characterized by low accessibility and utilization, especially by poor women. Monitoring is weaker than the other programs; in fairness clinical VAD and IDD are visible - thus easily detected, while IDA is not ("clinical pallor" being a weak substitute). Programs are often launched without national biochemical, clinical or functional deficiency surveys, so that "hotspots" for high prevalence of severe maternal anemia may not be the focus of concerted action to save women's lives. Community-based programs that integrate iron with infection control are rare, and the low coverage is unlikely to be overcome without a robust community health effort with social mobilization to create demand for antenatal services.

There is limited evidence of program effectiveness. Mason *et al.*, (2004) conclude: "Anemia, across all countries in the study, unlike Vitamin A and iodine deficiencies, is not showing marked improvement, but remains high. Evidence of effectiveness of iron deficiency programs, specifically, iron tablet distribution, is inconclusive due to lack of accurate coverage data and evidence that improvements in iron status may be due to improved living conditions where data is available (i.e. Thailand and Viet Nam)."

On the positive side, two developments offer hope that a scaled down and properly managed iron supplement program can save women's lives and enhance pregnancy outcomes. Galloway *et al.*, (2002) report on an eight country study testing women's perceptions about the importance of iron tablets in protecting their health during pregnancy. Side effects are not a serious obstacle. The main problems are procurement and logistics (the sheer volume of pills to be distributed globally is daunting), monitoring and appropriate communications from mixed media and health providers that benefits to mother and baby are undeniably good.

Two related studies in Bangladesh reinforce this point and suggest a shift to weekly supplements will help compliance. (Other studies take the same view: Gross *et al.*, Ridwan 1996). Hyder *et al.*, (2002) surveyed women receiving iron tablets in antenatal clinics, comparing daily and weekly supplementation regimes. Compliance was significantly higher among the weekly regimen clients, even though they reported higher incidence of gastrointestinal complaints. Compliance was 93% with good messages compared with 61%. Weekly regimen eases compliance for the consumer, lowers program management and supplement costs, and appears attractive if weekly doses are as effective in preventing illness and death due to the complications of birth. Ekstrom *et al.*, (2002) studied the bioavailability of weekly versus daily

supplements for women, and found they were equally efficacious. The first 20 tablets produced most of the effect; after 40 tablets there was no response. Over 12 weeks, 50% of the amount of iron in a daily regimen was sufficient for maximum hemoglobin effect. The weekly regimen (2 doses of 60mg Fe) provided a response almost equal to a daily dose of 60 mg Fe.

To increase program efficiency and lower costs, here are several suggestions:

- Scaling up the iron supplement programs should have more realistic goals. Linking them to antenatal programs is fine; a proxy for the use of those programs is the tetanus toxoid II vaccination, which reaches half of the pregnant women. Iron programs should aspire to reach the same target audience before expanding further.
- There is a logic to investing in lifecycle access to iron interventions, especially for young children and non-pregnant women of reproductive age. Several donors and governments aspire to this, for understandable reasons. It is argued that any additional claim on public finance should follow the pregnancy claim, where many lives remain in the balance. This doesn't argue against the lifecycle approach, on the contrary; Thailand and Viet Nam have moved into this area recently, though coverage is a problem. But maternal mortality through unprotected, iron-depleted pregnancies has the first call.
- The much higher delivery costs of iron supplements noted above should be broken down by distribution (governments versus donors) before deciding to scale up. The recurrent budgetary commitments that many resource-poor governments may expect to shoulder needs to be clarified, as donors undoubtedly will gradually shift their role to the investment cost side.
- Iron supplements will probably be included in a proposed mother-and-child essentials health services kit that community health workers and nutrition promoters will adopt, according to the current thinking in several UN and bilateral agencies. This might include iron, Vitamin A, salt testing kits, antihelminthes, antimalarials, oral rehydration salts, impregnated bed nets, IEC materials for home visits promoting exclusive breastfeeding, growth promotion and correct infant and young child feeding, along with community delivery of childhood vaccines. This would distribute management and logistics costs among many services. This is why WHO (2001) argues that program managers in health centers must integrate iron supplements into family planning and mother-child care programs, not just antenatal services, to distribute the costs, and that "when programmes are primarily community-based, costs are estimated to be further reduced by three-quarters". Helminthes control for mothers can thus be included in the package for non-nutritional anemia.
- Surveillance systems require investment and technical assistance to create better targeting mechanisms aided by tailored communications campaigns in selected areas.
- An animated debate has divided the iron community whether multiple micronutrient supplements with a

range of vitamins and minerals should replace the iron folate capsules, and seven country efficacy trials comparing the benefits of each will be reviewed by UNICEF and WHO. Early findings are equivocal regarding the new supplement's contribution to reducing mother's anemia and infant risk of low birth weight (Christian *et al.*, 2003; Rivera *et al.*, 2001; Ramakrishnan *et al.*, 2004). On the other hand, the VMD Report observes that most children with maladies have several vitamin and mineral deficiencies, and it would not be surprising if their mothers did too. Once a consensus is reached, UNICEF and WHO will have to guide countries' decision which to purchase and the basis for that decision.

- It is impossible to accurately cost a global iron supplement program for the next decade until a systematic review of program scope and purpose is concluded, with a hopeful emphasis on multifaceted approaches to IDA reduction including clinic to community service links, fortification, biofortification and dietary diversification.

IIIB3. Integrated strategy to eliminate Iodine deficiency disorders: universal salt iodization with emergency iodine supplementation as a back-up

For the next decade, the IDD community has positioned the Universal Salt Iodization Initiative (USI) to accomplish the global objective of reaching 90% coverage. This goal, set at the Millennium Summit, should be reached by 2005. The following analysis recognizes that great progress has been made, but possibly the target will be more feasible to reach by 2010. This notes assumes that some, but not all, of the needed resources are in hand. This is a sensitive point because the global partnership led by UNICEF and the salt industry, with philanthropies like Kiwanis International, playing an indispensable role, will see the job through to the ultimate goal: declaring the world IDD-free. This can be achieved well before the Millennium Development period ends in 2015.

IDD control addresses four MDGs: #1 food poverty; #2 universal primary education; #4 child mortality; and #5 maternal health. Respectively, reducing IDD reduces underweight prevalence among preschoolers (Mason *et al.*, 2002), raises IQ and educational achievement (Bleichrodt and Born 1991; Cobra *et al.*, 1997), reduces child mortality (Levin *et al.*, 1993; Cobra *et al.*, 1997), and reduces maternal hyperthyroidism (ICCIDD 1996).

Status: Global household consumption has increased from 20% to 69% since 1994. 12 million cases of mental retardation are saved annually, but 38 countries still have low salt iodization coverage. 79 million children are now protected because of this tremendous achievement, but 41 million children are still born unprotected. Up to 20 million of those children will suffer some significant degree of mental impairment. The global goal is 90% consumption on a sustainable basis, to be achieved by 2005. The question is whether the partnerships are in place, as well as the financing, to meet that goal, or perhaps it could be set back to 2010. UNICEF is leading the coalition, and currently preparing a five-year strategy to accomplish this. UNICEF and partners are debating the next five year plan to 2010. Without being presumptuous,

and taking into account lessons learned from the last successful decade, four approaches to achieving USI seem sensible:

(i) Stress the urgency of the situation to all governments, so that USI is seen as a governance issue. Advocacy at the highest level of the United Nations and the salt industry will be imperative. One is certain that UNICEF's leadership has persuaded many countries to avoid self-defeating tariff and VAT obstacles to move the fortificant and the fortified salt into and within all participating countries. An update on this situation from UNICEF would be helpful so that any advocacy for future financial support will not be undermined by a history of unnecessary price distortions.

(ii) Focus dramatic attention on the 10 largest countries not yet close to the 90% target and enable them to reach it by 2010 – i.e. biggest return and a framed focus for donors and UN/ bilateral agencies. This will include large countries like India (the previous government rescinded the salt iodization gazette leading to decline in household consumption from 80% to 50%) that have regressed and need technical support to move USI back on to the political agenda.

(iii) Focus on countries with the most unprotected infants (6 Asian countries account for over 19 million/yr, dominated by India's 12 m, about 2/3rds of the target group globally).

(iv) Relax the time frame to 2010, giving balanced attention to i-iii but also strategic focus to "hotspots" in both sub regions (e.g. Central Asia/CIS; parts of Sub-Saharan Africa) and sub-national problem areas, plus the inevitable "backsliders" that have not raised own capacity. In geographically remote areas and rural areas generally, this will require building alliances with small salt producers who constitute 75% of production units and deliver 25% of edible salt. The lowest consuming regions are CEE/CIS (39%), South Asia (49%), MENA (51%), and East Asia and Pacific (sans China) (53%).

Program Costs, to be shared by Public and Private Partners:

Rather oddly, there are no country studies on the costs of universal salt iodization. The facts are these:

- A unique partnership between the UN agencies and the salt industry has sustained the tremendous gains from 1994-2003, whereby an extra 3.3 billion people are covered. About 2 billion people remain uncovered. The cost of supplying potassium iodate has been \$.05 /K/yr but total cost of delivery is estimated as \$.10 (Allen, Benoist *et al.*, 2004 quoting an O. Dary source). These costs may rise as UNICEF and partners address the hard core countries and sub-regions that are problematic because of weak capacity, political obstacles, lack of Codex and WTO harmonization, and higher marginal costs for delivery and marketing to remote areas. Let's assume \$.02/person/year to bring 2 billion on board the USI crusade with great improvements in maternal health and school achievement the consequence.
- About \$2 billion was mobilized for the last decade's fight against IDD through USI, with a public investment of \$400 million leveraging more than \$1.5 billion of private investment in salt iodization (Mannar

2003). If one public dollar can mobilize four from the salt industry, that's probably a good basis for encouraging donors and governments to reach USI over the next five years. USAID, Kiwanis and Gates Foundation have provided critical support to UNICEF at \$19 million from 2001-05, and sustaining that financing as UNICEF finalizes its five year plan is crucial.

- Assuming USI will be reached by 2010, costs will include \$0.12/year for 5 years to estimate the expansion of salt iodization coverage for the unprotected 2 billion, plus additional costs for maintaining current momentum in the other countries with shaky participation, as well as iodized oil capsule (IOC) distribution in "hotspots". A rough approximation is about \$ 1-\$1.5 billion, \$200-300 million of public resources and \$800-1200 million financed by the private salt industry, based on the cost-sharing arrangement just experienced over the last decade. A ballpark figure at this stage.

Iodine Supplementation

Iodized oil supplementation: will probably be reintroduced into the strategy to deal with countries/sub regions where the salt industry is unable or unwilling to retrofit for iodization (Ethiopia comes to mind), and consequently many mothers and infants are unprotected. Costs of delivery are higher than reported in the past. Many trials have demonstrated the efficacy of iodine supplementation on the prevalence of goiter and other iodine deficiency disorder (IDD) signs, and the improvement of population iodine status. The study countries include China, India, Indonesia and Papua New Guinea, among others. "Mechanisms of supplementation tested include lipiodol injections, oral iodized oil supplementation, and salt iodization. Results of studies indicate efficacy for the prevention of cretinism, improvement of psychomotor skills and cognitive development, and prevention and treatment of goiter." (Mason *et al.*, 2004: Part III).

If iodized oil capsule distribution is part of the strategy for "in crisis" countries where the salt industry is less competent or resistant to change, then the costs have to be recalibrated because they are higher than has been claimed. The one published study on Tanzania (Peterson, Assey *et al.*, 1999) estimates the cost of delivering 2 IOC (total 400 mg iodine) within 2 years at \$0.26/ person, but that does not include the operational costs of running and evaluating a program (e.g. materials development/ dissemination, training, supervision, monitoring, and communications). Better cost estimates for Vit A supplement and iron folate supplement programs show the capsule cost is about 5% and 7% of total delivery cost, respectively. IOC is likely to be similar, and should be estimated upward as Peterson *et al.*, show the lack of long-term commitment in a stripped-down program without human resources development, management, supervision, and evaluation.

III C. Food fortification costs

CI. Forging an effective public-private partnership

Food fortification is an essential element of national food policies in Asia and Africa to ensure nutrition security for

all their citizens. Both food industry producers and consumers need to be fully informed about the minimal change in production or purchasing decisions required to shift preferences and demand to fortified foods. The technical costs of production are not prohibitive. The public sector has a major role to ensure quality assurance and a level playing field for all producers, and to assist the shift to fortified staples with aggressive social marketing to the less affluent. This is a proper use of public resources because it has a preventive health thrust and will allow people's needs to be felt and expressed. The result will be informed choices by all groups of society. The recent partnership of the UN, bilaterals, the development banks, and the Global Alliance to Improve Nutrition (GAIN) is emblematic of a new energy and approach that is animating international nutrition.

Technical and political breakthroughs are equally important at this juncture. A global alliance to fortify wheat flour with iron, called the Universal Flour Fortification Initiative (UFFI), is bringing millers, bakers, and consumers together in a common cause. Flour is a staple in 180 countries, yet in 1990 only a few countries fortified with iron. Today there are 48, most of which add folate to prevent birth defects. UFFI is building on the success of the public-private-civil partnership centered in Universal Salt Iodization, and may involve major millers associations in subsidizing both fortification costs and technical assistance to jump start Asia as a region. Latin America is openly sharing its experience with flour fortification with Asia and Africa, and all parties are backing a recent African regional declaration that maize meal fortification is essential to achieving Health for All in their region.

An exciting technical breakthrough described in the UNICEF-MI VMD report is the testing and release of "super salt" – double fortification of salt with iron and iodine for a new assault on anemia. Lastly, lagging sub-regions like Central Asia, helped by UNICEF and the Asian Development Bank, are catching up through regional salt and flour fortification, with all the attendant structural reforms covering regulation, trade and quality assurance that will modernize the food industry as it steps forward into a globalized world. Other exciting challenges involve getting micronutrients to young babies under 2 when brain development most requires them. A variety of "sprinkles" for home-made porridges and "spreads" for snacks are gaining attention in the developing world. "At home" fortification has a future because of its flexibility and responsiveness to the tastes of parents and other carers of children.

III C2. Fortification: cost-effectiveness

The arguments on why governments and the private sector should invest in this are obvious, but worth stating. Companies should invest because the raising of product quality will stimulate competition and trade. Economies of scale for fortified products will lower prices and reach new consumers, overcoming chronic micronutrient under nutrition, and will raise the general wage and consumer spending. The US Institute of Medicine summarized evidence on iron and vitamin A interventions, both

supplementation and fortification; most interventions cost less than \$25/DALY³ (Tables 2 & 3).

Returns on nutrition investments

The World Bank summarized the benefits of micro-nutrients in terms of cost per life saved and productivity gained per program (Table 4). For saving lives at least cost, targeted supplementation to at-risk groups (pregnant mothers for iron, under-fives for vitamin A) is more cost effective than fortification, although the latter is a more sustainable solution in the long run as incomes rise and households gain access to higher-quality primary health care. Nevertheless, properly targeted supplementation is

justified while fortification programs are in the early stage and expanding coverage, as long as the targeting principles reflect risk assessment and are consistently applied. Targeting fortified foods to poor women and children will improve their physical and mental development, raise earnings of the labor force, create demand, and give back to the community in a win-win situation. The US Institute of Medicine summarized evidence on iron and vitamin A interventions, both supplementation and fortification; most interventions cost less than \$25/DALY⁴ (Tables 2 & 3). From the perspective of enhanced productivity delivered by programs, where productivity is defined as the least-cost method of reducing clinical deficiency in the

Table 2. Cost and benefit/cost ratios of iron supplementation schemes and general iron fortification programs

Intervention	Benefit/Cost Intervention	No. DALYs ^a Achieved	Cost Per DALY (US\$)
<i>Short-term (daily, weekly) benefits and costs of iron-supplementation programs</i>			
Prenatal supplementation only	511	100	51
Widespread supplementation to all iron- deficient and anemic subjects and at-risk groups	4,665	88	24
Universal fortification	5,038	16	11
plus residual prenatal supplement ^b	5,394	39	16
<i>Long-term benefits and costs of iron-supplementation programs</i>			
Preventive supplementation	2,679	37	17
Fortification	3,332	9	

Source: Institute of Medicine; DALY = disability – adjusted life year.

^a Per 100,000 population, considering global birth rates, fixed and other operational costs, and current individual expenditures in purchasing iron-containing preparations (based on information from Guatemala).

^b Considering that in spite of iron fortification and adequate prepregnancy iron reserves, prophylactic iron supplementation will still be recommended during pregnancy

Table 3. Cost-effectiveness of some vitamin A interventions

Intervention	Target Groups	Approximate Cost (US\$)	
		Per Death Averted	Per DALY Saved
Supplementation	Children < 5 years	50	1
Fortification	Entire population	154	4
Food supplement	Children < 5 years	1,942	63
Food supplement	Pregnant women	733	24

DALY = Disability Adjusted Life Year. Source: Adapted from World Bank

Table 4. Returns on Nutrition Investments (World Bank: Enriching Lives 1994)

Deficiency/Remedy	Cost Per life saved (US\$)	Discounted value of productivity gained per program (US\$)	Cost Per DALY gained (US\$)
<i>Iron deficiency</i>			
Supplementation of pregnant women only	800	25	13
Fortification	2,000	84	4
<i>Iodine deficiency</i>			
Supplementation (repro-aged women only)	1,250	14	19
Supplementation (all people under 60)	4,650	6	37
Fortification	1,000	28	8
<i>Vitamin A deficiency</i>			
Supplementation (under 5 only)	325	22	9
Fortification	1,000	7	29
Nutrition Education	238		
Nutrition education and maternal literacy	252		

³ Prenatal iron supplementation and Vitamin A food supplements are higher but within the \$75/DALY group.

⁴ Prenatal iron supplementation and vitamin A-enriched food supplements are higher but within the \$75/DALY group.

population, fortification is clearly the public policy choice. Fortification is three times as productive as supplementation with vitamin A for under-fives or iron supplementation for pregnant women, and is four times as productive as general iodine supplementation and twice as productive as targeted supplementation for reproductive-age women. So the population-wide impact is greatly increased by fortification.

In the WHO-CHOICE analysis by Baltussen *et al.*, (2004), iron supplementation and iron fortification are compared for impact, using the conservative assumption that fortification is only half as effective (i.e. bio-available) as iron capsules. They concluded that the cost-effectiveness of fortification is always lower than that of supplementation, regardless of the coverage of fortification. Fortification should be the preferred option, particularly in low-income settings where the infrastructure to support supplements is not available.

In summary, the economic benefits of fortification are reduced morbidity, improved work capacity, and improved cognitive effects. Reduced morbidity will reduce health care costs and days lost in school or at work; improve school attendance, concentration, and performance; and strengthen both production and consumption benefits. Reduced public health and public education expenditure, and reduced school dropout and retention rates, will increase efficiency of public investment for essential social services and free resources for better uses. Economic value of fortification is expressed in improved work output due to increased work capacity and improved marginal productivity of labor.

Lastly, improved cognitive ability will allow realization of the benefits of education expenditure; raise the number of years of schooling and academic performance; and, in a growing economy, will also raise wages and household income invested in the quality of the next generation of children.

III C3. The Costs of Iron and Vitamin A Fortification

The standards for iron and Vitamin A fortification, with all the requirements for CODEX approval, are ably presented in Allen, Benoist *et al.*, (2004). Vitamin-A fortified cooking oil and iron-fortified wheat flour are well established and proven technologies with a history of significant impact. Maize meal fortified flour is somewhat newer as a technology, distinctive because most production originates from small hammer mills as opposed to large roller mills that dominate wheat flour production in many countries.

UNICEF and the Micronutrient Initiative has supported the wide-spread use of an investment model that is based on the Damage Assessment country reports, but also builds program costs by identifying the relative share of the fortificants and retrofitted equipment, on the one hand, and the public sector's role in providing inspection, quality assurance, regulation and trade protocols, and nutrition surveillance to identify the impact on consumers and "hot-spots" needing other forms of assistance, i.e. supplements. The investment model was developed by the Asian Development Bank (ADB 2004) working with five Asian countries to develop ten year fortification plans with costs and benefits included. As an example, ADB

estimated that a public investment of \$115 million in food fortification in the five countries⁵, supplemented with private investment of \$700 million, could deliver iron and folic acid to 1 billion people at a cost of \$.08 per capita and a benefit: cost ratio of 7.

The MI model⁶ has the following features:

- The widest possible coverage within the DARs database (i.e. 75 countries for cooking oil and wheat flour, 24 countries for maize meal flour);
- Inputs industrial level of fortificants based on FAO consumption data and WFP production "best practices";
- Estimates the percentage of WHO's "safe level" that the fortificant premix would deliver;
- Calculates the percentage points' decline of the deficiency that the admixture would induce;
- Applies the DAR methodology to translate the lowered prevalence leads to (e.g.) under-five lives saved by Vitamin A-fortified oil;
- Total annual costs are derived from premix cost, production costs (annualized capital costs, quality control, administrative) and government costs (regulation, enforcement, food control, nutrition surveillance monitoring, social marketing, advocacy and public education);

The results are then expressed as annual benefits from reduced prevalence of the particular deficiency in three forms: current savings and future productivity (wages from reduced anemia); lives saved (preschoolers from reduced VAD); and disabilities averted (birth defects from decreased folic acid deficiency). When the model is applied to the full complement of countries for the three food vehicles, the results are impressive. For an investment of \$2.4 billion over 10 years, with industry absorbing 85% of the cost, the benefits are:

- \$5.8 billion in current savings and future productivity, better than 2:1 return
- 2,530,000 lives saved
- 540,000 birth defects averted
- Benefit costs ratios: wheat flour 6:1 and maize flour 1.2:1

Table 5 provides the details.

There are fortification alliances preparing business plans for each product, expected to open new avenues for region-to-region dialogue and cooperation in the near future. Fortification represents a regional public good for industrial growth and human health.

III D. Biofortification - agricultural research where nutrition matters

"Finding sustainable solutions to micronutrient malnutrition will not be forthcoming in the foreseeable future if we do not start to adopt agriculturally based tools, such as plant breeding, to this important global crisis in human health and well being." Welch (2001)

The agricultural-industrial complex to support nutrition security and eliminate VAD, iron deficiency anemia (IDA) and zinc deficiency is an essential prong in protecting the health of mothers and the biological and

⁵ China, Indonesia, Pakistan Thailand, Viet Nam

⁶ Acknowledged with appreciation from MI consultant Jack Bagriansky.

Table 5. Global and Regional Multi-Country Cost, Benefit and Impact Analysis of Food Fortification based on the DARs

<i>Annual Cost of Wheat Flour Fortification for 75 Countries</i>	\$85,015,497
Added Iron from Fortification as % Estimated Average Requirements (13.4 mg/dy)	34%
Added Folic Acid as % of 400 ug RDA	40%
Annual Benefit: Current & Future Productivity Assuming 10% Reduction in IDA	\$477,461,097
Annual Benefit: Reduced Birth Defects Assuming 33% Reduction	40,771
Annual Benefit: Maternal Lives Saved Assuming 10% Reduction in IDA	2,795
<i>Annual Cost of Oil Fortification for 75 Countries</i>	\$70,429,020
Added Vitamin A Delivered to Consumer as % WHO Safe Level of 2000 IU/dy	44%
Annual Benefit Reduction in VAD Assuming 20% Reduction in VAD	154,293
<i>16 Countries Middle East & Central Asia Wheat Flour Fortification with Iron & Folic Acid</i>	
Annual Cost of Wheat Flour Fortification Cost 16 Countries	\$41,005,303
Added Iron from Fortification as % Estimated Average Requirements (13.4 mg/dy)	96%
Added Folic Acid as % of 400 ug RDA	115%
Annual Benefit: Current & Future Productivity Assuming 33% Reduction in IDA	\$275,352,792
Annual Benefit: Reduced Birth Defects Assuming 50% Reduction	505
Annual Benefit: Maternal Lives Saved Assuming 33% Reduction in IDA	8,392
<i>24 African Countries Cost of Maize Meal Fortification with Vitamin A, Folic Acid and Iron</i>	\$83,974,625
Added Iron from Fortification as % Estimated Average Requirements (13.4 mg/dy)	34%
Added Vitamin A Delivered to Consumer as % WHO Safe Level of 2000 IU/dy	36%
Added Folic Acid as % of 400 ug RDA	39%
Annual Benefit: Current & Future Productivity Assuming 10% Reduction in IDA	\$97,220,029
Annual Benefit: Maternal Lives Saved Assuming 10% Reduction in IDA	1,201
Annual Benefit Reduction in VAD Assuming 20% Reduction in VAD	94,199
Annual Benefit: Reduced Birth Defects Assuming 33% Reduction	13,325

neurological integrity of children. An example is iron deficiency. A dynamic approach is needed to thwart the restrictions that IDA imposes on the evolution of the embryonic and infant brain. The emerging agricultural-industrial partnership for ensuring children's iron sufficiency will address the preservation of early brain development, and the child's "readiness to learn" in school and subsequent "ability to earn" as mature citizens. The shift from alarming levels of harm to children towards life-long educability and productivity should be the main objective of the partnership. The contribution of the processed food industry in fortifying essential staples such as wheat and maize flour has been discussed, and now the potential contribution of plant breeding research must be emphasized. The Harvest Plus Challenge Program, managed by the Consultative Group for International Agricultural Research (CGIAR), with support from the Bill and Melinda Gates Foundation, World Bank and USAID, is in the first of a ten-year program that will support plant breeding research and nutrition efficacy trials for all major crops, beginning with the major cereals, sweet potato, cassava and beans.

Plant Breeding

The plant breeding strategy for micronutrient-enriched germplasm, called "biofortification", offers the opportunity to create an international public good through comprehensive benefits to producers and consumers with public health significance (Bouis 2000, Hunt 2001). Given the high payoffs to reducing micronutrient deficiencies and the current reservations about conventional approaches to solve the problem quickly and completely, plant breeding should be tried because of its potential

coverage of entire populations in developing countries deriving most of their consumption from cereals, especially the poor. Since the poor consume large amounts of staple foods on a daily basis, the prospect of improving nutrition status is encouraging if a high proportion of the domestic production of food staples can be provided by nutritionally improved varieties. The breeding strategy does not depend on shifts in behavior or preferences. Biotechnology also offers considerable promise, as reviewed in Bouis 2000.

Results so far obtained under the Micronutrients Project, sponsored by the Consultative Group for International Agricultural Research (CGIAR), indicate that the breeding parameters are not difficult and are highly likely to be low cost. In particular, (i) adequate genetic variation in concentrations of beta-carotene, other functional carotenoids, iron, zinc, and other minerals exists in the major germplasm banks to justify selection; (ii) micronutrient-density traits are sufficiently stable across growing environments; (iii) in all crops studied, it is possible to combine the high micronutrient-density trait with high yield, unlike protein content and yield that are negatively correlated; (iv) genetic control is simple enough to make breeding economic and it should be possible to improve the content of several limiting micronutrients together, thus pushing populations toward nutritional balance; and (v) bioavailability tests using animals are encouraging but tests using human subjects are a high priority (Graham and Welch 1996).

High Benefits to Costs

Importantly, high trace mineral density in seeds produces more viable and vigorous seedlings in the next generation,

and efficiency in the uptake of trace minerals improves disease resistance and agronomic characteristics, which improve plant nutrition and productivity in trace mineral-deficient soils. Farmer adoption and spread of nutritionally improved varieties can rely on profit incentives, either because of agronomic advantages on trace mineral-deficient soils or incorporation of nutritional improvements in the most profitable varieties being released. Because staple foods are eaten in large quantities every day by the malnourished poor, delivery of enriched staple foods (fortified by the plants themselves during growth) can rely on existing consumer behavior. Benefits to relatively small investments in agricultural research can be disseminated widely, potentially accruing to hundreds of millions of people and millions of hectares of croplands across countries and across time. Thus, the combined benefits for human nutrition and agricultural productivity resulting from breeding staple food crops that are more efficient in the uptake of trace minerals from the soil and which load more trace minerals into their seeds, result in extremely high *ex ante* estimates of benefit/cost ratios for investments in agricultural research in this area. Other complementary strategies run recurrent costs on a continuing basis which decline slowly over time and which increase proportionately with geographic coverage.

Because biofortification is a new strategy, definitive studies of the impact of this approach must await the efficacy and effectiveness trials that are either ongoing or proposed to be undertaken by an interdisciplinary consortium of collaborating partners organized by the CGIAR. In general, however, poor consumers in developing countries acquire roughly one-half of their total iron intake (and a higher percentage of zinc intake) from staple foods. Results from germplasm screening suggest that the iron and zinc content of staple foods can be doubled through conventional breeding. This in turn implies that iron and zinc intakes can be increased by a minimum of 50% in poor people's diets. This should result in an appreciable improvement in nutrition and health even for those whose intakes remain below recommended daily rates.

An example of the enormous economic benefits of the biofortification strategy based on numbers for India and Bangladesh. This example is based on development of iron- and zinc-dense varieties of rice and wheat. The somewhat conservative assumptions suggest that the undiscounted returns that come on-stream during the second decade of R&D would be about \$4.9 billion on a total investment of \$42 million, \$1.2 billion in benefits from better nutrition and \$3.7 billion in benefits from higher agricultural productivity.

A more formal benefit-cost ratio evaluation, in which the ratio of the present value of benefits divided by the present value of costs, at a 3% discount rate (commonly used for social benefits), for returns to better iron nutrition in humans is about 19, similar to that found by Horton and Ross (2001) for fortification in South Asia. This ratio rises to 79 if benefits to higher agricultural productivity are included. A different way of expressing the concept of discounting over time is the internal rate of return, in which the interest rate at which benefits equal costs plus interest if the funds were borrowed to make the

investment, is calculated. In this case the internal rate of return is 29% if only benefits to human nutrition are considered and 44% if both benefits to human nutrition and higher agricultural productivity are considered.

Bioavailability

Rice research provides the model that other crops will follow in testing whether the extra iron through breeding will improve iron status of consumers. A double-blind efficacy trial (2003-2004) involving 300 religious sisters in the Manila area (randomized for high-iron and normal rice consumption). Pending a set of publications by the research team from three universities, the preliminary results show that women who consumed the high-iron rice ingested about 20% more iron per day than those who consumed the control rice, increased their body iron by 10% (while the control group lost 6%), and the women who were more iron-deficient absorbed the most iron from the high-iron rice.

The conclusion is that, among other strategies, there's a niche for plant breeding and for reducing population prevalence at lowest cost. If it proves to be inexpensive and cost-effective by improving plant nutrition and increasing yields, it will complement but not in any way substitute for supplements or fortification, which are equally important for targeted groups. A considered view is that the agricultural-industrial partnership becomes all the more critical in the coming years as one sees the explosion of urban populations and therefore urban children in Africa and Asia, to about three billion people by 2025, increasing dependence on food-based solutions from both green revolutions.

IV. Community-based health and nutrition programs to optimize child growth

MDG#1 will be judged by progress towards halving underweight prevalence of under-fives in Asia and Africa, where most of the malnourished children live. Recent analysis of WHO's global database on child growth revealed contrasting trends for Asia and Africa. Children are growing heavier in Asia, though South Asia trails far behind most of the developing world. But the trends are positive in most of the Asian mainland. In large parts of Sub-Saharan Africa, underweight and stunting are increasing, so much so that for every 4 underweight children in Africa today, WHO predicts there will be 7 by 2015.

The bulk of under weights are in South Asia and a dozen African countries with high prevalence of underweight and child mortality (interrelated phenomena as discussed earlier). The following countries have the highest priority for increased investment in child nutrition through community action. In South Asia: India, Pakistan, Bangladesh, and Sri Lanka; in Sub Saharan Africa: Angola, Burkina Faso, Burundi, DR Congo, Eritrea, Ethiopia, Madagascar, Mali, Mauritania, Nigeria and Sudan. De Onis *et al.*, (2004) note that (i) during 1990-2000 all regions declined in underweight and stunting prevalences except Africa where stunted children increased from 40 to 45 million (35%), and underweight children increased from 25 to 31 million (24%). The authors comment: "To achieve the Millennium Development Goal for Hunger, more concerted efforts are needed

in those regions with stagnating and increasing trends of malnutrition, but without diminishing support to those which show progress, given that this is where the majority of children are to be found” (i.e South Asia and Africa). The highest numbers of stunted children are in South Asia (projected as 63.5 million in 2005), Eastern Africa (21.6 million) and Western Africa (13.9 million), almost 100 million or two-thirds of the global total. About 100 million children in South Asia and the referenced 12 Sub Saharan countries are the core target for reducing child underweight and stunting, and related/preventable child mortality. This would make a great contribution to reaching MDGs #1 and #4.

IV A. Evidentiary basis for investing in community-based child health and nutrition programs

The micronutrient issues benefit from centralized programs by the public and private sectors that can be executed with a high degree of uniformity. Community health and nutrition programs (CHNPs) to increase the birth weight and the physical and mental development of young children are complex, but there is a growing body of evidence about what works and why. Given the gaps between public health program goals and reality-low coverage, access and affordability, CHNPs offer access to technology and resources, support caring practices to link health to psychosocial, psychomotor and cognitive development, deploy communications and social mobilization both to change behaviors of service providers and carers of children and to create unmet demand for services. CHNPs address 40% of global diseases burden (expressed in DALYs for under fives (malnutrition and infectious diseases) plus maternal and perinatal conditions. CHNPs are more oriented to prevention. This is briefly discussed, and then a range of costs from country studies is reviewed.

Efficacy

Two studies provide evidence that a mixture of nutrition and health interventions can be brought to at-risk children that will save lives and reduce the risk of underweight and stunting. Both studies confirm the advantage of combining facility-based health services for delivering nutrition and health services and home-based surveillance and care through interventions by community health workers. The first study, by the Public Health Intervention Unit, London School of Hygiene and Tropical Medicine (Hill *et al.*, 2001) reviewed a comprehensive range of health and nutrition practices to determine which ones were successful in randomized, case-control efficacy trials and which ones were tested and implemented successfully in programs. The basis for selecting these practices was a literature review of published studies and health programs through 2000. Twelve practices were recommended for wide dissemination in developing countries, through a combination of facility-based and community- and home-based interventions. The best practices are:

- Completion of the child immunization schedule before first birthday
- Exclusive breastfeeding for six months

- Provision of nutrient-enriched complementary foods at six months, with continued breast-feeding
- Assurance that children receive adequate amounts of micronutrients (vitamin A, iron and zinc in particular) either in the diet or through supplementation
- Good hygiene practices regarding food preparation and consumption and faeces’ disposal
- Provision of insecticide-treated bed nets for children in endemic malarial zones
- Continued feeding, including breast milk, for sick children
- Sick children receive appropriate home treatment for infections, especially oral rehydration therapy for diarrhea
- Timely referral of sick children to health facilities when appropriate
- Adherence to the health worker’s advice about treatment, follow-up and referral
- Promotion of psycho-social and mental development of very young children through talking and play
- Adequate antenatal care for every pregnant woman.

The powerful conclusion is that a broader health care delivery system, linking the public health facilities to communities and homes, is crucial for survival, growth and development of young children. The Bellagio Study Group on Child Survival also prepared a global assessment on how to meet MDG #4 to reduce child mortality by two-thirds by 2015. In a five part series published in *The Lancet*⁷ in 2003, the following conclusions merit attention:

1. *Health Movement Adrift.* The child survival movement has lost its focus and attendant resources (‘means’), even though proven technologies (‘ways’) are effective. Half of the preventable under-five child deaths are concentrated in 6 countries and more than 90% in 42 countries. Most of these countries are in South Asia (34%) and Sub Saharan Africa (41%). The overlap between underweight and mortality is striking. Of the 10.8 million child deaths each year, under nutrition is the underlying cause for most, led by 1.5 million each for diarrhea and pneumonia (43% of the total), malaria (9%), neonatal causes (33%), and others. Underweight status is associated with 54% of child deaths.

2. *Proven Technology is no Obstacle.* There are many health and nutrition interventions (23 in all) that can reduce the majority of child deaths (63%) when applied systematically across the developing world. This is based on the Bellagio Study Group’s thorough review of the efficacy trials in public health and nutrition. Since MDG#4 is to reduce child deaths by two-thirds between 1990 and 2015, the conclusion is that proven interventions can reach the goal, but most of them have coverage rates below 50% globally, from a combination of under-financing and poor management.

3. *Nutrition programs are essential to reach the MDG.* Among the 23 interventions, four nutrition interventions

⁷ Black R *et al.*, 2003; Jones G *et al.*, 2003; Bryce J *et al.*, 2003; Victora C *et al.*, 2003; Bellagio Study Group on Child Survival 2003.

(exclusive breastfeeding, complementary feeding for under twos, Vitamin A and Zinc supplementation in both prevention and treatment modes) can reduce child deaths by 25% (2.4 million annually), and the addition of oral rehydration therapy and nevirapine/replacement feeding increases that to 46% (4.2 million annually).

4. *Integration of Nutrition with Health Works Best.* The Integrated Management of Childhood Illness initiative, which is struggling to reach the poorest and most vulnerable (Victora *et al.*, 2003), has the capability of averting one-third of child deaths (3.5 million annually). IMCI is based on addressing both infectious diseases and under nutrition (weight, height and micronutrient deficiencies) and to capture synergies of wellness through joint attacks on comorbidities. This is a sound principle, illustrated by the power offered by home-based IMCI. The Bellagio Group estimates that one-third of all child deaths (3.5 million) can be averted through a home-based package including (i) exclusive breast feeding up to six months; (ii) family-based education on infant feeding practices including the proper nutrient content and hygiene preparation of complementary foods with continued breast-feeding up to two years; (iii) oral rehydration therapy with commercial or home-prepared salts; and (iv) insecticide-treated bed nets for young children in malaria-endemic zones. Access to health services is inequitable, and a shift to community programs is imperative to reach the children who never get to the health facilities. Gender and class disparities are striking: the child mortality rate (CMR) for the poorest quintile is four times the richest in Indonesia, and an Indian girl is 40% more likely to die before her fifth birthday than a boy. The CMR is 175/1000 in Sub Saharan Africa and 100 in South Asia; by contrast the rest of the world is mostly under 50 at this juncture. An example: In Africa, DPT coverage has declined over the last decade from 60% to 46%, despite acknowledged evidence that EPI saves lives cost-effectively. In South Asia, DPT coverage has dropped below 70%, the second lowest region.

5. *Funding needs for essential health care are competitive with aircraft carriers.*

The Bellagio Study Group endorses the recommendation of the WHO Commission on Macroeconomics and Health that annual additional resources for EPI (\$1 billion), treating childhood illnesses (\$4 billion) and malaria prevention and treatment (\$2.5 billion) are worthy investments without which the MDG for child mortality will be difficult to reach. The Bellagio Study Group on Child Survival comments: "These costs might seem expensive, but they are not when compared with the more than \$4 billion needed to add two aircraft carriers to a fleet, or the \$17 billion yearly expenditure on pet food in North America and Europe. Even in relation to the cost of public-health initiatives, child survival is good value for money." Succinctly, a Hausa proverb from Northern Nigeria cautions: "*Don't look for speed in a cheap horse. Be content if it neighs.*" Child survival, in its facility and community modes, is breathing but barely. Until funding

is matched to true need, there is no horse race for human development to show up for.⁸ The Commission's essential health care package costs \$34 per person annually, and we will see that additional needs for nutrition are considerably less and their payoff in CMR reduction strongly recommends those resources be raised and deployed. The additional needs for reducing prevalence of underweight children are detailed later.

Effectiveness

A number of reviews have been consulted to draw lessons on successful community-based nutrition and health programs (Ismail *et al.*, 2002; Jonsson 1997; Mason *et al.*, 2001; Mason 2002; Tontisirin and Gillespie 1999; Tontisirin and Winichagoon 1999; Sanders 1999). The most recent overview, prepared by Mason *et al.*, 2004 for the Disease Priority Control Project (a World Bank – WHO US National Institutes of Health study of global disease burden and control strategies) to be published in 2005, attempts a synthesis of these studies for application in Asia and Sub Saharan Africa where the child growth crisis is concentrated. The DCPD chapter by Mason *et al.*, (2004) (referenced herein as the "DCPD synthesis") is a draft pending publication, and the authors' permission to make its findings available for this review is appreciated. The DCPD synthesis is based on a detailed study of 15 well-known community health and nutrition programs (CHNPs) in Asia, Africa, and the Americas. The core success factors for community health and nutrition programs (CHNPs) are described in Jonsson (1997) based on a review of many such programs throughout South Asia. Similar overviews for Africa (e.g. Sanders 1999) confirm these factors, adapted from Gillespie and Haddad (2001).

Contextual Success Factors

- Political commitment at all levels of society, reflected by the integration of nutritional goals in national strategies for economic growth and sustainable development.
- Gender mainstreaming and people's participation in planning and decision-making processes that "hears" bottom-up demands. A high level of literacy, especially among women, aid meaningful participation.
- Community organizations along with conditions for effective service delivery should be present.
- Charismatic community leaders area major asset
- Nutrition programs benefit from the umbrella of poverty-reduction programs carried out in parallel.

Mason *et al.*, (2001) added two contextual factors: women's status and education, and lack of social exclusion.

Program Success Factors

- A high level of awareness regarding the causes and consequences of malnutrition, and the best

⁸ USAID's budget for child health and survival has reached the lowest level since 1995, one-sixth of the health budget at \$326 million, with further reductions proposed to the US Congress. The World Bank's outlay to maternal and child nutrition as a proportion of its health, nutrition and population portfolio has declined steadily since the early 90s, according to the Bellagio Study Group.

practices to address the immediate, underlying and basic causes.

- An authentic process to assess the nutrition problem with all stakeholders participating and a consensus-based action plan.
- Accepted time-bound goals at all levels of the program. Young children from birth to 2-3 years, pregnant and lactating women, and adolescent girls are normally the focus.
- Facilitators and community mobilizers are identified, leading to mutual support systems for community and government.
- Good management of the program includes effective leadership, training and supervision, links among levels of action, and consistent monitoring.
- Local NGOs, accountable to the community, are involved.

Community Program Content. In the DCP synthesis, Mason *et al.*, (2004) describe the core content of CHNPs as follows (directly quoted):

Program components, implemented by village workers and/or in facilities, come under the following headings; this is the 'menu', perhaps, as the actual mix depends on local capabilities and conditions.

Ante-natal care: checking weight gain in pregnancy, pre-pregnant weight, anaemia, blood pressure; providing multiple micronutrient supplementation, immunization (tetanus); counseling on diet, workload, breastfeeding; predicting and arranging for delivery.

Women's health and nutrition: counseling on health and nutrition, check ups, promoting improved status and resource allocation in home and outside, access to health services; often family planning services are included (or may even be an initiating factor for CHNPs, e.g. in Indonesia).

Breastfeeding: knowledge on practices (initial, exclusive, continued), arrange mutual support, build confidence, prevent misinformation and undermining, facilitate time for breastfeeding; provide information along the lines of the WHO infant formula code.

Complementary feeding: knowledge/counseling (timing of introduction, type, energy density, frequency, etc), sometimes promoting village or urban area production of weaning foods, sometimes marketing inexpensive food; facilitate mother's time allocation; food technology (hygiene, storage, preservation via fermentation or even refrigeration), *monitoring and promotion:* equipment-scales, charts, manuals; training/supervision; training of weigher to interpret charts and counsel mother; should if possible include birth weight; referral system for problems is crucial (either for treatment, or if flat, no-growth chart).

Micronutrient supplementation: vitamin A, for women non-pregnant and during pregnancy: low dose weekly, preferably as part of multinutrients; for women within 1 month of delivery, massive dose to protect infant via breastmilk; vitamin A, for infants and children: massive dose at 9 months immunization contact, thereafter every 6 months and when medically indicated; Vitamin A days/weeks, with immunization campaigns, etc; iron, daily or weekly for women, especially during pregnancy, also

others; usually with folate; may be with multiple micronutrients; iodine usually by fortification, but should be part of multiple micronutrients, probably for pregnancy; can be infrequent (6 monthly) oral supplement if necessary.

Micronutrient fortification: local fortification is unusual – although an important central program – but local *monitoring* is a coming opportunity, especially iodized salt testing kits.

Supplementary feeding, using external supplies: this may be appropriate sometimes in emergencies, and in conditions of extreme poverty (e.g. Bangladesh Integrated Nutrition Project (BINP)), providing 200-500 kcals/person/day, but otherwise is to be avoided as costly, not very effective; moreover, feeding can distort programs, which come to be seen largely as a source of free food.

Supplementary feeding, using local supplies: this can be useful for complementary feeding (weaning) if carefully organized (which requires some resources); village community production and processing is useful if feasible (e.g. Zimbabwe); system can move to coupon rather than direct food distribution (e.g. Thailand).

Oral rehydration: local preparations for dehydration in acute diarrhea, as well as (or better than) standard oral rehydration salts (ORS), are highly effective; these need counseling of mothers, and take a lot of parents' time; persistent diarrhea needs other intervention, especially nutritional. Care of children during sickness, especially continued breastfeeding and other foods, needs to be stressed (applies also to other illnesses).

Immunization: inform, refer, facilitate.

Deworming: Mebendazole every few months is a highly effective nutrition intervention; distribution methods and supervision are issues (UNICEF, 1998).

The relative suitability of community- and facility-based operations for the different components again depends on local conditions, but are fairly obvious: community activities are essential for infant and child feeding, other caring practices, environmental sanitation, and the like; facilities have a key role in immunization, antenatal care, and of course referral for treatment. Growth monitoring, micronutrient interventions, oral rehydration, and similar activities may be focused in either.

Even in devolved government systems, central government support is also crucial: central inputs of training, supervision, wages, supplies, facilities, and policy-related operations research and evaluation. The DCP synthesis reviews four other important program factors necessary for success (coverage; targeting; resource intensity to create effective provider to child ratios and similarly strong supervisor (*facilitator*) to community work (*mobilizer*) ratios; and technology. These elements are described in detail in the later discussion of Asian programs.

Impact: The underlying rates of improvement in the developing world are around 0.5 percentage points per year (ppt/yr) in reduced prevalence of underweight under-fives. How much more can successful programs achieve that incorporate the programmatic and contextual factors described above? The DCP synthesis concludes that:

- Successful CHNPs reduce underweight prevalence by an additional 1.5 – 2.0 ppt/yr, but

- The dose-response relationship is not linear; i.e. programs that invest \$1-2/child/year cannot meet the technical quality, coverage and intensity for mobilizers and facilitators that will make a difference. Small funding is wasted.
- Resource intensity matters, both technology and personnel per child cohort.
- Multi-faceted, integrated health and nutrition packages are more effective in assuring survival, growth and development, and more efficient from an organizational, logistical and management perspective.
- After an initial “burst of improvement” (reducing underweight prevalence of up to 2.5 ppt/yr from program impact plus underlying trend), a second phase kicks in where sustained improvement adjusts to 1-2 ppt/yr until prevalence approaches 10-15 % of under-fives. Below that threshold, cost-effectiveness is less likely and the remaining malnourished children should be nurtured by families rather than initiating a national public policy thrust.
- Most of the successful programs are in Asia and the Americas, but unfortunately programs in Africa, such as Iringa in Tanzania (Dolan and Levinson 2002) that were initially successful have not been sustained.

Cost-effectiveness

Cost-effective nutrition interventions are available and should be used more consistently (World Development Report, 1993; Del Rosso and Marek, 1996; Horton, 1999; Institute of Medicine 1998). Expressed in terms of Disability-adjusted Life Years (DALYs)⁹ or healthy years of life saved, the following interventions cost less than \$25/DALY: breastfeeding promotion, salt iodization, staple fortification with vitamin A, semi-annual mass dose of vitamin A, iodine injections for pregnant women, and daily (probably weekly also) oral iron for pregnant women); parallel health interventions at similar cost are the Expanded Program on Immunization Plus (immunizations plus Vitamin A semi-annual doses); school health (particularly integrated iron supplements with deworming medication); and health, nutrition and family planning information and education campaigns. There are obvious synergies in promoting joint health and nutrition interventions for mothers and their young children in the form of family-based packages of services. Education and supplementation must be linked, along with superior logistics and management, for micronutrient enrichment programs to be effective, e.g. iron (Gillespie 1998).

Other interventions are available for under \$75/DALY: improved weaning practices for children, and food supplements for children and pregnant women. The US Institute of Medicine (1998) summarized evidence on iron and vitamin A interventions, both supplementation and fortification; most interventions cost less than \$25/

DALY¹⁰, as do some school health and nutrition programs that are competitive with immunization programs (Del Rosso and Marek, 1996). In the DCP synthesis, Mason *et al.*, (2004) calculate the cost per DALY saved in CHNPs, based on a methodology explained in the paper. They estimate \$200-\$250/DALY saved in sustained programs, where the investment is sufficient to reduce underweight prevalence of under-fives by 2 ppt/yr. This estimate errs on the conservative side, for two reasons: (i) because the authors ignored DALYs gained from reduced incidence of diseases that do not show up as related to underweight, which is probably substantial, and (ii) because in three of the country case studies the initial improvement was four times the long-run trend and that has not been factored in the cost-effectiveness. Mason *et al.*, comment: “*Moreover, if this calculation is applied just to the first rapid fall, typically (in the three cases analyzed around 8 ppts/yr, the ratio might fall by a factor of 4, to \$50-60/DALY saved (but start up costs are higher too).*”

Community health and nutrition program costs

The UN accurately estimated the cost of successful programs in *How Nutrition Improves* (Gillespie, Mason and Martorell 1996): “... *there seems to be some convergence on around \$5-10 per head (beneficiary) per year being a workable, common level of expenditure in nutrition programmes, though not generally including supplementary food costs...*”

That range is borne out by the DCP synthesis (Mason *et al.*, 2004) as described later. The cost per beneficiary to mark a successful program is about the same in Africa as in Asia. Without supplementary feeding in Asia and Africa, a consistent outlay of \$5-\$10 per child per year (sometimes the “beneficiary” is the mother and child) allows community programs to achieve results. Below that threshold of \$5 per child, programs have little impact. Adding supplementary feeding as a prime input generally doubles the cost/child, and that option should be reserved for extreme emergencies in areas of severe poverty. Here are several examples of successful community programs that focus on child growth and health with links to micronutrients and maternal health.

The findings of the CHNPs studied in the DCP synthesis are shown in Table 6. CHNPs’ cost per child is usually a small percentage of public health budgets, illustrated for a sample of Asian countries in Figure 1 (analysis in Mason *et al.*, 2001).

ANP/Kenya: \$4/child/yr. Sponsor: LINKAGES (USAID)

SCSP/Uganda: \$5/child. Sponsor: LINKAGES

Micronutrient & Health Project: \$2.20/child. Sponsor: USAID, World Vision.

Tanzania/Madagascar: \$7/beneficiary. Sponsor: World Bank Second Community Nutrition Project

AIN/Honduras: \$4/child. Sponsor: USAID

Integrated Child Development Project, Philippines: \$11/child. Sponsors: Asian Development Bank, World Bank

Here are the findings of the CHNPs studied in the DCP

⁹ DALY is a composite index of health linked to a productive life usually referred to as a “year of healthy life saved”. DALY is a weighted index that takes into account loss of life, morbidity, and disability and their collective impact on productivity.

¹⁰ Prenatal iron supplementation and vitamin A-enriched food supplements are higher but within the \$75/DALY group.

synthesis. CHNPs' cost per child is usually a small percentage of public health budgets, 1-6% for a sample of Asian countries (analysis in Mason *et al.*, 2001).

IV B. Regional Reviews

IV B1. Community nutrition in Asia: core programmatic and contextual factors for success based on a regional UNICEF-ADB assessment

An eight country assessment covering South and South-east Asia involved country studies on investment require

to halve underweight prevalence and cure micronutrient deficiencies. Since there is a decade left before the MDG deadline, these country assessments are useful to meeting MDG#1. Cambodia and Viet Nam were also part of the review. The following is condensed from Mason, Hunt *et al.*, (2001) and Mason *et al.*, (2004).

The extent of CHNPs in Asian countries was recently reviewed, in the context of a study aimed at identifying ways of investing in improved child nutrition sponsored by the Asian Development Bank (ADB) and UNICEF

Table 6. Characteristics of selected programs : DCP Synthesis (Mason *et al.*, 2004)

Country (F: see note)	Coverage, targeting	Resources, intensity
<i>Africa</i>		
Tanzania – Iringa F: (+)	Popn served =250,000 in 6 districts, 610 villages, 46,000 children, of which 33,700 participated (73%). Targeting: children <5yr & women, no selection of communities. Progressed from 168 to 610 villages 1984-88	\$8 – 17 /child/y (~\$30 /child/y from total costs: ~\$6 m) 2VHWs/village, = 1,220 total ~1:40 children [Volunteers]
Tanzania – CSD F: 0	9 of 20 regions (popn total approx 12 m, 2 m children). Aimed for complete coverage.	\$2-3/child/y [Volunteers]
Zimbabwe – SFP F: ++	56,000-96,000 with suppl feeding; up to 60% of all children in community-based growth monitoring.	External: \$3 m over 10 yrs. E.g. 1990, \$0.5 m, ~ \$0.5/child/y (:10 – 200, based on numbers per project) [Extension agents]
<i>Asia</i>		
Bangladesh – BINP F: +	BINP: in 6 (?) thanas (7% of popn), children<2y, pregnant and lact women, 8 m.	1 community worker per 1000 popn ~1:200 children \$14m/yr, ~\$18/child/yr [Project supported]
Bangladesh – BRAC	Health coverage 25%. Nutrition with BINP, now expanding	1 CHV: 300 households. Community nutrition promoters (CNP) 1:200 households; Community Nutrition centers, 1:120 mothers/children. Supervision of CNPs by CN Organizer, 1:10.
India – ICDS F: ++/+	Children 0-6 y & p/l women, in 3900 of 5300 blocks, ~74% popn. Coverage expanded without targeting except by area.	Community worker (: ANW) ~1:200 children. 1 supervisor:20 ANW Non-food costs ~\$2/ch/y [ANW is paid, at low rate]
India – TINP F: +	Children 6-36mo, p/l women. Children with growth failure selected. 40% of blocks in TN, 20% of children, in 1990.	Community nutrition workers (CNW), 1:300 children, supervisors, 1:10 CNW. \$9/child/yr, plus ~\$3 on food. [Project supported]
Indonesia F: (+)	By 1990, 60,000 villages (of 65,000: 92%) had posyandus (village health/nutrition center). Women and young children. (H, p63)	\$2-11/ch/y, depending on suppl food. (Rohde gives <\$1 recurrent). Village workers (~3 m total) 1:60 people, ~1:10 children; supervision 1:200. [Volunteer]
Philippines – natl F: 0	Several programs, all targeted, e.g. to poorer areas, none with national coverage.	\$0.4/child/yr in targeted areas; village workers (nutrition scholars) ~ 1:300 children (example of LAKASS) [Low allowance given]
Thailand: PHC+ PAP + BMN F: (+)	Expanded over about 5 yrs to cover 95% of villages. 600,000 village health communicators (VHC: 1% of popn) trained, 60,000 VH volunteers.	MOPH, approx \$11/hd/y (1990) VHC/V 1: ~20 children; supervision – extension workers: VHC/V ~1:24. [Volunteer]
<i>Americas</i>		
Costa Rica F: ++ to 0	Expanded rural health program coverage 19% to 67% (1974-89).	RHP: \$1.7 /child/yr FNP: \$ 12.5 /child/yr 2 health workers (full time)/ 5000 popn, ~ 1: 350 children. [Health worker]
Jamaica F: 0	Community health aides (CHA), waged, cover most of country from health centers, with home visiting.	CHAs, full time, 1:500 households. Approx \$7/household/yr. [Health worker]
Nicaragua F: 0	Community health workers (<i>brigadistas</i>) with 'multiplier' approach, training others; 1980 ~ 1% trained, many more for malaria control.	Volunteers, approx 1:20 households.

Note. F in first column refers to role of supplementary feeding in the program. F: ++ means mainly a feeding program, or primary role; F: + means significant but not main role; often to selected children. F: (+) means existed but relatively minor. F: 0 means none. The status of community workers is given in []s in the right hand column. ANW – Anganwadi worker; BINP – Bangladesh Integrated Nutrition Project; LAKASS – national community nutrition program in Philippines; posyandu- integrated health post at village level in Indonesia; TN – Tamil Nadu; TINP-Tamil Nadu Integrated Nutrition Project; VHW – Village health worker

(Mason, Hunt, Parker & Jonsson, 1999, 2001). This gives a basis for assessing the present extent of these programs in Asia (which has the largest share of the disease burden, and of child malnutrition, of any region), and led to some approximations as to what it would take to close the gap to provide full population coverage. CHNPs as considered here are mainly a rural model, and some transference of ideas to urban settings is needed. The structure for successful CHNPs is adapted throughout the region along the lines of the Thai model, illustrated in Figure 2.

Community health workers act as nutrition promoters to help families prevent the onset of malnutrition with children under three, and through support of growth monitoring identify children whose growth has faltered and recommend a family-based course of action. This may or may not involve food supplied outside the household.

Current and planned programs relevant to nutrition should be analyzed first by indicators of their *coverage* and *targeting*. That is, as percent of the at-risk population participating in the program; then by how far this coverage is oriented towards the neediest. A third criterion is described as '*intensity*': how much resources are used per participant—who may be quantified as US\$/participant/year, or by the number of children per mobilizer, facilitator/mobilizer ratios, and so on. Some levels of resource use for comparison purposes can be suggested.

Around US\$5 to \$15/participant/year seems to be associated with effective programs, at least those that do not include provision of supplementary food, which

could double the cost. In principle, these three measures — coverage, targeting, and intensity — can be obtained from program data. In many cases well-conceived programs may be ineffective simply because their coverage is too low (Fig. 3) to have a broad impact on the problem, or because they do not reach those most in need. In other cases, the principles may be correct but an unrealistically low level of resources is committed, so nothing much really happens. These indicators pick up such issues.

Moreover, programs are not usually positively targeted towards the most malnourished, except sometimes growth-faltering children are selected for special feeding. It is unclear whether the content of many programs is best designed to address important causes of malnutrition. Related to this, the issue of using scarce resources for supplementary food versus other uses (e.g. behavioral change) remains unresolved - in practice often in favor of supplementary food. The supervision ratios (mobilizers/facilitator) are also suggested as 1:20; this is in line with small-scale program experience, e.g. Vietnam. Since there are too few mobilizers, fewer facilitators will do for now, and these ratios are better, e.g. 1:20 in India. But if the mobilizer numbers expand, more facilitators will be needed in proportion.

Gaps

This review of country programs was intended, in part, to lead to an estimate of gaps in resources. Around US\$1.4 billion per year is the estimated cost of effective programs

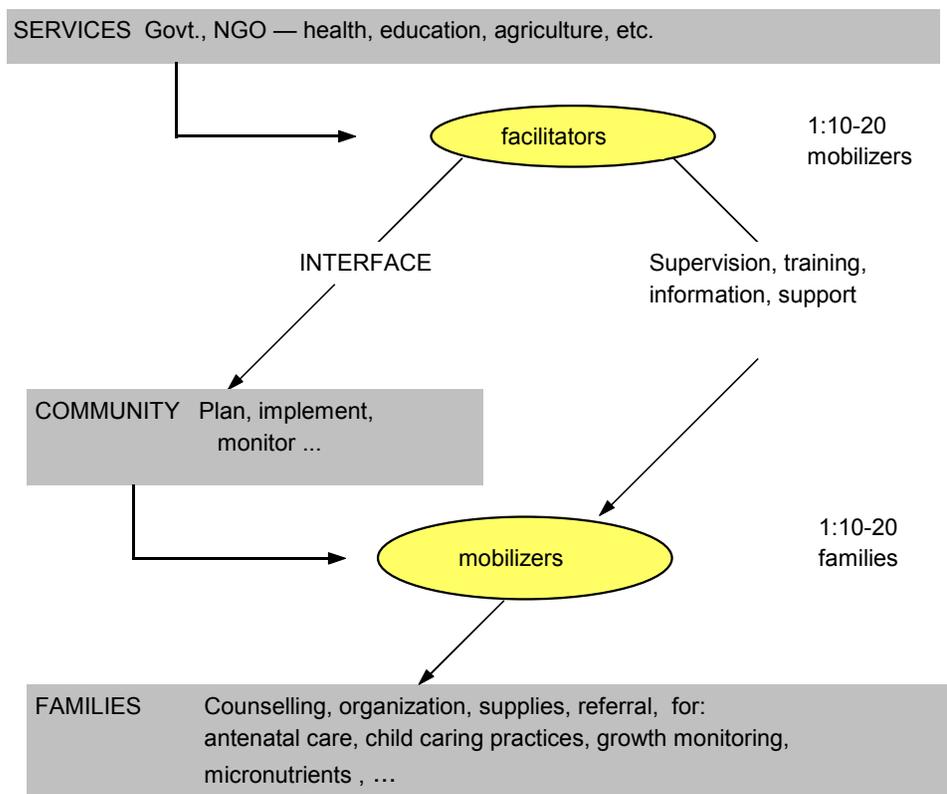


Figure 2. General structure for community-based programs based on Thailand's. Adapted from Tontisirin, 1996

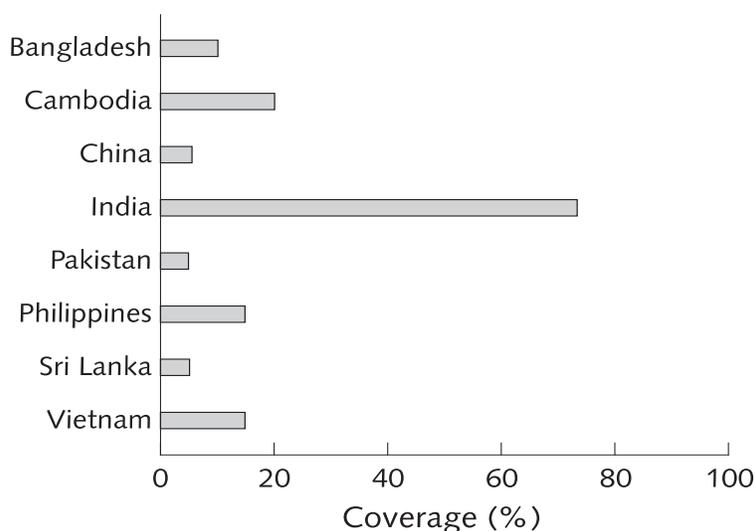


Figure 3. Coverage of current community-based nutrition-oriented programs.

for the approximately 273 million children in the eight countries. This resource level could reduce the underweight prevalence by an additional 1.5 to 2 percentage points per year (pp/yr), thus broadly halving the prevalence on average over 10 years. This figure is derived from standardized costs per child. Existing resources should in principle be deducted to estimate the gap, but these are not readily available. However, the present coverage and intensity of programs indicates that less than 10% of the required resources are currently being applied, so much of the estimated needs in fact represent the gap. These financial results were calculated from estimates of community-based programs. Micronutrient deficiency control programs were not included.

So, in rough terms, accelerating nutrition improvement by the 1.5 to 2 pp/year needed to halve the prevalence of underweight children in 10 years will require about US\$1.4 billion per year, and some 15 million people trained as community workers, with 750,000 facilitators to support them. This is a probably a realistic estimate.

Supplementary feeding is a crucial issue, largely because it can take up much of the resources available for nutrition. Using external supplies - food aid - does not solve the problem, as personnel are then occupied with administration; anyway, this source is phasing out. Internal resources can be used for complementary foods as well as supplementing those at high risk of malnutrition; Thripasha in Sri Lanka is an example.

Generally provision of supplementary food is not regarded as either a good use of funds, nor necessarily as very effective, in fact sometimes it can be counter-productive. The Integrated Child Development Services (ICDS) in India has come to be seen as a food distribution program, and people attend when there is food available, which was neither its intent nor the best approach. An exception may be among extremely poor populations, as with the Bangladesh Integrated Nutrition Project (BINP), where the meager resources simply are not available to adequately feed young children. This question of the proper place (if any) of supplementary feeding remains to be fully resolved; it probably could be with research using existing data. Meanwhile, the policy put forward in most

of the country studies of preferring to use resources for other actions is likely to be correct.

Extending CHNPs' coverage and intensity¹¹

The extent of programs at that time (data from late 1990's) was assessed in terms of the population covered - intended to participate in the programs - and then the resources per head (intensity) *within* the program; that is, the denominator is the intended participants, *not* the overall population. Resources were estimated in terms of annual expenditures per child, and of ratios of population to community workers ('mobilizers'). Eight countries were considered (Bangladesh, Cambodia, China, India, Pakistan, Philippines, Sri Lanka, and Vietnam), and previous experience in Indonesia and Thailand also provided much guidance.

The population coverage of CHNPs was estimated as around 5-20%, except for India with the ICDS, which reports around 70% coverage. The next indicators refer to estimates *within* programs. The calculated intensity was commonly 200 children: 1 community worker (e.g. Bangladesh, India, Sri Lanka), up to 100:1 reported in Pakistan and Vietnam, and 60:1 in the Philippines. Further research has stressed the variation in time commitment of community health and nutrition workers (CHNWs) in different places, hence the need to convert to full-time equivalents (FTEs). The ratios used as norms, from Thailand and Indonesia, of around 1:20 are probably equivalent to 1:200 in FTEs. In India opinion has been that about a doubling of the ratio of *anganwadi* workers per child is needed to get the full potential impact. From this perspective these estimates indicate that both coverage and intensity are low. Although intensity may be half that needed, coverage (except in India) is far too low. Calculations from scarce financial resource data show that most government programs were spending around \$1/child/year or less within programs, whereas Bangladesh (BINP, with donor support, and in line with other donor-supported programs) reached \$15-20/child/year. By this calculation the resources per head, as well as the

¹¹ Taken from Mason *et al.*, 2004.

coverage, were in most cases too low for widespread impact. Supervision ratios are estimated as around 1:20 and higher. Expanding the numbers of CHNWs also means increasing the supervisors (usually from the health system), with associated costs.

The estimates of coverage and intensity can be combined to calculate the extent of current programs in relation to that needed for full coverage at adequate intensity. The results based on a 1:20 ratio of CHNW: children suggested that less than 1% of the need was currently available; at 1:200 (which would cost more, as this implied full time equivalence) perhaps 10% of the need is covered. Either way a massive expansion would be called for to use CHNPs as a means for widely improving health (but still only calling for around 20% of the typical public budget for health).

To achieve an expansion requires major resources, and not only finance. Thailand trained 1% of the population as community health workers (part-time), and established an extensive supervision and support structure, including re-training. The estimates for the ADB-UNICEF project in financial terms were that, for Bangladesh, Cambodia, Pakistan, Sri Lanka and Vietnam together, some \$190-280 million per year would improve underweight prevalence by an additional 1.5 ppts/year above the trend line of 0.5 ppt/year (Mason, Hunt, Parker & Jonsson, 2001, pp 64-68).

IV B2. CHNPs in African as settings

African children deserve the support of the global community, especially since the alarming rates of stunting are getting steadily worse. Without major interventions in rural Africa where poverty rates are much higher than urban areas (Sahn and Stifel 2002), the MDG for halving underweight will have to be abandoned, and African children will lose connection with their peers across the globe as they continue to shrink far below their physical and intellectual potential.

Having said that, the CHNP experience is mixed and the costing and impact analysis is inadequate even compared to the Asian overview above. Programs like Iringa in Tanzania have not sustained early momentum. On the positive side, the core activities discussed above have been followed in some parts of Africa with some measure of success. Briefly, two external evaluations of community health and nutrition will be reviewed in order to ask whether a foundation exists for program expansion and replication. First, The USAID-supported BASICS I project recently evaluated its Essential Nutrition Actions (ENA) program in Africa. Second, Project LINKAGES draws lessons on successful community nutrition programming from East Africa.

The BASICS II Evaluation

The BASICS II project has made nutrition a central piece of its child health package, targeted at reaching 80% of under-fives with a combined package of health and nutrition services, with nutrition defined as a group of evidence-based micronutrient and infant feeding interventions known as ENA. The ENA package promotes and

supports the achievement of six priority nutrition behaviors¹²:

- Exclusive breastfeeding for six months;
- Adequate complementary feeding starting at about six months with continued breastfeeding for two years;
- Appropriate nutritional care of sick and severely malnourished children;
- Adequate intake of vitamin A for women and children;
- Adequate intake of iron for women and children;
- Adequate intake of iodine by all members of the household through iodized salt promotion.

Benin

All of these interventions pass the efficacy test bar described earlier. Working with BASICS II, UNICEF and NGOs, Ministry of Health adopted the ENA that was addressed through a health facilities component, a community component, and a multimedia communications component. The Bourgo Regional Health Department was the implementer (1999-2003). The 2003 evaluation showed that after five years these lessons have been learned:

- Operations research involved local people, helping to turn results into action
- Political commitment at national level strengthened MOH's resolve.
- Capacity building elevated community health worker skills and bridged facilities and homes through counselling of child caretakers.
- MOH leveraged ENA in other donor programs, broadening coverage and impact. Effective communications campaigns linked formative behavior change for EBF promotion, integrated attention to nutrition and infectious diseases, and linking education for better child care to effective parenting. Impact of communication was reflected in 80% of mothers recognizing all the ENA messages on proper infant feeding and child care and micronutrients, Vitamin A coverage increased to 60%, and EBF nearly tripled to 50%. This is just a start but a good one.

The most interesting characteristic of BASICS II/ENA, in support of raising the level of resources to African communities, is its flexibility and adaptability to health systems and local contexts. In other countries (Senegal, Madagascar, Nigeria) a viable model was created linking health facilities with communities and families, with similar results. In Madagascar, the health services ran the BASICS/ENA model through peripheral health teams that linked mobile clinics to community based organizations and to home visits for children faltering in growth or failing in EPI attendance. The MOH introduced a mass education movement directed to micronutrient supplementation and fortification, ORT, EPI behaviors, and Growth Monitoring and Promotion. From the BASICS evaluation, flexibility and targeting are strengths, as well as novel configurations of community workers, supervisors, links between mobilizers and facilitators, and the

¹² A subset of the London School of Health and Hygiene, DCP, and Bellagio Study Group "core packages" described earlier.

holistic communications package that includes information, education and communications campaigns, training monitoring and evaluation, as well as curriculum and product development with regulatory reform.

The BASICS II/ENA programs fit the mold of best practices discussed by the DCPD synthesis authors, but reliability and scaling up remain challenges. This deserves a serious look in light of the challenge thrown by the Bellagio Study Group on Child Survival, because the ENA experience demonstrates that commitment and capacity to reach children with a package of priority, evidence-based interventions can be stimulated. The ENA package has not been costed.

The LINKAGES Evaluation

This June 2002 evaluation looked for common features in East African community nutrition programs that could lead to replication. Lessons from 10 community nutrition projects in Kenya, Tanzania and Uganda were drawn, as follows:

- Successful efforts to overcome malnutrition hinge on participatory, community-based programs financed at least at the \$5/child level to have impact
- Programs for the poor to access social services, improve women's status and education, and foster equitable economic growth sustain the impact
- A policy process leading to program development as discussed in the DCPD synthesis is critical
- The full range of programmatic and contextual factors for success applied to East Africa
- Program content, design and capacity issues were similar to Asia
- Community involvement strengthened program management and implementation
- Similar challenges for evolution, sustainability and scaling up as in Asia and the Americas

There are no remarkable differences in Africa except the possible dismantling of the community health movement stimulated by the Bamako Initiative and undermined by AIDS. That aside, the rationale for scaled up effort and investment in Africa is as imperative as in South Asia, given the intractable rise in underweight and stunted African children. Operations research and evaluation need greater attention as an established percentage of project and program budgets.

Research needs

Enough programs have been in operation for long enough that much of the needed research on processes of implementation could be based on these, only launching new trials where this experience does not provide information. Impact evaluation, in contrast to this, requires new and preferably prospective studies. Remuneration and incentives, for part-time volunteers, or part- or full-time waged workers, needs to be investigated and resolved, for different cultures. Optimal supervisory and worker-to-household ratios need to be better understood. Methods of training, retraining, and related information and practice support need to be reviewed and related to effectiveness.

A major gap is the application of community-based programs to urban areas. Here communities are conceived

differently to the rural areas of most CHNPs, organizations run along different lines, and so forth. Yet population growth is in urban areas, and some problems, notably HIV-AIDS, are worse there. An extensive search might have found equivalent urban programs, but these are certainly less well known. Finally, the CEA results given in an earlier section are based on rather few and approximate results. CHNPs may well provide a viable and cost-effective approach under many circumstances in poor countries, and it may be necessary to demonstrate this better and more quantitatively for support to CHNPs to compete with more traditional service delivery interventions: that too would constitute worthwhile research (Mason *et al.*, 2004).

V. Nutrition investment for human and sustainable development

This review is premised on the importance of reducing both underweight prevalence of children, as the key policy variable for hunger reduction, but also reducing "hidden hunger" - the micronutrient deficiencies that rob life, health, ability and productivity. The exercise affirms the importance of existing strategies but suggests that certain approaches (e.g. vitamin A and iron folate supplementation) may benefit from coverage limits in light of their higher-than-expected costs. Better targeted supplementation could follow the pattern of IDD where fortification has become the principle approach because of efficiency in reaching population coverage at very low cost. Biofortification offers the best bargain for the dollar in theory, but is years away from yielding nutritionally improved varieties from plant breeding in several crops. The biggest decision in this cavalcade of options is whether to mobilize major resources for community programs, and that is desirable even imperative given the stubborn rates of underweight and stunting and their life-long threats to health, mental acuity and longevity. A summary of program costs on a 10 year basis (2005-2014) is shown in Table 7. Certain assumptions behind these numbers may not be valid, or are at least questionable.

First, full coverage of Vitamin A supplements for under-fives is costed, even though this would involve doubling the present coverage without knowing the delivery mechanism to replace the NIDs. Low and high estimates are included to reflect the likelihood that rural programs (post-NID) will be much more expensive unless an essential health care "package" including Vitamin A moves through the hands of community health workers all over the developing world.

Second, the Copenhagen Consensus' recommendation that \$12 billion be used to reduce iron deficiency anemia would support the full costs of iron fortification of flour and biofortification globally, plus iron folate supplementation for somewhere between 50 and 100 million pregnancies over the next decade. This would fall far short of universal coverage for supplementation, but would make better sense as a residual strategy if major efforts by donors and governments enabled iron-fortified flour to reach poor women in the 100 countries consuming wheat and maize flour daily. Another assumption is that efforts to reach the severely anemic pregnant women with iron folate supplements will involve community-

Table 7.

Micronutrient Supplementation	\$ billion
Vitamin A for under-fives @\$1.50/child (full coverage)	7.5-15.0
Iron folate per pregnancy @\$14.00/pregnancy@50-100 million	7.0-14.0
Integrated IDD Control	1.0-1.5*
Micronutrient Fortification	
Wheat Flour	0.85*
Maize Meal Flour	0.84*
Cooking Oil	0.70*
Biofortification	0.15
Community-based Health and Nutrition Programs	
<i>Focus:</i> South Asia and Priority 12 Sub Sahara African countries 100 million children X 2 yrs @\$5-10/yr	10.0-20.0
Total	28.0-53.0

* The public sector share is less than a fourth.

based health workers, since antenatal clinics are used less often by the most at-risk women.

Third, the costs of IDD control may be understated if iodine supplementation has to be resuscitated as an emergency response for “hotspots” where the iodized salt option is not available.

Lastly, a range of costs for CHNPs are included, but the author’s bias is toward the upper end (\$10 per child per year) based on successful experience without including the cost of supplementary feeding. While the costs are targeted for South Asia and Sub-Saharan Africa, it is imperative to reach all moderately and severely underweight and stunted preschoolers wherever they live, and additional resources should be sought.

Economies will be captured if health and nutrition are integrated in community programs, including supplements with essential health care through health posts and/or home visits. Communications campaigns in communities and through messages delivered in home visits can improve compliance for supplements and shift consumer preferences to fortified essential staples, especially fortified complementary foods that improve the physical and mental development of very young children. Compliance will lower supplementation costs considerably, as purchased or home prepared micronutrient-enriched foods reduce the need for supplements.

The rough nature of this estimation exercise is neither deplorable nor adequate for serious investment decisions. But it can be argued, even at this level, that nutrition improvement is a very sound investment. Recall the WHO Commission on Macroeconomics and Health bargained for \$75 billion over ten years to address childhood illnesses and malaria, while the nutrition investment bundle addresses a third of global disease burden and half of child mortality at one-third to two-thirds that amount (even assuming there is no redundancy in population coverage for the various micronutrient vehicles). Both sets of investments are critical to child survival, adult productivity, and decreased income poverty over the full life cycle of today’s newborns, and conjointly such investments may contribute to global peace and justice more effectively than any other. But nutrition should not take a back door to other claimants for the public purse.

In summary, three decision points deserve attention before further investment is mobilized.

First, a decision is needed on how to limit the coverage of iron folate (or the multiple micronutrient alternative) and Vitamin A supplementation while strengthening the delivery mechanisms to combine health facility-based and community programs. Without programmatic clarity, donor fatigue and governmental scepticism about the recurrent cost burden will undermine future progress. Scaling down, rather than up, is likely.

Second, since fortification of staples lowers the delivered cost by a factor of ten or twenty depending on the micronutrient and food vehicle, major efforts to build capacity for regulation, quality assurance/quality control, food safety and trade of fortified food products, with enhanced public health surveillance to target residual supplementation to at-risk sub-populations, are necessary and should receive priority financing.

Third, evidence that biofortification works (*vide* the rice convent trial in the Philippines) raises the possibility that population prevalence of iron deficiency and possibly other deficiencies (e.g. zinc) will effect a food policy solution through agriculture, two orders of magnitude cheaper than supplementation and a tenth the cost of fortification *sans* a recurrent cost burden.

Put differently, the joint mobilization of fortification immediately and biofortification within the next decade may very well permit governments and donors to shift their resources to other pressing public policies for human development after achieving the first and fourth MDGs by reducing malnutrition sustainably through affordable diets of high quality.

There is a paradigm shift in international public health toward the deployment of food science and technology in agriculture and industry for the benefit of humanity that could shift the trajectory of poor women’s and children’s lives from tragedy to hope. The paper concludes with examples of how nutrition and health improve through strategic investments in infra-structure (notably water and sanitation in both rural and urban areas) to meet the MDGs by reducing disease burden synergistically with direct investments in food and nutrition; and the increasing importance of regional public goods for nutrition and health is illustrated through the liberating potential of international trade.

VI. Environmental and regional economic policies to support health and nutrition of the poor

VI A. Water supply and sanitation

A recent review of the contribution to global disease burden attributable to poor water, sanitation, and hygiene estimates that these account for 4.0% of all deaths and 5.7% of the total disease burden (in DALYs) occurring world wide, including diarrheal diseases, schistosomiasis, trachoma, ascariasis, trichuriasis, and hookworm disease (Pruss *et al.*, 2002) These estimates are based mainly on intervention studies and are probably understated.¹³ The proportionate burden is likely to be higher in poor developing regions. Some 40% of the environmentally related disease burden falls on children under five, who account for only 10% of the world's population. Thousands of children die daily from polluted drinking water and food. Ten million children under-five in developing countries die needlessly each year, and the capacity of health services to cope with this load is limited. Environmental protection through safe energy and safe water and sanitation would reduce deaths from diarrhea and pneumonia by millions each year, and create a new child health revolution. Global immunization and child survival programs do not easily reach the poorest children and the remotest regions in the developing world, where investments in environmentally benign technologies would reap the greatest benefits.

Polluted drinking water and lack of adequate sanitation are responsible for 1.8 million deaths annually, mostly poor children under five suffering from severe diarrhea in developing countries. Some 80–90% of diarrheal disease events are environmentally related. Children drink twice as much water as adults, so the frequency and severity of diarrhea is proportionately higher. Public health programs worldwide have done a good job of saving one million lives each year through case treatment over the last 10 years, but diarrhea prevalence is still very high because of inadequate investment by countries in water supply and sanitation. Children who survive frequent diarrhea bouts early in life are likely to be stunted and frail, with negative consequences later in life.

In providing the hardware of water supply and sani-

tation, hygiene education has been recognized as a critical disease intervention measure. WHO and UNICEF estimate that approximately 1 billion cases of diarrhea occur each year with 3.3 million deaths, mostly among children under 5-years old. However, it has been proven effective that hand washing with soap and water after using the toilet and disposing of children's feces can reduce diarrhea by 35% or more. It is therefore important to effect behavioral change as part of projects in this sector by encouraging personal and domestic hygiene.

Water sector programs are critical to saving lives of young children, and ensuring that the physical and mental development of preschoolers allows them to learn well, to complete schooling, and become productive adults. The benefits increase when water and sanitation are combined (Fig. 4) with behavioral change about domestic hygiene and child-feeding practices in the home, as illustrated by Esrey (1991) on reducing diarrhea morbidity through integrated strategies.

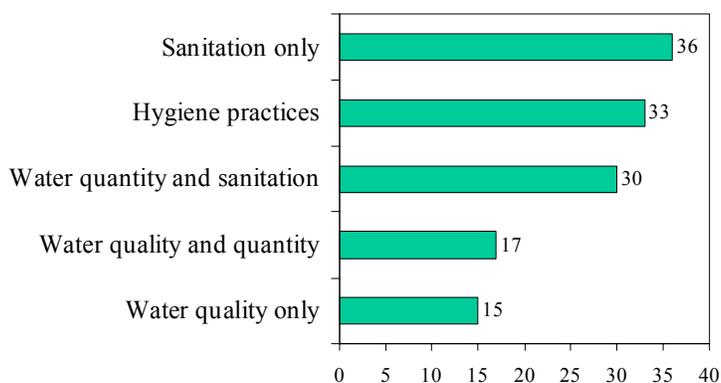
VI B. Regional public goods

In developing countries, there is an opportunity to view the broader context of health, environment, and development through regional approaches linked to established global initiatives.

Definition

Regional public goods (RPGs) are increasingly seen as a viable option that developing countries and the donor community should use to address compelling problems of transnational scope. Infectious diseases that disrespect national borders, disputes over trade and fairness in international business practice, harmonizing regulations that govern the exchange of health goods and services, establishing fair and consistent prices for essential goods at the regional level, and coping with natural crises including the impact on economic migration, are transboundary development challenges that call for solutions at a regional level. RPGs respond to market failures, common among health-related policies and interventions, where investment particularly by the private sector may be constrained by disproportionate benefits accruing to

Figure 4. Simultaneous improvements in sanitation, water quantity and water quality give large reductions in diarrheal morbidity. Source: Esrey *et al.*, 1991



¹³ For example, both malnutrition and vector-borne diseases (e.g., malaria) account for a considerable proportion of the disease burden, and are related to quality of water, sanitation, and hygiene, but because the attributable fraction of water-related disease burden is not precisely known, no estimate has been included in the water cluster.

the poor and lowered profits are expected. RPGs stipulate the provision of non rival benefits so that one country benefiting does not provide obstacles to another also benefiting; countries that do not pay for the RPG are not excluded from its benefits (i.e., benefits from an RPG are not held by a selective “club” of stakeholders, instead received by all parties). Also, RPGs reduce overall transaction costs for delivering benefits by spreading responsibility and building regional institutions that will assume the burden of sustained capacity building over the long-term.

Applications

1. Urban Development and Health

Water for Asian Cities

Based on an agreement between ADB and UN HABITAT in March 2003, ambitious regional program for integrating water, sanitation, wastewater management, and solid waste disposal in Asia’s urban slums has begun, with a projected investment level of US\$500 million re ADB lending. This initiative has arisen from stakeholder participation and consultation processes, and the firm direction of the program was confirmed at special sessions at the 3rd World Water Forum in Kyoto.

The objective is to provide integrated services for 10 million urban dwellers; to cover the region with representative “flagship” programs; to ensure beneficiary participation and ownership for sustainable service delivery; to adopt a total river basin systems approach within which reliable water availability and drinking water quality can be assured; to reduce nonrevenue water and develop local systems for governance and sustainable financing; and to promote good hygiene and health practices by linking infrastructure development to community health outreach programs. This is a promising model for bringing essential services to the urban poor and upgrading slums in line with the regional coordination and multiple donor partnerships should be developed using the ADB–UN HABITAT alliance as the prototype.

2. Trade and health

The benefits of trade liberalization are often questioned, not least because of the impasse at the WTO Cancun talks on global trade and development (September 2003) that stymied progress in reducing subsidies from developed countries to agricultural products, among other areas. Nevertheless, all countries are permeable to the influences of globalization and two essential commodities needed by the poor—processed foods and medicines—can benefit from trade because international standards of quality, transparent pricing, and product labelling are required by the WTO agreements. A trade approach amenable to agreement is food fortification, addressing micronutrient deficiencies disproportionately suffered by the poor. ASEAN has recently signed a free trade agreement with the PRC that could very well facilitate fair pricing, high quality, and universal access of commonly consumed commodities like fortified foods.

Creating an ASEAN-PRC Alliance for Nutritionally Fortified Foods

Food fortification is an essential element of national food policies in Asian and Pacific countries to ensure nutrition security for all their citizens. Asia is poised to apply food science and technology in the food industry and make strides in solving the lingering micronutrient deficiencies (vitamins and trace minerals) that impede human development (and indirectly economic development) on a massive scale. Three-quarters of the children and adults suffering from micronutrient malnutrition in the world (iodine, iron, Vitamin A and zinc are the main culprits) are living in Asia, as are three-quarters of the world’s underweight and stunted children.

Food fortification is a proven technology that has been used in the industrialized world for 70 years. A mature food industry in Asia will soon be prepared to deliver micronutrients through fortified foods at the population level, substantially reduce maternal and young child deaths, and also help children achieve optimal physical growth and mental development at very low cost. The technical costs of production are not prohibitive. ADB has shown regional leadership in implementing fortification programs in Central Asia, and helping mainland Asian countries define through country investment plans a niche for the food industry to improve the health of the poor, as well as the educability of their children, through fortification of essential, commonly consumed foods. A variety of foods can deliver iron and reduce anemia (wheat flour, condiments like soy and fish sauce and monosodium glutamate), reduce vitamin A deficiency (cooking oils, margarine, sugar), reduce iodine (salt) and zinc deficiencies (wheat flour), and all forms of malnutrition in infants and very young children (through multiple micronutrient-enriched complementary foods).

The ASEAN-PRC free trade agreement offers an opportunity to place fortified foods in major production systems throughout this region, and the proposed regional initiative would promote harmonization of standards to effect rapid adoption of fortified staples and to tap the power of regional trade to induce competition and institutionalize structural reform packages that will raise the credibility of ASEAN and PRC as formidable partners in global food trade. Donors working in collaboration with the ASEAN Secretariat, should examine how the Asian region can create common approaches to regulation, quality assurance and food control systems, and trade. Harmonization of all regulatory and trade protocols in the 12 nations with Codex Alimentarius standards for food safety and product labelling, as well as the WTO agreements with member states, should be the goal by 2005.

Conclusion

It is economically rational to direct both public and private resources to health services and community organizations to improve nutrition, in partnership with the private food-related industrial and agricultural sectors. It is equally rational to build approaches that help infrastructure work for the help of the poor, and to scale up

successful experience through regional public goods that ensure efficient and equitable sharing of low-price, health-enhancing tradable goods. Deeper pockets outside the health sectors may thus be open to realizing the MDGs for hunger, women's and child health, and the educability of humanity.

References

- Administrative Staff College of India. National strategy to reduce child malnutrition: Investment Plan. Final Report. Mimeo. Manila: Asian Development Bank. December.1997
- Allen L, Benoist B, Dary O, Hurrell R. Guidelines on food fortification with micronutrients. Geneva: Department of Nutrition, World Health Organization. *In Press*.
- Allen L, Gillespie S. What Works? Efficacy and Effectiveness of Nutrition Interventions. ACC/SCN Nutrition Policy Paper Number 19 and ADB Nutrition and Development Series Number 5, 2001.
- Asian Development Bank. Food fortification in Asia: improving health and building economies – an investors' primer. Manila: Asian Development Bank Nutrition and Development Series No 7. June 2004.
- Baltussen R, Knai C, Sharan M. Iron fortification and iron supplementation are cost-effective interventions to reduce iron deficiency in four subregions of the world. *J Nutr* 2004 Oct; 134 (10): 2678-84.
- Barker D. Growth in Utero and Coronary Heart Disease. *Nut Reviews* 1996; 54 (2): S1-7.
- Barker D 1998. Mothers, Babies and Diseases in Later Life. London: Churchill-Livingstone.
- BASICS ENA Country Reviews: Benin, Madagascar, India BASICS2003. Improving child health through nutrition: the nutrition minimum package. Washington, D.C.: United States Agency for International Development, 2004
- Basta S, Soekirman MS, Karyadi D, Scrimshaw NS. Iron Deficiency Anemia and the Productivity of Adult Males in Indonesia. *Am J Clin Nut* 1979; 32: 916-925.
- Beaton G, Martorell R, Aronson KA. Effectiveness of vitamin A supplementation in the control of young child morbidity and mortality in developing countries. Toronto, Canada: University of Toronto, 1993
- Beaton G, McCabe G. Efficacy of intermittent iron supplementation in the control of iron deficiency anaemia in developing countries. Ottawa, Canada: Micronutrient Initiative, 1999.
- Behrmann J, Alderman H, Hoddinott J. Hunger and Malnutrition. Copenhagen Consensus Challenge Paper, 2004.
- Behrman J. The Economic Rationale for Investing in Nutrition in Developing Countries. Washington DC: USAID, 1992.
- Black R, Morris S, Bryce J. Where and why are 10 million children dying every year? *Lancet* 2003; 361:2226-34.
- Bleichrodt N, Born M. A metaanalysis of research on iodine and its relationship to cognitive development. In: Stanbury JB, ed. *The Damaged Brain of Iodine Deficiency*. New York: Cognizant Communication, 1994; 195-200.
- Bloom D, Canning D 2000. The health and wealth of nations. *Science* 287(5456):1207-1209.
- Bouis H. (ed). Special Issue on Improving Human Nutrition through Agriculture. *Food and Nutrition Bulletin* 2000; 21 (4): 351-570.
- Brown K, Pollitt E. Malnutrition, Poverty and Intellectual Development. *Scientific American* 1996; 26-31.
- Bryce J el Arifeen S, Pariyo G, Lanata C, Gwatkin D, Habicht JP; Multi-Country Evaluation of IMCI Study Group. Reducing child mortality: can public health deliver? *Lancet* 2003; 362:159.
- Christian P, West KP, Khatri SK, Leclercq SC, Pradhan EK, Katz J, Shrestha SR, Sommer A. Supplementation with micronutrients in addition to iron and folic acid does not further improve the hematological status of pregnant women in rural Nepal. *J Nut Nov* 2003; 133:3492-98.
- Clugston GA, Dulberg EM, Pandav CS, Tiden RL. Iodine Deficiency Disorders in Southeast Asia. In: Hetzel BS, Dunn JT, Stanbury JB, eds. *The Prevention and Control of Iodine Deficiency Disorders*. New York: Elsevier, 1987: 65-84.
- Cobra C, Muhilal, Rusmil K, Rustama D, Djatnika, Suwardi SS, Permaesih D, Muherdiyantiningsih, Martuti S, Semba RD. Infant survival is improved by oral iodine supplementation. *J Nutr* 1997; 127 (4): 574-78.
- Del Rosso J.M, Marek T. *Class Action: Improving School Performance in the Developing World through Better Health and Nutrition*. World Bank: Directions in Developing Series, 1996.
- Deolalikar, A. Nutrition and Labor Productivity in Agriculture: Estimates for Rural South India. *Rev of Econ and Stats* 1988; 70 (3): 406-413.
- Dolan C, Levinson J. Will we ever get it back? The derailing of Tanzanian nutrition in the 90s. Background paper for the UNICEF-World Bank Review of Nutrition Practice, 2001.
- Esrey SA, Potash JB, Roberts L, Schiff C. Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. *Bull World Health Organ*, 1991; 69 (5): 609-21.
- Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJ. Selected major risk factors and global and regional burden of disease. *Lancet* 2002; 360: 1347-1360.
- Ezzati, M, van der Hoorn S, Rogers A, Lopez AD, Mathers CD, Murray CJ. Estimates of Global and Regional Health Gains From Reducing Multiple Major Risk Factors. *Lancet* 2003; 362; 271: 280.
- Galloway R, Dusch E, Elder L, Achadi E, Grajeda R, Hurtado E, Favin, Kanani S, Marsaban J, Meda N, Moore KM, Morison L, Raina N, Rajaratnam J, Rodriguez J, Stephen C. Women's perception of iron deficiency and anemia prevention and control in eight developing countries. *Social Science and Medicine* 2002 Aug; 55 (4): 529-544.
- Galloway R, Maguire J. Determinants of compliance with iron supplementation: supplies, side effects, or psychology?. *Soc Sci Med* 1994; Aug 39 (3): 381-90.
- Gillespie S, Haddad L. *Attacking the double burden of malnutrition in Asia and the Pacific*. Manila and Washington, DC: Asian Development Bank and International Food Policy Research Institute, 2001.
- Gillespie S, Mason J, Martorell R. How Nutrition Improves. ACC/SCN Nutrition Policy Discussion Paper No 15. UN ACC/SCN. Geneva. <http://www.unsystem.org/scn/archives/npp15/index.html>, 1996
- Gillespie S. (ed). *Major Issues in the Control of Iron Deficiency*. Ottawa: Micronutrient Initiative/UNICEF, 1998.
- Gonzalez MA, Menendez C, Font F, Kahigawa E, Kimario J, Mshinda H, Tanner M, Bosch-Capblanch X, Alonso PL. Cost-effectiveness of iron supplementation and malaria chemoprophylaxis in the prevention of anemia and malaria among Tanzanian infants. *Bulletin of the World Health Organization* 2000; 78 (1): 97-107.
- Grantham-McGregor S. A review of studies on the effect of severe malnutrition on mental development. *J Nutr Supplement* 1995; 125 (8): 2234S.
- Gross R, Angeles-Agdeppa I, Schultink W, Dillon D, Sastroamidjojo S. Daily versus weekly iron supplementation: Programmatic and economic implications for Indonesia. Undated; Processed.

- Gupta A, Rohde J. Economic Value of Breastfeeding in India. *Economic and Political Weekly* 1993; 1390-93.
- Haddad L, Bouis H. The impact of nutritional status on agricultural productivity: wage evidence from the Philippines. *Oxford Bulletin of Economics and Statistics* 1991; 53 (1):45-68.
- Heaver R, Hunt J. Improving early child development: an integrated program for the Philippines. Washington DC and Manila, Philippines: World Bank and Asian Development Bank, 1995.
- Hill Z, Kirkwood B, Edmond K. Family and community practices that promote child survival, growth and development: a review of the evidence. London: Public Health Intervention Research Unit, London School of Hygiene and Tropical Medicine, September 2001.
- Horton S. Options for Investment in Nutrition in Low-income Asia. *Asian Development Review* 1999; 17 (2): 246-273.
- Horton S, J Ross. The economics of iron deficiency. *Food Policy* 2003;28: 51-75.
- Hunt J. The Agricultural-Industrial Partnership for Eliminating Micronutrient Malnutrition: The Investment Bargain of the Decade. *Biomedical and Environmental Sciences*, 14 Nos. 1-2, 2001; 104-23.
- Hunt J. Why countries and companies should invest to eliminate micronutrient malnutrition, In: Manila Forum 2000: Strategies to fortify essential foods in Asia and the Pacific. ADB Nutrition and Development series No.2: 2001; 32-42.
- Hunt J. Costs of Halving Global Hunger: Reducing Micronutrient Deficiencies, Child Underweight Prevalence and Child Mortality in Accord with Millennium. Development Goals #1 and #4. Background Paper under IFPRI Management for the United Nations Hunger Task Force. August, 2004.
- Hyder SM, Persson LA, Chowdhury AM, Ekstrom EC. Do side-effects reduce compliance to iron supplementation? A study of daily- / weekly-dose regimens in pregnancy. *J Health Popul Nutr* 2002; 20 (2): 175-9.
- ICCIDD 1996. Iodine-induced Hyperthyroidism. Report of a March Workshop. Institute of Nutrition and Food Science (INFS) and Department of Economics, University of Dhaka and Dhaka Urban Community Health Program.
1998. Strategies for Bangladesh. Mimeo. Manila: Asian Development Bank, February Institute of Medicine 1998. Control of micronutrient deficiencies. Washington, D.C.: National Academy of Sciences.
- Ismail S. Community-based food and nutrition programmes: what makes them successful. Rome: FAO Food and Nutrition Division, 2002.
- Jonsson U. Success factors in community-based nutrition-oriented programmes and projects. In: S Gillespie, ed. Malnutrition in South Asia. ROSA Publication #5, Kathmandu: UNICEF, Regional Office for South Asia. November, 1997; 161-189.
- Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS; Bellagio Child Survival Study Group. How many child deaths can we prevent this year? *Lancet* 2003; 362: 65-71.
- Jukes P. Nutrition and education. In: UN ACC/SCN ed. Nutrition: A Foundation for Development. Geneva: ACC/SCN, 2002
- Levin HM, Pollitt E, Galloway R, McGuire J. Micronutrient deficiency disorders. In: Jamison DT, Moseley W, eds. Disease control priorities in developing countries. NY: OUP, 1993: 421-451.
- Levine R, Huffmann S. The economic value of breastfeeding. USAID/AED Oct 1990. LINKAGES. Successful community nutrition programming: lessons from Kenya, Tanzania, and Uganda. June 2002.
- Mannar V. Public-Private Partnership for Improving Nutrition: How do we make them work for the public good? Presentation at the UNSCN Annual Meeting, Chennai India. February 2003.
- Mason JB, Lotfi M, Dalmiya N, Sethuraman K, Deitchler M. The Micronutrient Report. Ottawa, Canada: International Development Research Centre, 2001.
- Mason J. How Nutrition improves and what that implies for policy decisions. NY: UNICEF, 2002.
- Mason J, Musgrove P, Habicht J-P. At least one-third of poor countries' disease burden is due to malnutrition. World Bank/WHO/NIH. DCPW Working Paper No 1. March, 2003.
- Mason J, Deitchler M, Gilman A, Gillenwater K, Shuaib M, Hotchkiss, Mason K, Mock N, Sethuraman K. Iodine fortification is related to increased weight for age and birth weight in children in Asia. *Food and Nutrition Bulletin* 2002 Sep; 23 (3): 292-308.
- Mason JB, Deitchler M, Mathys E, Winichagoon P, Tuazon MA. 2004. Lessons from Successful Micronutrient Programs. *In Press*.
- Mason J, Sanders S, Musgrove P, Soekirman-Galloway R. Community Health and Nutrition Programs. Draft Chapter for the "Disease Control Priorities Project" (for developing countries book). A joint project of the World Bank, WHO and NIH. June, 2004.
- Mason J, Hunt J, Parker D, Jonsson U. Investing in Child Nutrition in Asia. *Asian Development Review* 1999; 17 (1/2): 1-32.
- Mason J, Hunt J, Parker D, Jonsson U. Improving Child Nutrition in Asia. *Food Nutrition Bulletin* 2001; September Supplement.
- McKeon. The modern rise of population. New York: Academic Press, 1976.
- Murray C, Lopez A. The Global Burden of Disease. World Health Organization, 1996.
- Neidecker-Gonzalez O, Nestel P, Bouis H. Estimating the global costs of Vitamin A capsule distribution – a review of the literature and development of a country –level model. Harvest Plus Challenge Program, CGIAR.
- de Onis M, Blossner M, Borghi E, Morris R, Frongillo EA. Methodology for estimating regional and global trends of child malnutrition. *Int J Epidemiol.* 2004 Dec; 33 (6): 1260-70.
- de Onis M, Blossner M, Borghi E, Frongillo EA, Morris R. Estimates of global prevalence of childhood underweight in 1990 and 2015. *JAMA* 2004; 291: 2600-2606.
- Pelletier DL, Frongillo EA Jr, Schroeder DG, Habicht JP. A methodology for estimating the contribution of malnutrition to child mortality in developing countries. *J Nutr* 1994; 124: 2106S-2122S.
- Peterson S, Assey V, Forsberg BC, Greiner T, Kavishe FP, Maluma B, Rosling H, Songa A, Gebre-Medhin M. Coverage and cost of iodized oil capsule distribution in Tanzania. *Health Policy and Planning* 1999 Dec; 14 (4): 390-9.
- Pruss A, Kay D, Fewtrell L, Bartram J. Estimating the burden of disease from water, sanitation, and hygiene at a global level. *Environ Health Perspect* 2002; May; 110(5): 537-42.
- Ramakrishnan U, Aburto N, McCabe G, Martorell R. Multiple Micronutrient supplements during pregnancy do not reduce anemia or improve iron status compared to iron-only supplements in rural Mexico. *J Nutr* 2004; 134 (3): 898-903.
- Ridwan E, Schultink W, Dillon D, Gross R. Effects of weekly iron supplementation on pregnant Indonesian women are similar to those of daily supplementation *Am J Clin Nutr* 1996; 63: 884-90.
- Rivera J, Gonzalez-Cossio T, Flores M, Romero M, Rivera M, Tellez-Rojo MM, Rosado JL, Brown KH. Multiple micronutrient supplementation increases the growth of Mexican infants. *Am J Clin Nutr* 2001; 74: 657-63.
- Rivera J, Hotz C, Gonzalez-Cossio T, Neufeld L, Garcia-Guerra A. The effect of micronutrient deficiencies on child growth:

- a review from community-based supplementation trials. *J Nutr* 2003; 133: 4010S-4020S.
- Ross J, Steifel H. Calculating the consequences of micronutrient malnutrition on economic productivity, health and survival. Washington, DC: The Academy for Educational Development, 2003.
- Ross J, Thomas EL. Iron deficiency anemia and maternal mortality. PROFILES Working Notes Series No. 3. Washington, D.C.: Academy for Educational Development, 1996.
- Sahn D, Stifel D. Progress towards the MDGs in Africa. June 2002.
- Sanders D. Success factors in community-based nutrition programmes. *Food Nutrition Bulletin* 1999; 20 (3): 307-314.
- Sen A 2002. Why Health Equity? *Health Economics* 11:659-666.
- Smith L, Haddad L. Explaining child malnutrition in developing countries: a cross-country analysis. IFPRI Research Report 111. Washington DC: IFPRI.
- Spurr GB, Barac-Nieto M, Maksud MG. Productivity and Maximal Oxygen Consumption in Sugar Cane Cutters. *Am J Clin Nut* 1977; 30: 316-321.
- Subbarao K, Bonnerjee A, Braithwaite J, ezemenari K, Carvalho S. Safety net programs and poverty reduction. Lessons from cross country experience. Washington DC: World Bank, 1994
- The Bellagio Study Group on Child Survival. *Lancet* 2003; 362:323-27.
- Tontisirin K, Gillespie S. Linking community-based programs and service delivery for improving maternal and child nutrition. *Asian Development Review* 1999; 17 (1): 33-65.
- Tontisirin K, Winichagoon P. Community-based pro-grammes: success factors for public nutrition derived from experiences in Thailand. *Food Nutrition Bulletin* 1999; 20 (3): 315-22. United Nations. Sub-Committee on Nutrition 1998. Ending Malnutrition by 2020: An Agenda for Change in the Millennium. Geneva: United Nations, 2004.
- Victora C, Wagstaff A, Schellenberg J, Gwatkin D, Claeson M, Habicht J-P. Applying an equity lens to child health and mortality: more of the same is not enough. *Lancet* 2003; 362: 233-41.
- Welch RM. Breeding Strategies for "Biofortified" Staple Plant Foods to Reduce Micronutrient Malnutrition Globally. Ithaca, New York: USDA-ARS, 2001.
- World Bank. Enriching Lives: Overcoming vitamin and mineral malnutrition in developing countries. Washington DC. 1994.
- World Bank. World Development Report: Investing in Health. Washington DC, 1993.
- World Health Organization. Iron deficiency anemia: assessment, prevention and control – a guide for programme managers. Chapter 4: economic implications of iron deficiency, 2001; 11-14.
- WHO Commission on Macroeconomics and Health. Macroeconomics and health: investing in health for economic development. Report of the Commission on Macroeconomic and Health. Geneva: WHO, 2001.