
Controlling Micronutrient Deficiencies in Asia

John Mason, Venkatesh Mannar, and Nancy Mock

Abstract. *Vitamin A deficiency (VAD), iodine deficiency disorders (IDDs), and iron deficiency anemia (IDA) affect large numbers of the populations in Asia, often overlapping. Clinical VAD is probably declining, but subclinical VAD is common and carries significant mortality risk. IDDs fall when there are effective iodized salt programs. IDA persists unchanged at high levels, particularly affecting women and children. Deficiency control programs—notably high-dose vitamin A capsules six-monthly for children and iodized salt—are under way in many areas, and need to be sustained and made universal. Fortification is a key long-run solution, and multiple fortification and supplementation need to be researched and implemented. Better information is needed on programs and their impact; even baseline data are scarce. Public-private coalitions should be fostered with the food industry and others concerned. Capacity-building for the range of actions for controlling deficiencies should be an early next priority.*

Current Deficiencies and Control Programs

Micronutrient deficiencies affect a majority of the population in the eight Asian countries covered by the ADB-UNICEF Regional Technical Assistance Project on Reducing Child Malnutrition in Eight Asian Countries (hereafter referred to as the Project). Usually several deficiencies are present at a time. Iron and iodine deficiencies are the most common currently known. About half the reproductive age women in most of the countries have iron deficiency anemia (IDA), and preschool children and other groups are extensively involved. Iodine deficiency disorders (IDDs, assessed as goiter in school-age children) strike from 20-60 percent of the population in different areas. Vitamin A deficiency has been widely recorded, although with much lower clinical preva-

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lences (around 1 percent in preschool children). However, serum retinol assays indicate that the subclinical prevalence, associated with increased mortality risk in children and pregnant women, may be around 10-25 percent. Other deficiencies are certainly widespread but far less well described. Rickets in young children, associated with calcium and vitamin D deficiencies, is probably widespread in the PRC and possibly elsewhere. Indirect evidence points to zinc deficiency as common. Selenium and a number of other micronutrients with effects on chronic disease (e.g., cancers) are emerging as problem areas. A brief review follows of the current situation, much of which draws on the country reports, summarized in Mason et al. (1999).

The consequences of micronutrient deficiencies can be devastating, and not only when they are clinically apparent. Iodine deficiency is the commonest cause of mental retardation (and is completely preventable), and has other far-reaching effects on cognitive and neuromotor function, reproduction, and on the development of the individual and of society (WHO 1993, Stanbury 1998). Vitamin A deficiency not only causes blindness (which is relatively rare today), but more importantly subclinical deficiency appears to be a major risk factor for both child and maternal mortality. The reduction in mortality from providing vitamin A supplements in large-scale experimental studies is impressive—about 25 percent reduction in children in deficient areas (Beaton et al. 1993), and recently shown as nearly half among pregnant women in Nepal (West et al. 1999). Iron deficiency, of which anemia is only one consequence (itself a risk for mortality, especially maternal), also has extensive effects on cognitive development and educability (Gillespie 1998, Viteri 1998). Given how widespread the deficiency is, the cumulative effects on society are enormous, and (like iodine) some of these are irreversible within the lifetime of the individual and can affect the next generation.

Effective policies for controlling malnutrition depend on whether the problem is perceived as a priority, and how easy it is to deal with. So far, those problems with the most dramatic presentation have been those most easily addressed, and vice versa, as illustrated in Table 1. Thus iodine deficiency disorders and vitamin A deficiency (VAD) are being tackled effectively, but iron deficiency (usually measured as iron deficiency anemia, IDA) remains highly problematic, and other possible deficiencies, like zinc, vitamin D, and calcium, have only recently begun to be taken seriously. Iodine deficiency disorders and VAD present dramatically and have straightforward technical solutions. Iron and other deficiencies are subtle and the solutions are not clear, partly because they are more difficult, and partly for lack of adequate research.

Table 1: **Perceptions and Relative Priorities of Interventions**

Problem	Presentation	Intervention
Vitamin A deficiency	Striking: blindness, increased child and maternal mortality risk	Easy in children: infrequent high dose capsules
Iodine deficiency	Striking: cretinism, dwarfism, goiter	Easy: iodized salt
Iron deficiency	Subtle: anemia, reduced cognitive development	Difficult: e.g., frequent supplementation
General malnutrition–growth failure	Subtle: smaller children	Difficult: community-based programs
General malnutrition–starvation in emergencies	Striking: emaciated and dying children and adults	Easy (in principle): emergency food aid and other assistance

Source: Mason (1999).

Prevalences and numbers affected by general and micronutrient malnutrition among priority groups by region are shown in Table 2 (taken from Mason et al. 1999). For all except IDD, South Asia has the highest prevalences in the world, and IDDs are of similar prevalences for most developing regions. But significant progress is being made in most of the deficiencies and regions.

The progress among interventions to control IDDs and VAD is encouraging, with major acceleration in recent years, whereas control of iron and other less well-known deficiencies is not yet apparent. This can be related to the inherent nature of the deficiencies. Iodine and vitamin A are needed in minute (microgram) quantities daily, and the effects of one intervention last for several months: thus they are the most open to rapid attack. In contrast, the other minerals of immediate concern are needed in much larger daily amounts (milligrams), should be ingested more frequently, and have complex biological mechanisms. Current evidence is that IDA is persisting at high levels throughout Asia, with no sign of improvement. Trends in other deficiencies are unknown. In addition, the metabolism of iron, calcium, and zinc can be readily inhibited by other dietary constituents, and traditional eating patterns may make it almost impossible for some populations to get enough iron from their diet. Rapidly changing diets may pose other risks. The position for VAD, IDDs, and IDA is reasonably well known, as discussed below.

Table 2: Regional Prevalences and Numbers Affected by Micronutrient Deficiencies

Region	Underweight (preschool)		Anemia (nonpregnant women 15-49 years)		Subclinical Vitamin A Deficiency (preschool)		Iodine Deficiency TGR (all ages)	
	1995		1975-98		1995		1985-1996	
	Prevalence (%)	Est. No. Affected (millions)	Prevalence (%)	Est. No. Affected (millions)	Prevalence (%)	Est. No. Affected (millions)	Prevalence (%)	Est. No. Affected (millions)
South Asia	52	87.4	59	149.0	35.6	59.5	17	203
Sub-Saharan Africa	30	30.9	38	41.5	35.3	36.0	18	91
East Asia Pacific	23	39.3	42	140.4	18.2	29.6	21	329
Middle East & North Africa	16	7.4	33	20.3	9.8	4.2	20	42
Latin America and Caribbean	11	6.2	24	27.2	19.6	10.2	11	41
Total	31	171.2	43	378.4	26.5	139.5	18	706

Notes and Sources:

Data assembled for "Progress in Controlling Micronutrient Deficiencies" (Mason et al. 2000).

Underweight: Figures are from UNICEF (1997) for the % children suffering from moderate or severe underweight, based on 1997 SCN using 1995 as base year.

Anemia: Prevalence data is from Progress in Controlling Iron Deficiency, Tulane University and Micronutrient Initiative June 1998. For Latin America and Caribbean: the regional prevalence was determined by weighting the prevalence figures of 27% and 17% with 0.675 and 0.325 for South America and Middle America/Caribbean respectively. Anemia estimated numbers affected were estimated by calculating the percent pregnant in each region using WHO estimations 1995 and applying these percentages to the 1995 population figures for the regions from UN Population Division 1995 (SOWC 1997). These estimations of non-pregnant women were multiplied by the prevalence of anemia in the region to determine the number of affected women. Adjustments to the age structure from 15-59 used by WHO to 15-49 used in this presentation were made using 1995 population estimations for women (UN 1996).

VAD: Prevalence data is from MI/UNICEF/Tulane (1998). VAD Sub-clinical for SSA: weighted the E. & S. Africa and W. & C. Africa figures to collapse into SSA. E & S. Africa was 37.1 % VAD and 18.6 million affected, W & C. Africa was 33.5% VAD and 17.4 million affected, whereas the combined region of SSA is 35.3 % VAD and 36 million affected.

IDD: Prevalence data is from Mason et al. (2000). IDD for East Asia/Pacific: weighted the PRC and SE Asia figures to collapse into East Asia /Pacific. The PRC was 20.4% TGR and 236 mill affected, SE Asia was 21% TGR and 93 million affected, thus the combined region is 20.6% TGR and 329 million affected. IDD for Latin America/Caribbean: weighted Middle America and South America figures to collapse into Latin Am./Caribbean. Middle America was 6% TGR and 8 million affected, South America was 13% TGR and 33 million affected, thus the combined region is 10.6% TGR and 41 million affected.

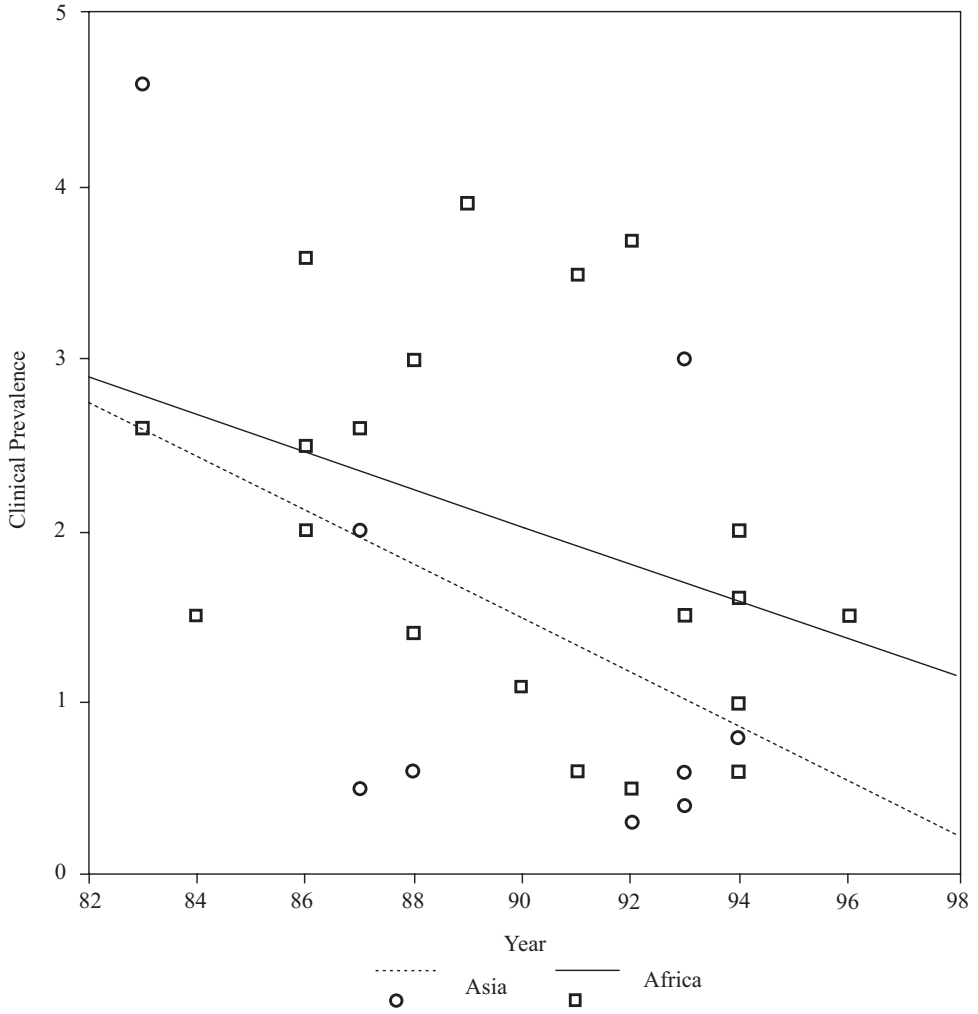
Clinical Vitamin A Deficiency

Clinical VAD assessed by eye damage (xerophthalmia) is considered a public health problem at more than 1 percent prevalence, which is low compared to other deficiencies (MI/UNICEF/Tulane 1998). However, by the time clinical signs appear, the deficiency is dangerously advanced. Subclinical deficiency, assessed by levels of vitamin A in the blood (serum retinol) is much more widespread, and considered to be responsible for much of the risk associated with VAD. Prevalences of low serum retinol ($<0.7 \mu\text{mol/l}$) are in the range of 10-30 percent in the study countries. The estimated prevalences for clinical VAD for 1995 are 0.95 percent for South Asia, and 0.25 percent for East Asia and the Pacific, affecting some two million preschool children in these regions (which include the study countries). The prevalence in South Asia is higher than anywhere else in the world except Sub-Saharan Africa, and compares with an estimated developing country average of 0.6 percent. The estimates for subclinical deficiency are around 10-20 percent, with nearly 50 million children affected.

The trend in clinical VAD prevalences can be assessed from certain countries where surveys have been repeated. On average, these indicate that the clinical prevalence has roughly halved over 1985-1995. As examples (from MI/UNICEF/Tulane 1998, Table 2): India from 1.4 percent in 1976 to 0.7 percent in 1989; Sri Lanka from 1.1 percent in 1976 to 0.3 percent in 1987; Indonesia from 1.0 percent in 1977-1978 to 0.3 percent in 1992; Philippines from 3.2 percent in 1982 to 0.5 percent in 1993. These changes between successive surveys at country level are similar to the global estimates. Thus it does appear that there is a strong underlying trend of improvement in clinical VAD. The estimates from large-scale surveys ($n>1000$) since 1980 for Asia, and Africa for comparison, are shown in Figure 1a. Asian results are in Figure 1b. While the scatter is large, the improving trend is apparent here (and is significant for the combined data).

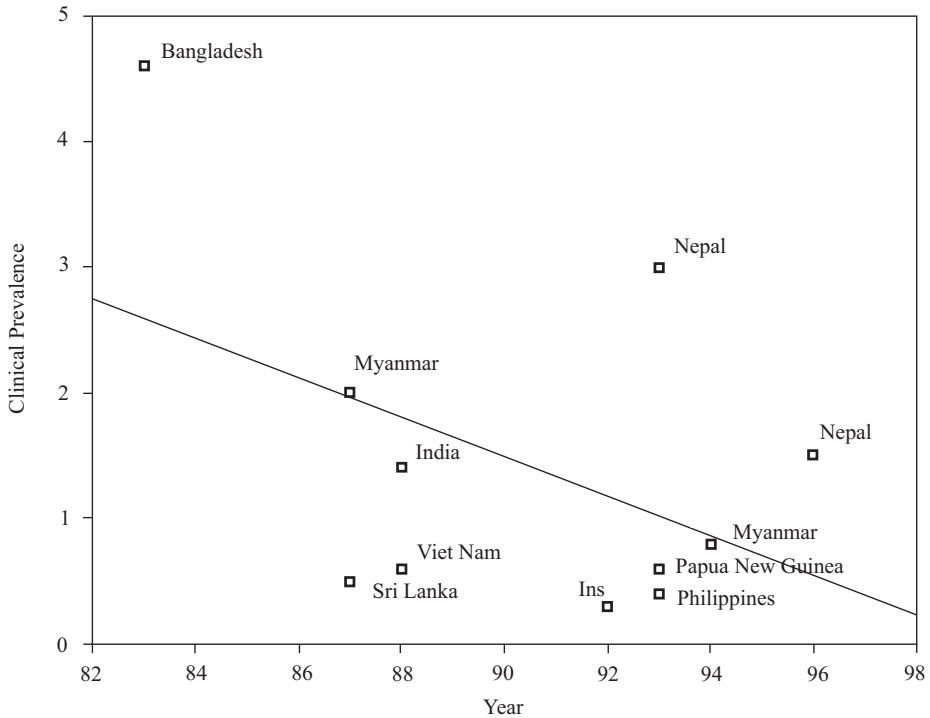
Attention is turning to subclinical VAD, catalyzed by the finding that child mortality is greatly reduced by prevention of VAD, and that this must operate through preventing subclinical forms (Beaton et al. 1993). Recently, supplementation to prevent subclinical VAD has also been shown to dramatically reduce maternal mortality (West et al. 1999). It is likely that subclinical VAD is declining in general, but nonetheless it will be at least 20 years before the average subclinical prevalence is down to 5 percent, and meanwhile many preventable deaths will have occurred, and many highly vulnerable groups will still be affected. The country-specific VAD prevalence and trend estimates, largely from the country reports, are given in Mason, Jonsson, and Hunt (1999). All this argues for building on the presently favorable underlying trend, to maintain supplementation programs, and to develop effective fortification in the interim.

Figure 1a: Clinical Vitamin A Deficiency (xerophthalmia): Prevalence Trends in Preschool Children from Surveys since 1980



Source: MI/UNICEF/Tulane (1998).

Figure 1b: Clinical Vitamin A Deficiency Prevalance (xerophthalmia):
Prevalance Trends in Preschool Children from Surveys since 1980



Supplementation with high-dose vitamin A capsules has reached high coverage in most of the study countries in the last few years. Data from the country reports is summarized in Mason, Jonsson, and Hunt (1999), and is attached here as Table 3. Estimates of program coverage for 1994-1996, from UNICEF supply data and country office reports (MI/UNICEF/Tulane 1998), indicated that Bangladesh, Philippines, and Viet Nam had around 90 percent capsule coverage; reports from India vary from 25-90 percent; whereas Sri Lanka had virtually no program at all during that time.

Table 3: Characteristics of Selected Current Programs Addressing Micronutrient Malnutrition

Project	Type, Content	Coverage, Target Groups	Resources
Bangladesh			
VAD: Nutritional Blindness Prevention Programme	VAC distribution with National Immunization Day and EPI; home gardens; education	85% coverage of children with VAC; postpartum supplementation also, coverage not known	\$0.8 m/yr for VAC for children
IDA: with ANC	Fe-folate given at ANC visits; fortification: not yet	ANC coverage 20% (R)–50% (U); compliance not known	NR
IDD: Control of IDD program (CIDD)	Salt legislation enacted 1995; mass communication; iod-oil injections phased out	Highly variable iodine content in salt; 265 refineries	Monitoring and quality control is issue
Cambodia			
VAD control: HKI & UNICEF	VAC with National Immunization Day, changing to with EPI	99% of target children reported, survey shows 47%	NR
IDA: no national Programme	Fe-folate available in health centers, use probably low		
IDD: control programs	Salt iodization programs beginning; salt production is mainly in one area; iodized capsules in interim bad areas; Well water iodization also tried	Coverage low now, programs starting	\$0.5/hd/yr
PRC. Report not yet available on current programs and gaps. 76.3% coverage of iodized salt reported for '95.			
India			
VAD: massive dose; fortification	Vitamin A in oil dispensed; vegetable oil fortified but limited outreach	68% of 6-12 mos., 25% of 12-60 mos. reported covered; fortified oil reported not to reach poor	NR
IDA: National Nutritional Anaemia Control Programme	Fe-folate supplements; diet promotion; rehabilitation	P&I women targeted; supplements low coverage and variable supply	NR
IDD: Universal Salt Iodization Programme (USI)	650 salt iodization plants established; mobile labs; quality still highly variable	In principle all areas should have access, but remote areas vulnerable	Quality control major issue

Table 3. (cont'd.)

Project	Type, Content	Coverage, Target Groups	Resources
Pakistan			
VAD	No national program		
IDA	No national program; Fe presumably in ANC		
IDD: National Programme	Social marketing to create demand; support to producers (600+); Iodized Salt Support Facility	70% of producers iodizing (1996), 50% hhs with iodized salt; endemic IDD areas in north targeted.	Approx \$1.5 m/yr; 4 cents/ beneficiary
Sri Lanka			
VAD: no policy, but recent survey demonstrated problem; VAC postpartum to start; supplement food for poor mothers and children (Thripasha) fortified, with VA and range of micronutrients.			
IDA: in ANC	Fe-folate given with ANC which has high participation. Fortification of wheat flour being considered.	ANC covers most pregnant women. Wheat flour mainly in urban Areas	NR
IDD: salt iodization	Law enacted in 1995. Quality highly variable, only 30% adequately iodized.	National program.	NR
Philippines			
VAD control program (ASAP)	VAC with National Immmn Day. Several foods fortified with VA	Pre-schoolers, 100% reported, 80% on survey.	VAC \$0.4/hd/yr incl program costs
IDD control	1. Iodized oil capsules, with VAC (ASAP) 2. Salt iodization	Capsule targets ? Salt: whole population	Iod capsules: calculates at \$0.1/hd/yr Iod salt: \$0.3/hd/yr
Viet Nam			
VAD: National VAD Control Programme	VAC distribution; education; dietary improvement; VAC postpartum.	VAC 6-60 mos., 98.5% coverage reported; mothers 53%.	878 commune workers, 940 district, 106 province. \$0.08/hd/yr
IDA: National IDA control program	Iron tablets, deworming, fortification planned, diet diversity.	Pregnant women, children <2 yrs, girls >15 yrs. 425,000 pregnant women reached with tablets in 1995 (20%?), now <25. Impact reported.	200 commune workers (1/10,000) women. \$0.55/hd/yr
IDD: National IDD control program	Salt iodization.	Hhs using iodized salt: 40-90% by area ('96). 86% salt produced iodized.	\$0.05/hd/yr

Note: NR means not reported.

Sources: Country studies, with additional information from MI/UNICEF/Tulane (1998); Mason et al. (1999, tables 1.5 and 2.2).

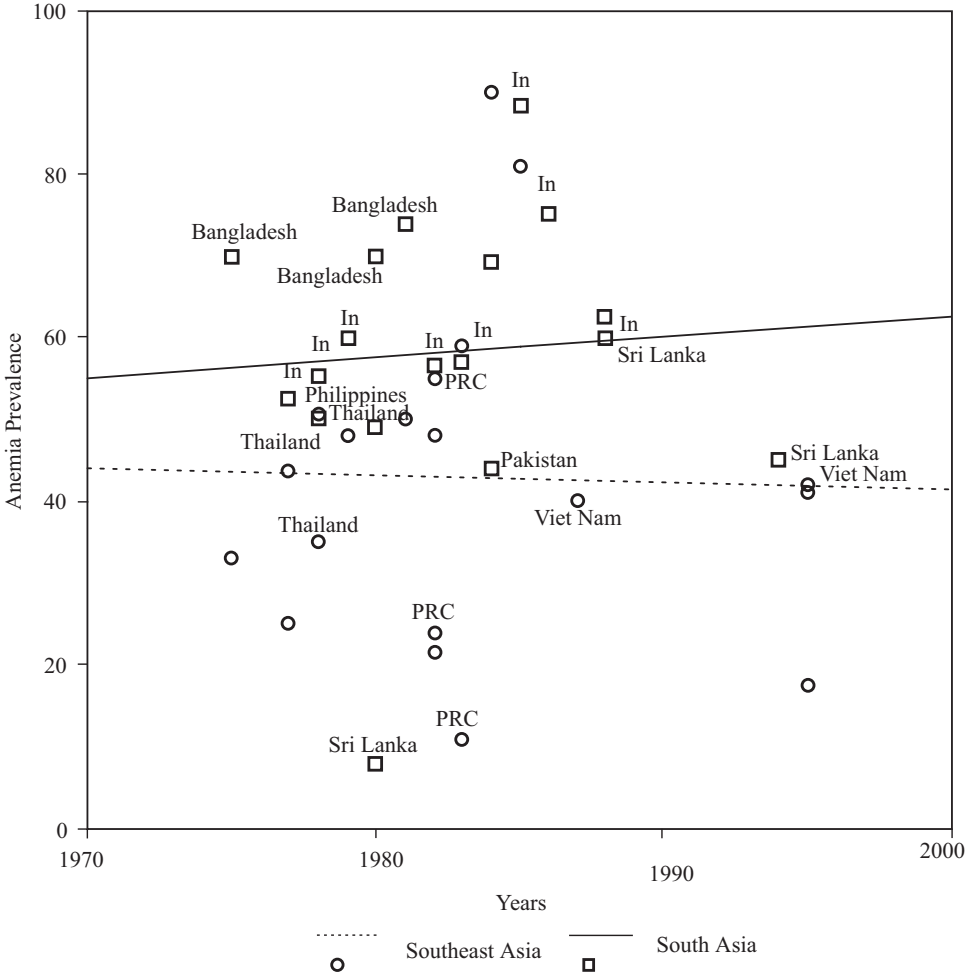
Iron Deficiency

Iron deficiency is usually assessed as iron deficiency anemia (IDA). Data are mostly available from small-scale surveys, national coverage is rare. The prevalences shown in Table 2 for non-pregnant women, taken from WHO compilations, indicate that between half and two-thirds of women of reproductive age in Asia are anemic, totaling some 250 million women. Trends are hard to assess because there are no comparable repeated surveys with any significant coverage (e.g. sample size more than 100). Putting together the point estimates over 1970-1995 (Figure 2) showed no significant trend (Mason et al. 1999); the data for the two Asian sub-regions are reproduced in Figure 1b. The average level in South Asia is seen as around 60 percent prevalence among reproductive age women, and around 40 percent in the South East Asian countries (only those covered by the Project, plus Thailand, are labeled). But the variation in the data is so great that, even if there were an underlying trend, it would be hard to find. The best we can say is that there is no sign of improvement (compare with the VAD scatterplot and repeated surveys), and that a priority should be to get representative data so that any change from current levels can be assessed in the future.

Information on coverage of supplementation programs is patchy. Where reported, indications are that around 50 percent of women receive iron/folate as part of antenatal care (Mason et al. 2000). Programs are reported in Bangladesh, India, Sri Lanka, and Viet Nam (see Table 3). The coverage assessment probably substantially overestimates the percentage of pregnant women taking iron supplements daily. However, the existence of programs aiming to provide these supplements gives a basis to build on. One way ahead is to examine what the real situation is in selected areas, and what it would take to overcome the constraints. Nonetheless, it remains improbable that this method of providing iron will ever become more than a secondary method for reducing anemia, even if weekly supplementation is shown to be efficacious. Medical use of iron preparations could be improved, and a suitable pediatric preparation for young children needs to be developed and used.

Fortification is again likely to be the most important approach to dealing with iron deficiency. Work has begun on fortifying wheat in India, Indonesia, and Sri Lanka, but while useful, the overall effect will be limited as the staple for the majority of the population is rice. The PRC and Viet Nam have recently starting exploring the use of condiments such as soy sauce and fish sauce as vehicles for iron. Bioavailability and consumer acceptability studies are under way. In sum, not a great deal is happening to address iron deficiency at present, and it should be a much higher priority.

Figure 2: Anemia Prevalences (<12g/dl Hb), Nonpregnant Women 15-49 Years



Source: WHO and UNICEF data, forthcoming in Mason et al. (2000).

Iodine Deficiency Disorders

Iodine deficiency disorders are very widespread in Asia, but prevalences are likely to be declining as salt iodization spreads. However, as with other deficiencies, the significance of mild, subclinical deficiency has probably been underestimated. The situation as reported by the country studies is summarized in Table 4, which is taken from Mason, Jonsson, and Hunt (1999).

Table 4: Iodine Deficiency Disorders: Goiter Prevalences and Salt Iodization

	Prevalences of Goiter(%), in Specified Population Groups (Year)		% Households with Adequately Iodized Salt	Range Reported in Goiter Prevalences
	A		B	C
Bangladesh	47.1% 55.6%	All (1993) Women, 15-44y	44% (1993)	27.2% (hills, M) to 59.8% (flood, F)
Cambodia	12% 17%	8-12 years (1997) all	7% (1995-98)	1-39% by area
PRC	20%	Adults, year not specified	76% (1995)	
India	25%	Endemic areas, Age, year not specified	50-75% (1995)	1.5% (Assam) to 68.7% (Mizoram)
Pakistan	30% 40%	6-12 years, (<1993) all	23% , year not specified	14-82%
Sri Lanka	7-30%	All (1980s)	47% (1995-98)	
Philippines	21-27% 6%	Pregnant women (1993) All ages	15% (1995-98)	
Viet Nam	9-40%	8-12 years (1993)	6% (1997)	9-40%

Source: Mason et al. (1999, table 1.5).

The prevalence of goiter ranges widely, varies between areas, and is not consistent through time. For example, three surveys in Bangladesh reported goiter rates of 29 percent in 1962-1964, 11 percent in 1981-1982, and 56 percent in 1993; however, the latter figure included palpable, not just visible, goiter and more extensive training of investigators, and the comparability of samples is uncertain (Yusuf et al. 1993). In any event, it is clear that IDD, as assessed by goiter, is widespread. It is likely that salt iodization will result in a major improvement, if quality control can be strengthened.

Better data are available on the extent of salt iodization, as manufactured and at the household level. Country reports are shown in Table 4, column B, with a range of 23 percent to 76 percent in the countries providing data. An average of 60 percent of households in Asia were reported by UNICEF to be consuming iodized salt in 1997. However, some household surveys directly assayed the iodine content of salt, and found it to vary considerably. Anecdotal reports indicate that iodine content can bear little relation to package labeling. While there is no doubt that promotion of iodization of salt has had enormous impact, the urgency now is to assure quality control.

Multiple Deficiencies and Interactions

Multiple deficiencies and interactions must be very common, although seldom assessed. Interactions may mean that reducing only one deficiency when there are several affecting the same individual may have no effect. We have calculated from the simple assumption that the worst off are those likely to have multiple deficiencies, to try to get an order of magnitude estimate of the extent of two or more deficiencies concurrently in the same children; results are shown in Table 5 (Mason, 1999). In South Asia, over one-third of children may have at least two deficiencies, and around 20 percent is the estimate for East Asia and the Pacific, which includes the PRC. Getting on for 100 million children would thus be affected.

Table 5: **Illustration of Possible Overlap of Micronutrient Deficiencies in Preschool Children, Approximately 1995**

Region	Anemia		Vitamin A Deficiency (subclinical)		IDD Affected		Percent with 2 or more Micronutrient Deficiencies	
	Prevalence (%)	Estimated Number (millions)	Prevalence (%)	Estimated Number (millions)	Prevalence (%)	Estimated Number (millions)	Prevalence (%)	Estimated Number (millions)
South Asia	52.7	93.8	35.6	59.5	17	28.4	35.6	59.5
Sub-Saharan Africa	35.2*	63.6	35.3	36.0	18	18.4	35.2	35.9
Middle East/ North Africa			9.8	4.2	20	8.6	20.0	8.6
East Asia/Pacific	14.1	20.0	18.2	29.6	21	34.2	18.2	29.6
Latin America and Caribbean	22.9	13.0	19.6	10.2	11	5.7	19.6	10.2
Total	34.2	190.4	26.5	139.5	18	95.3	27.3	143.8

Notes and Sources:

Data assembled for MN-Net update and Mason et al. (2000).

Anemia: Prevalence and number affected data is from WHO (1993, Table 8). Prevalence of anemia among different populations based on 1996 national data. Some approximations were used for anemia by region including: South Asia is the approximation for the WHO Southeast Asia; Sub-Saharan Africa and Middle East/ North Africa are weighted and combined into one region including the WHO Africa and Eastern Mediterranean; East Asia /Pacific is the approximation for the WHO Western Pacific Non-industrialized; Latin America and Caribbean are the approximation for the WHO Americas non-industrialized.

VAD: Prevalence and number affected data is from MI/UNICEF/Tulane (1998).

IDD: Prevalence data is from data assembled in Mason et al. (2000). All IDD data is just an illustrative example that sets the prevalence of iodine deficiency in preschool children to the same prevalence of that found in 6-11-year-olds. Although the prevalence of iodine deficiency is likely lower in preschool children than that in school-age children, no adjustment factor was used due to assumed vulnerability of the children in utero from the mother's iodine status.

A number of important interactions are indeed emerging. Both iron and vitamin A deficiencies cause anemia (Schultink and Gross 1996); most micronutrient deficiencies (e.g., zinc, iron) affect the immune system; both iron and iodine affect cognitive development; protein/energy, calcium, and vitamin D affect longitudinal growth; and so on. If any of these relate to consecutive steps along a metabolic pathway (and this is likely) then fixing one deficiency alone will not improve the situation. This is in line with work by Golden (pers. comm.), who showed much increased recovery rates in severe malnutrition when a complete range of micronutrients was provided. It is argued that this is relevant because children's growth patterns in poor countries are typically of successive episodes of growth failure (with infectious disease) and catch-up growth. Wasting involves loss of tissue and its contents, which need to be replaced for adequate catch-up; inadequate catch-up is the proximal cause of much of the growth failure in Asia.

Multiple micronutrient supplementation and fortification, discussed in the next section, is thus indicated not only on the grounds of operational advantage, but may actually be essential for biological impact in many circumstances.

Strategies for Controlling Micronutrient Deficiencies

The principles for effective control of micronutrient deficiencies are covered authoritatively and in detail in a number of recent publications. The Institute of Medicine of the US National Academy of Sciences (NAS) recently published the results of extensive consultations and the associated background papers (IOM/NAS 1998). The volume contains an important synthesizing chapter on program design by Howson, Kennedy, and Horwitz (1998). What follows is in line with these views, focused on the specific needs of Asia. Papers by Viteri (1998) on iron deficiency, Underwood (1998) on vitamin A deficiency, and Stanbury (1998) on iodine deficiency provide much of the general background and justification, and this paper does not attempt to duplicate this definitive material. Specifically on iron, a recent publication by Gillespie (1998) for the Micronutrient Initiative (MI) goes into more detail than the NAS document in examining issues of supplementation and fortification. Recently, an expert consultation on "Strategies to Accelerate Programs to Reduce Iron Deficiency" was convened and provided broad consensus on key issues (UNICEF/UNU/WHO/MI 1999).

The conventional framework of "supplementation, fortification, food-based approaches, and public health control measures", is laid out in these and other documents—for example it is clearly explained in the NAS report (see IOM/NAS 1998, Table 1-1 for a summary). Within the framework, supplementation and fortification can be universal or targeted; and "food-based approaches" refer to nutrition education, food production, and "food-to-food fortification", meaning mixing of staple

foodstuffs, like mango with gruel, at the household level. The “public health control measures” (as formulated in the NAS report) are immunization, parasite control, water and sanitation, control of diarrheal diseases and acute respiratory infections, and personal sanitation/hygiene. These undoubtedly account for much of the recent reduction in deficiency diseases (notably of VAD). These programs are covered more usually in health sector reviews and policies, and are not greatly influenced by consideration of micronutrient deficiency control. They will thus not be a focus here.

In the long run, fortification is likely to play a central role in the control of most micronutrient deficiencies in Asia, as it has already in the industrialized world. But a mix of strategies will be needed to reach this stage. Here we lay out the steps and their linkage as they appear appropriate for the next 10-20 years, bearing in mind that new research in both the deficiencies and the technology for their control may change this perspective—indeed supporting such research is likely to be an excellent investment. A summary is given in Table 6.

Table 6: **Priorities for Controlling Micronutrient Deficiencies in Asia**

Nutrient	Method		
	Supplementation	Fortification	Food/nutrition education
Vitamin A	VAC high dose for children. Research: VA low dose, in multinutrients, especially for ANC	Situation-specific research, then applied (e.g. in vegetable oil).	Education of doubtful wide effectiveness.
Iron (/folate)	Tablets in ANC, as part of multinutrients; also population groups.	Nonrice staples: situation-specific research, apply in cereals and other foods. Rice staples: general research is high priority.	Possibly try to reverse trend in falling production and consumption of pulses. Education largely inapplicable in vegetarian cultures.
Iodine	Not current, but might apply as part of multinutrients in ANC.	Quality control main issue; try community-based testing and enforcement.	Raising awareness about iodized salt.
VitD/Ca/P rickets/stunting	Research needed into epidemiology, causality, and significance of rickets, stunting (and whether related) especially in China (and Mongolia).		
Water-soluble vitamins (B-vitamins, C)	Likely benefit as part of multiple nutrient supplementation and fortification.		
Ca, Zn, other minerals	Research is indicating possible generally important role, notably for Zn. Probably indicated for supplementation and fortification; watch for interactions e.g. with iron.		
Other-fat-soluble vitamins (E,K)	Research needed. Are they a problem of public nutrition significance?		

Note: See tables 1-1 and 2-1 of IOM/NAS (1998), based on levels 2 and 3 of deficiency (mild–moderate).

A medium-term strategy should build on current programs and experience in supplementation, fortification, and food-based approaches. It should include research in a number of areas, including the effects of the deficiencies and their extent, and effective control. Only for iron is efficacy of programs an issue, and this is more social than biological—supplements or fortification can improve iron status if there is accessibility and compliance. New research into basic mechanisms will almost certainly establish a wider range of important micronutrient deficiencies, and, crucially, the interactions between them. This may be one key to progress. For example, as mentioned earlier, if both VAD and iron deficiency cause anemia then trying to control one deficiency at a time will not be effective in reducing anemia.

Thus the usual approach of tackling one micronutrient at a time no longer makes sense. Vitamin A may be a partial exception as high doses for children and for mothers just after delivery give a unique opportunity to reduce deficiencies, but this cannot work for most reproductive-aged women, who are emerging as a key target group and need more frequent low doses. Nor should the aim be restricted necessarily to the three high priority deficiencies of iron, iodine, and vitamin A. The better focus will be on multiple micronutrient fortification and supplementation, and this should be a central feature of a new strategy.

Vitamin A Deficiency Control

The number of children given high-dose vitamin A capsules or solution (India) twice yearly is already large. Data from the country reports is based on estimates of program coverage, and assessments can also be made from the numbers of capsules distributed (MI/UNICEF/Tulane 1998). Essentially, those countries that officially recognize the problem have access to and are distributing about enough capsules to reach all children under five years of age, and those that do not recognize the problem have minimal coverage. Thus in 1994-1996, Bangladesh, Cambodia, Philippines, and Viet Nam reported around 90-100 percent program coverage (although Cambodia and Philippines reported lower supplies of capsules at 31 percent and 62 percent). In India, erratic supply of vitamin A syrup and distribution logistics are reported to have depressed coverage to below 30 percent of all children under three years of age. Pakistan and Sri Lanka reported no coverage and less than 5 percent potential coverage from capsule supply, and had not at that time recognized the problem (this may have now changed for Sri Lanka, but not yet in Pakistan). Recognizing and giving continuing priority to the problem is a prerequisite, and steps are needed to ensure this. These may start with an assessment: a recent survey in Sri Lanka (Government of Sri Lanka 1997) showed around 30 percent prevalence of low serum retinol and was instrumental in creating the awareness that is now leading to VAD control programs.

High-dose vitamin A capsules are delivered as a blanket approach for children through National Immunization Days (NIDs) (e.g., Bangladesh, Cambodia), through Vitamin A days (or weeks), and otherwise with immunization contacts and through the health services. Through a combination of NIDs and a specially organized annual Vitamin A week, Bangladesh is achieving coverage rates of over 90 percent. Medical use of vitamin A, when children present with infections, is common. Providing a vitamin A capsule to mothers within one or two months of delivery is also catching on—policies exist in Bangladesh, Cambodia, Philippines, and Viet Nam. These methods are becoming well tried and tested. The policy should be to sustain and expand them to full coverage for at least the next 10-20 years, even though clinical VAD is disappearing, because subclinical VAD is dangerous and is likely to continue to affect children for this period. Monitoring of programs and periodic assessment of impact should be an additional priority (Mock and Mason 1999).

The next steps are to shift toward fortification, and to include vitamin A in low doses in multiple nutrient supplementation. In most of the study countries, fortification of various foodstuffs with vitamin A is under active investigation. The country reports and information from a UNICEF survey in 1997 (MI/UNICEF/Tulane 1998) indicate that the Philippines, India, and Pakistan (AERC 1998) have current vitamin A fortification programs—the latter two of limited outreach. The common vehicles used or under study are vegetable oil and hydrogenated fats, margarine, sugar, wheat flour, and milk. Soft drinks and convenience foods (e.g., instant noodles) are fortified in the Philippines. In Thailand, a triple-fortified spice package is widely marketed with several instant foods (such as noodles) and is reported to be commercially viable (Chavasit and Tontisirin 1998).

Investment in research and development now could ensure that all the study countries have national vitamin A fortification programs providing for much of the needed dietary intake over the next five to ten years. At the same time, dietary promotion should be supported, extending beyond the conventional focus on fruits and vegetables to include other dietary sources whose efficacy has been demonstrated, such as red palm oil and eggs. Malaysia and Indonesia are among the world's largest producers and exporters of palm oil, mostly refined. The refining process removes most of the betacarotene present. However, a process has been developed recently by the Palm Oil Research Institute of Malaysia that removes the characteristic odor and taste of red palm oil without losing the betacarotene. If this refined red palm oil can be offered at prices competitive with normal refined palm oil, it could be a major dietary strategy to improve vitamin A status in several Asian countries.

Iodine Deficiency Control

Iodine deficiency control is being tackled effectively in some areas in the region through salt iodization. All the countries in the Project have salt iodization programs

supported by legislation. The major issues are that the iodine content varies very widely between manufacturers, wholesalers, and retailers, and that remoter areas, which are often also the most affected, may not have access to the iodized salt. These may simply be rectified with time and vigorous support to the programs.

Some innovations are possible. The iodine content of salt can be tested semi-quantitatively, with kits produced in India, Bangladesh, Thailand, and Indonesia, (also available through UNICEF), at the local level, in community-based programs, and through health facilities and schools. Awareness of whether the salt they are currently eating is actually iodized (as it is supposed to be, according to the label), plus knowing the consequences of deficiency, could do a lot to produce pressure leading to better quality control. This approach seems ready for pilot-testing, and could lead to an appealing program design. Salt-testing kits could be considered not only as the critical tool for alerting people to the absence of iodine in their salt, but also as the center piece of an education effort to teach children the basic facts about IDD and the practice of using iodized salt. School health education is one of the best ways to establish the universal norm of using iodized salt. There should also be discussion on how to get the mass media involved in periodically reminding the public of the danger of IDD and the proper use of iodized salt. Norms need reinforcement from time to time if they are to be sustained.

Iodized salt is not the only way to supply iodine. Blended foods, for example, can be fortified, like Thripasha in Sri Lanka, which provides significant amounts to the poorer 30 percent of households who have access. At least until the iodine content of the salt supply can be better assured, it may be worth including iodine when there are suitable opportunities in both multiple fortification and multiple supplementation.

In many Asian countries, salt iodization is the first large-scale experience in national fortification of a commodity. This has provided valuable lessons in collaboration between government, industry, NGOs, the media, and other sectors. It has also offered insights into building and sustaining an intervention politically, technically, financially, and culturally. Success with salt iodization is generating the confidence to address other more complex micronutrient problems. But sustaining iodine programs calls for continued political commitment and the motivation of industry. Producer compliance, quality assurance, logistics problems, and bottlenecks need to be addressed through effective advocacy, social communications, monitoring of salt iodine levels, regulation, and enforcement.

Iron Deficiency Control

Iron deficiency control is far more difficult. One underlying problem is that the iron content of the Asian diet has been falling since about 1970, not only the overall supply, but also the concentration of iron in the diet has fallen (e.g., as iron per

kilocalorie). This is probably partly due to the substitution of pulses (e.g., beans and peas) by cereals associated with the green revolution (ACC/SCN 1987,1992; World Bank 1994). Moreover, most of the iron is from vegetable sources and thus is of low bioavailability. The most available source, haem iron from meat, is excluded from the vegetarian diets of large sections of the population. In fact, Viteri (1998) estimates that it is difficult to obtain enough bioavailable iron at all on vegetarian diets.

Most countries have some form of iron supplement distribution, often with antenatal care. But problems include poor compliance with taking tablets daily, and inadequate distribution, logistics, and counseling. It has been reported that, in India, an adequate procurement of millions of iron tablets at state level became a meager and quite inadequate supply in clinics (Gillespie, Kevany, and Mason 1991). Weekly supplementation has some effect, although it is less effective than daily supplementation, but even a weekly regime will pose major problems in reaching those that need it. While undoubtedly iron (or usually iron/folate) supplementation should form a regular part of antenatal care, clinic attendance and adherence are likely to remain sporadic.

Iron fortification of cereals, especially wheat and corn flour, is rapidly gaining ground in parts of the world where these are staple foods. Indeed, in these areas, which include Pakistan and northern India, this approach may have the potential for a coverage and impact comparable with salt iodization. An important factor determining the absorption of the iron in milled flour is the level of extraction. High extraction flours (with extraction rates above 82 percent) have high phytate contents, which restrict the bioavailability of the nutrients in the flour. For this reason, a recent assessment of flour fortification in India indicated that fortifying whole wheat flour with the traditional iron compounds would not be worthwhile. Concern regarding absorption has prompted renewed interest in the use of newer iron compounds: specifically sodium iron ethylenediaminetetraacetic acid (NaFeEDTA) and amino-chelated iron. In diets containing inhibitors, the iron in NaFeEDTA is two to three times more available than from ferrous salts and an absorption of 8-10 percent can be expected. Studies to test the use of NaFeEDTA are currently in progress in India (wheat flour), PRC (soy sauce), and Viet Nam and Thailand (fish sauce) (Sinawat 1998).

There is also an urgent need to ensure that young children obtain enough iron in their diets through commercial or household levels, and to fortify complementary foods. However, many of those who most need increased intake of bioavailable iron have rice as their staple food. Fortification of rice with iron-containing products is not easy, it washes out with cooking, discolors the rice thus reducing acceptability, and is processed by many small-scale producers, among other problems (Gillespie 1998). Research is being done in a number of centers, and more support for such research can be expected to yield dividends. Widespread fortification with iron will eventually be possible. The issue is to invest now to hasten that process.

No single intervention will solve the iron problem, although fortification should play a central role. Deciding what to do should not be seen as “either-or”, but as “and-and”. Supplementation of at-risk groups (including young children), fortification, dietary modification, parasitic disease control, and the overall education of policymakers, professionals, and the public, all have their place. The relative prerequisites, costs, constraints, and opportunities all need to be explored in each situation to determine the appropriate mix of interventions. These should be integrated and mutually reinforcing—for instance, the focus on supplementation can benefit from being reinforced by greater attention to fortification or dietary promotion.

In the wider picture, technological problems are not nearly as serious as the operational issues related to making programs work and reach their targets. Supply and logistics, communications and community participation, and partnership building across a wide range of players, public and private, are all important to ensure the effectiveness of efforts to reduce anemia and iron deficiency in large populations. Many of these needs interact, and many of the interventions are mutually reinforcing.

Developing a new and medium-term strategy for investment support provides an opportunity for considering emerging needs and problems. A number of other issues can be considered as indicated in Table 6.

Rickets

The persistent reports of very high prevalences of rickets in the more northern parts of the PRC are very striking (PRC 1999), and rickets has also recently been reported in Mongolia (D. Fraser, pers. comm.). In the PRC, prevalences as high as 44 percent are observed, and while young children are the most affected, rickets is also reported in adolescents. The existence of rickets may be linked to the slow progress in reducing stunting in the PRC, in contrast to the more rapid reduction of underweight. If so, this has major implications for general nutrition programs. But rickets must also be addressed as a problem itself, and here a better understanding of the etiology is needed—it is almost certainly not as simple as a straightforward lack of vitamin D due to limited exposure to sunlight, although seasonal changes in incidence are suggestive. Dietary calcium and phosphorus are likely to be involved, as are dietary factors that inhibit their absorption, as well as other possible growth factors. Nonetheless, the problem may respond to increasing dietary vitamin D intakes. As this can be approached relatively easily through fortification, it should be investigated as a matter of priority. If low intakes of calcium are responsible, then there are important implications for food policy.

Zinc Deficiency

There are no specific signs for zinc deficiency (Golden 1994, 1995), so its detection depends on measuring responses to changing intake, usually in supplementation trials. These have only been done in sufficient numbers recently, and, while the results are not always consistent—as might be expected as the deficiency is likely to interact with other factors—it is likely that zinc deficiency is widespread and contributing to childhood illness (Gibson, Ferguson, and Lehrfeld 1998). Diarrhea in particular has been studied (Mehta and Blecker 1998).

The policy for addressing additional possible micronutrient deficiencies, once it is accepted that tackling one at a time may no longer be appropriate, is based on a different set of considerations. The better approach, as argued above, is going to be:

- (i) to promote fortification widely, often multiply in the same commodity or processed food, otherwise by fortifying a range of suitable vehicles; and
- (ii) to promote multiple nutrient supplementation, with some variation between different target groups (e.g., iron especially for women and children).

This being so, the question of whether to include a wide range of nutrients, such as zinc, or the water-soluble vitamins (Bs and C), turns more on the possible cost-effectiveness in terms of health and nutritional outcome, than on the extent, consequences, and presentation of the deficiency. The argument may be the reverse of the usual—do we have reason not to include a micronutrient that may be limiting? For example, a cheap vitamin (say thiamine) might be included even if the evidence for deficiency is sparse. Indeed, this is what happens with blended foods like Thriposha, commercial weaning foods, and breakfast cereals. Hence the undramatic deficiencies (like zinc, folate, and perhaps other water-soluble vitamins) may finally get attention through a policy of multiple fortification and supplementation. Table 7 sets out the costs of addition of several micronutrients and demonstrates that the actual additive costs are quite small and possibly affordable in many Asian countries.

Table 7: **Cost of Food Fortification with Micronutrients**
(additive cost only)

Vitamin	1/3 RDA	Cost/Person/Year (\$)
A (250 CWS)	1111 IU	0.073
D (100 CWS)	133 IU	0.016
E (50% CWS)	5 IU	0.139
B1	0.47 mg	0.004
B2	0.57 mg	0.013
B6	0.73 mg	0.006
Niacin	6.3 mg	0.019
Folic Acid	66.7 mcg	0.001
B12	1 mcg	0.014
C	20 mg	0.055
Total		\$0.339

Note: Hoffman Laroche prices in November 1997.

Multiple Fortification and Supplementation

Multiple fortification is common in commercial products, breakfast cereals being a good example. Double fortification with specific nutrients, notably iron and iodine in salt, has been investigated for some time; here there are a number of problems of interaction and acceptability. The effectiveness of doubly fortified salt in improving iron and iodine status among women and children in Ghana has been demonstrated only recently (Assibey-Berko 1999). But, as the scope of possible products to fortify expands, this will become easier technically, and the issue will increasingly be to implement feasible solutions. Thus in the context of the Project, support for the necessary research, promotion, pilot testing, and policy commitment for multiple fortification, in close cooperation with the food industry, represents an important opportunity to make a real difference.

There has been a growing consensus on the need to provide a multiple micronutrient supplement to women on a daily basis during pregnancy and on a weekly basis ahead of pregnancy. The minimum suggested contents for such a supplement are vitamins A, B6, B12, and D, with iron, folic acid, riboflavin, zinc, and possibly thiamine and vitamin C (Huffman 1998). There is clear evidence that these nutrients are strongly related to safe motherhood (reducing anemia and other maternal health concerns) and pregnancy outcomes. Thailand has already been providing multiple micronutrient supplements (containing vitamins A, D, thiamine, niacin, and B6) to pregnant women since 1980. The cost is estimated at less than US\$1 per pregnancy.

The feasibility of multiple supplementation as pills or tablets is not very different from that of single nutrient supplementation, but the main issue is that they would need to be taken regularly and frequently. One parallel is iron supplementation for women, which is not widely successful. While the side effects of taking iron tablets may be a constraint, there are many others, including distribution, counseling, and

the simple difficulty of taking tablets every day. Test marketing and promotion of multiple supplements may be practical in some societies, perhaps those that are more urbanized and developed, but other means of providing multiple supplements also need to be looked into.

The use of a spice or condiment mixture containing multiple nutrients looks very promising. In Thailand, a small packet of tasty spice-nutrient mix is marketed (e.g., with instant noodles), and appears widely accepted. Engaging the food industry in developing such approaches is clearly a way ahead.

Finally, we should keep in mind that there are many other food constituents that may have an important impact on health. Some are now being shown to have large effects on chronic disease, such as the impact of selenium on cancer initiation (Clark et al. 1996, Nelson et al. 1999). More generally, certain foods, of which fruits and vegetables are the most obvious, appear to have a surprisingly large protective effect against cancers (Miller 1990, 1995); and dietary links to circulatory diseases are well established (e.g., Lichtenstein et al. 1998, Suter 1999). In view of the likely emergence of chronic diseases, such as diabetes and heart disease, as a critical health problem in midlife—perhaps triggered by a combination of intrauterine growth retardation and inappropriate diet in early life—it may be wise to take a closer look at how these protective factors can be promoted, including possible fortification.

Information

Setting policies and designing programs for addressing micronutrient deficiencies requires detailed and extensive information, but the current information situation in the study countries is very inadequate, all the way from basic research, through evaluation, to monitoring interventions and trends in deficiency. Moreover, misunderstandings and even misinformation are common. The NAS highlighted that “there are a number of widely held beliefs among designers and implementers of micronutrient interventions that have not been empirically tested and that require such testing” (IOM/NAS 1998). Two examples of this conventional wisdom are quoted. The first refers to the belief that social marketing and education of recipients are essential—in fact the one example quoted to support this idea, the Thai ivy gourd experiment, showed little biological impact, although production and dietary habits changed (Smitasiri and Dhanamitta 1996); and this, as the NAS report states, is one of very few such examples. We had earlier noted the absence of evidence for impact of dietary change efforts on VAD (Gillespie and Mason 1994), and this does not seem to have improved much. The second is “the belief that community-level involvement is critical to high-coverage and sustainability of progress achieved by programs”. Again, this points to the urgent need for rigorous and clear-sighted evaluation.

Monitoring of trends in the deficiencies is still at an early stage. Only recently were data assembled to demonstrate the rapidly improving trends in clinical VAD (MI/UNICEF/Tulane 1998). This has important policy implications, for instance for the timing of interventions, but needs more confirmation and continued assessment. Equally, subclinical deficiencies are emerging in importance, but we have much less idea of the current situation, let alone the trends. More investment in assessments would pay off in terms of better planned and evaluated programs.

Because some of the important interventions are of known effectiveness, notably salt iodization and high-dose vitamin A capsule distribution, much is to be gained by the relatively easy monitoring of these interventions. If this were done systematically, fewer impact evaluations would be necessary.

Technical and sociological research, as has been stressed, is urgent for progress in tackling iron deficiency in particular, as well as for better fortification with other nutrients like vitamin A. The growing acceptance of multiple nutrient interventions, for example using condiment mixes containing several nutrients, is calling for both general and situation-specific research on practical ways of proceeding on a large scale.

Finally, focused research is indicated for problems whose significance is only now becoming clear. The most prominent of these are rickets in the PRC, and zinc deficiency probably throughout the region. For these we need to understand everything better: the extent, severity, causes and consequences of the deficiencies; feasible interventions and their priority; and the expected benefits to justify the investment. All of this is within the scope of applying present knowledge and research methods, as has been described for the progress in applying science to policy formation and program design in relation to vitamin A (Bouis and Mason 1996).

Public–private Partnerships to Address Micronutrient Malnutrition

The food industry is playing an increasingly critical and complex role throughout the world. In developed countries, changes in living and marketplace patterns have stimulated changes in food industry practices, the result being a diversity of food processing technologies bringing ever-changing numbers and types of foods onto the market shelves. Food fortification has played a major role in the health of these populations over the last 40 years, and most of the known nutritional deficiencies have been eliminated. In several Asian countries, fortification is increasingly recognized as the best long-term measure to improve the micronutrient status of large populations. Simple technological solutions to the problems of micronutrient deficiencies exist but are often complicated by economic, social, and political factors. Intervention strategies must take these factors into account. This is the challenge as well as the opportunity for the food industry—both multinational and domestic, small and large-scale—and active support from the other sectors should be sought. What is

urgently needed is to identify a set of priority actions and initiate a continuous dialogue between the various sectors so that the implementation of schemes that will permanently eliminate malnutrition moves quickly. Specifically, a multisectoral partnership needs to be built between industry, national governments, international agencies, expert groups, and other players to work closely on specific issues relating to technology development, food processing and marketing, free market approaches with minimum price support mechanisms, standards, quality assurance, product certification, social communications and demand creation, monitoring, and evaluation. Guidelines on these issues should then gain acceptance and be implemented at the country level. A multisectoral group within each country should define a feasible affordable strategy designed for the target population, identify opportunities for the involvement of the food industry, and assist in promotional and educational efforts to reach the target population.

This coalition will benefit private sector partners, not just as a lever to improve performance in the marketplace, but also to show that the private sector has social as well as economic interests. It will benefit governments, which have a mandate to improve the lives of their peoples. And it will allow national and international development agencies to provide technical support and seed money in an efficient and economic way.

The basic challenge is to bridge the communication gap between the public and private sectors in understanding their needs and respective roles and responsibilities. While constraints and shortcomings do exist, there is no need to delay immediate action in the following areas:

- (i) *Opening channels of communication.* Providing communication to all partners regarding the distribution and impact of macronutrient and micronutrient malnutrition, public and private resources that potentially can be brought to bear, and benefits accruing to each sector.
- (ii) *Creating public awareness.* Making consumers aware that malnutrition diminishes the quality of their lives and that nutritious foods can play a role in a more prosperous future. How this promotion will be handled collaboratively by the public and private sectors will be one of the first issues to address in the public–private collaboration.
- (iii) *Developing consumer demand.* Informed consumers choosing to purchase nutritious products will determine the success of food enrichment and promotion both as a public health strategy and as a private investment. Developing consumer demand entails not simply targeting populations and promoting nutritious products, but also developing the right product, price, and packaging.

- (iv) *Defining coverage and market segments.* While the public health community seeks high coverage of large populations, the private sector segments the market to identify niches of opportunity. How large must a market segment be before it can be recognized as contributing to a public health goal, and therefore eligible for public recognition or support? Each national dialogue will determine its own approach to this issue.
- (v) *Identifying food vehicles.* Food vehicles should be selected through a process of market research that demonstrates that they are consumed by a vast majority of the population, are affordable to those most in need, and respect both political sensitivities and consumer preferences. A number of food products can play complementary roles in a national food and nutrition strategy.
- (vi) *Marketing campaigns.* With broad agreement that public awareness and consumer demand are high priorities, collaborative public–private marketing campaigns are important issues for national dialogue. While public agencies have the credibility to market the health benefits of good nutrition in general, private companies can effectively promote consumer benefits of specific products.
- (vii) *Keeping products affordable.* Consumer prices and producer costs must be balanced so as not to discourage demand or supply. With strong communication between public and private sectors, purchasing, processing, marketing, and distribution activities can be coordinated across market segments to keep cost increases to a minimum.
- (viii) *Assuring quality.* Complementary public–private roles need to be defined in developing legislation and regulations, providing resources for laboratories and technical personnel, and establishing quality assurance and monitoring methodologies at the producer and retail levels.

Specific Opportunities for the Immediate Future

There are many opportunities to improve child nutrition in the study countries through micronutrient deficiency control programs. As the calculations of cost-benefit indicate (Mason, Jonsson, and Hunt, 1999, chapter 5), they are likely to be among the most attractive for investment, whether compared to other nutrition, or health, or indeed other development policies. From the range of possible opportunities, we highlight some broad and some focused actions below:

- (i) Promote sustained awareness-building of all those concerned, from policy-makers, through health and nutrition professionals and ultimately to the consumer, regarding the consequences of micronutrient deficiencies, the ready availability of cost-effective solutions, and the urgent need to take action.
- (ii) Create multisectoral partnerships that draw on the active participation of the private sector, NGOs, the education sector, and the agricultural sector to eliminate micronutrient malnutrition.
- (iii) Create the capacity to assess micronutrient status and to plan, implement, and monitor interventions through information dissemination and by updating the medical/health training curricula.
- (iv) Improve quality control of iodized salt, using testing kits, possibly included in community-based programs.
- (v) Support vigorous research into the technical and sociological issues of fortification through a wide variety of foodstuffs, giving top priority to iron, but also considering all other nutrients in short supply.
- (vi) Continue support for massive vitamin A dosing campaigns.
- (vii) Test and promote multinutrient supplementation.
- (viii) Solve the queries about rickets, calcium, and vitamin D where prevalent, and design interventions.

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