Solving the micronutrient problem in the Asia Pacific region

Ian Darnton-Hill MBBS, MPH, MSc(Med)

ONMI Project/USAID, John Snow Inc., Arlington, VA, USA

Over two billion people, or more than one out of three individuals throughout the world, are at risk of iron, vitamin A and iodine deficiencies. Although countries of the Asia Pacific region have generally shown a remarkable decline in the proportion of malnourished children, micronutrient deficiencies remain significant public health problems. The World Summit for Children in 1990, and the FAO/WHO International Conference on Nutrition held in Rome in 1992, affirmed that the elimination of the various forms of micronutrient malnutrition would constitute a significant contribution to social, economic and public health development. Governments and non-governmental organisations from virtually all nations, together with the international development community, have made the elimination of iodine deficiency disorders and vitamin A deficiency important goals to be achieved by the end of the decade, along with a substantial reduction in the levels of iron deficiency anaemia. A further important factor in implementing multisectoral micronutrient interventions is the cost-effectiveness of such interventions. The three main complementary intervention strategies to controlling and preventing micronutrient deficiencies are: (i) food-based approaches such as fortification and dietary diversification; (ii) supplementation when appropriate; and (iii) public health measures to control infection, including incorporating micronutrients into other child survival activities such as immunisation. Much of the global experience in these strategies comes from countries of the Asia Pacific region, with some significant examples of success.

Key words: micronutrient deficiencies, anaemia, iron, vitamin A, iodine, Asia Pacific.

The problem

Micronutrient malnutrition is a serious threat to the health and productivity of more than 2000 million people worldwide, despite being largely preventable.[1] Because of their high prevalence and close association with childhood illness and mortality, the three micronutrient deficiencies of current greatest public health significance are iron, vitamin A and iodine,[2] although zinc is receiving increasing attention.[3] Other micronutrient deficiencies such as thiamin, riboflavin and selenium are reported in the Asia and Pacific Region.[4] Rickets continues to be described sporadically, for example, in China[5] and Bangladesh.[6] Women and children are more vulnerable to micronutrient deficiencies because of their added requirements for reproduction and growth.[7]

This paper uses a clinical public health approach to look briefly at: (i) the magnitude and consequences of micronutrient malnutrition globally and in the Asia Pacific region ('diagnosis of the problem'); (ii) the intervention options for addressing the deficiencies and associated critical issues ('how to treat'); (iii) current programmes ('the treatment'); (iv) next steps and remaining challenges ('disease outcomes'); and (v) conclusions. A comment from a recent *Lancet* article in relation to micronutrient malnutrition stated: 'Success is at hand or not far away'.[8] It is also the intention of the paper to discuss the relevance of that statement to countries of the Asia Pacific region.

Globally, the iodine deficiency disorders (IDD) are currently a significant public health problem in 118 countries due to iodine-poor environments.[1] Iodine deficiency is the most common cause of preventable intellectual impairment in the world today, as well as having negative effects on the reproductive experience of women and on economic productivity.[9,10] Children born in iodine-deficient areas have been estimated to lose the potential of at least 10 IQ points compared with those born in iodine-replete areas. A recent report from Indonesia raises the possibility of a significant impact on deaths in infants, as iodine supplements given to infants of 6–10 weeks halved the risk of dying in the 4 months following supplementation.[11]

In the Asia Pacific region, the total population at risk is over 900 million and in 1990, 317 million were estimated to be goitrous[12] (Table 1). The loss of intellectual potential, and economic productivity must be enormous.[13] In the region in 1990, there were over 7 million cretins. In Asia, just by sheer size alone, Bangladesh, China, India and Indonesia together account for over 50% of the world's population at risk of IDD.[14] However, nearly all the countries in Asia have a problem to a greater or lesser degree; this is less so the Pacific although IDD have been reported in Fiji and remain a significant problem in the highlands of Papua New Guinea (Table 2). Goitres affect up to one-fifth of the population in Cambodia (total goitre rate (TGR) of 17%), Laos (25%), and

Correspondence address: Dr Ian Darnton-Hill, Helen Keller International, 90 Washington St, New York, NY 10006, USA.
Tel: 1 212 943 0890; Fax: 1 212 943 1220
Email: idarnton-hill@hki.org

An abbreviated version of this paper was presented at the Asia Pacific Clinical Nutrition Society 2nd International Conference.

Vietnam (20%).[14] Both Australia and New Zealand previously had a significant problem.

The total Asian and Pacific population with subclinical vitamin A deficiency (VAD) is estimated to be approximately 47 million, with a resulting significantly increased risk of early mortality in children (Table 3). Globally, over 3 million preschool children are estimated to have clinical signs with resulting serious risk of blindness and early death; 2 million of these children are in Asia.[15] Although the region has shown notable success in controlling and preventing VAD, some countries, and particularly socially disadvantaged areas within countries, still show levels in excess of the prevalence at which WHO defines there to be a public health problem.[16]

Including clinical and subclinical forms, VAD has been identified in 20 countries in the region at levels representing severe and moderate degrees of public health significance[16] (Table 4). Well over half of those with subclinical VAD are found in Asia, notably South Asia[15] but also in China, particularly in minority populations,[17] and in Micronesia.[4] Subclinical vitamin A deficiency is not uncommon in schoolchildren, adolescents and pregnant women in some settings,[18] and may have an important role in HIV-transmission from mother to child;[19] it may also be a significant contributor to maternal mortality.[20]

The main causes of vitamin A deficiency in the developing world are insufficient dietary intake of vitamin A and poor bioavailability of provitamin A sources (vegetables and fruits). Other important contributing factors include the increased requirements at certain stages in the life cycle; increased utilisation of vitamin A during infection, especially measles; and socio-cultural factors such as intrahousehold distribution and gender.[18,21]

Conservative estimates indicate that 1500 million people are anaemic world-wide, with perhaps over 90% of these in the developing world, mainly South Asia and Africa.[22,23] This is over half of all women in developing countries. Iron deficiency, the main cause of anaemia, is a major contributor to low birth weight, prematurity and maternal mortality.[22,24] Iron deficiency anaemia (IDA) is even more prevalent in infants and young preschoolers, and while there are no global data on prevalence of IDA in infants and children, in some sample populations prevalence reaches 70% or more.[25] It has recently been re-recognised as an important cause of cognitive deficit in this age group.[26] Iron deficiency also has a profound effect on productivity and hence has economic implications for countries in which it is a significant public health problem,[27,28] with physical work capacity being reduced even in moderate anaemia.[29]

For pregnant women prevalences range from 5% in Australia to approximately 30% in East Asia, over 50% in many countries of South-East Asia and much of the Pacific, and over 80% in parts of South Asia[4,30] (Fig. 1). In a survey in India, 62% of adolescent girls in urban areas were anaemic and 81% in rural areas.[31] In many countries in both Asia and the Pacific, the picture is made worse by other dietary factors (folate, vitamin A, vitamin B12), malaria, associated helminthic infection and other infections (including, now, HIV/AIDS), as well as congenital haemolytic diseases such as sickle cell anaemia and thalassaemia.[32] In some Asian countries, for example Laos, Vietnam and in parts of the Pacific, high prevalences of thalassaemia have been described. Up to 36% of women of north Indian origin in Malaysia who have anaemia, have megaloblastic anaemia.[4]

Deficiencies of these micronutrients clearly remain major problems in the world, and the region, today. This was recog-

Table 1. Iodine deficiency in populations in Asia and the Pacific[12]

WHO Region	At risk		Affected by goitre		Cretins	
	Millions	%	Millions	%	Millions	%
SEAR	486	36	176	13	3 2	1.3*
WPR	423	27	141	9	4.5	2.9*
Total	909	31	317	11	7.7	0.26*

* Percentage of goitrous population.

Table 3. Vitamin A deficiency in Asia and the Pacific[15]

UNICEF Region	Populations with clinical signs		Populations with subclinical signs*	
	Millions	%	Millions	%
South Asia	1.58	0.95	32.3	19.2
East Asia and the Pacific	0.40	0.26	14.8	9.1
Total	1.98	0.62	47.1	14.2

* Serum retinol < 0.7 μmol.

Table 2. Countries according to iodine deficiency status in Asia and the Pacific[14]

WHO Region	Severe (TGR > 30%)	Moderate (TGR > 20 < 30%)	Mild (TGR > 5 < 20%)	No problem
SEAR	Nepal	Bhutan	Bangladesh	Maldives
		Indonesia	India	
			North Korea (DPR)	
			Mongolia	
			Myanmar	
			Sri Lanka	
			Thailand	
	Fiji	Brunei	Cambodia	Australia
	PNG	Laos	China	Japan
		Malaysia	Philippines	New Zealand
		Vietnam		South Korea (PR)
				Singapore
				Pacific Island nations

TGR, total goitre rate; SEAR, South East Asia Region.

Table 4. Countries according to vitamin A deficiency status in Asia and the Pacific[15]

UNICEF Region	Clinical	Sub-clinical	No VAD	Likely problem
South Asia	Bangladesh India Nepal Sri Lanka	Bhutan		Pakistan
East Asia and the Pacific	Cambodia Mongolia Myanmar Philippines Vietnam	China Indonesia Laos Thailand	North Korea (DPR) South Korea (PR) Malaysia	
Less populous countries	Kiribati Marshall Islands Micronesia Solomon Islands		Other Pacific Island nations	PNG

VAD, Vitamin A deficiency.

nised and acknowledged globally in December 1992 at the International Conference on Nutrition (ICN), where representatives of 159 countries agreed to eliminate IDD and vitamin A deficiency as public health problems by the end of the century and to substantially reduce the prevalence of iron deficiency anaemia.[2] In 1990 the World Summit for Children had established broader goals for the health and well-being of children, and the nutrition goals, including those for the micronutrients, agreed to at that forum were echoed at the ICN.[33] Given this demonstration of apparent political will, how is micronutrient malnutrition being addressed?

Options for prevention and control

One commonly used categorisation of interventions comprises: (i) food-based approaches including fortification and dietary diversification; (ii) supplementation, for example, vitamin A capsules and iron/folate supplements; and (iii) public health interventions such as control of infectious diseases, collaboration with National Immunization Days, and promotion of breast-feeding.

The important point about these different approaches is that they are complementary and should be started in concert, as they may have different time frames and differing feasibility depending on local circumstances (Fig. 2). Behaviour change to improve the intake of micronutrients is an essential part of whatever method is being used: through communications, social and political facilitation, social marketing, and nutrition education.

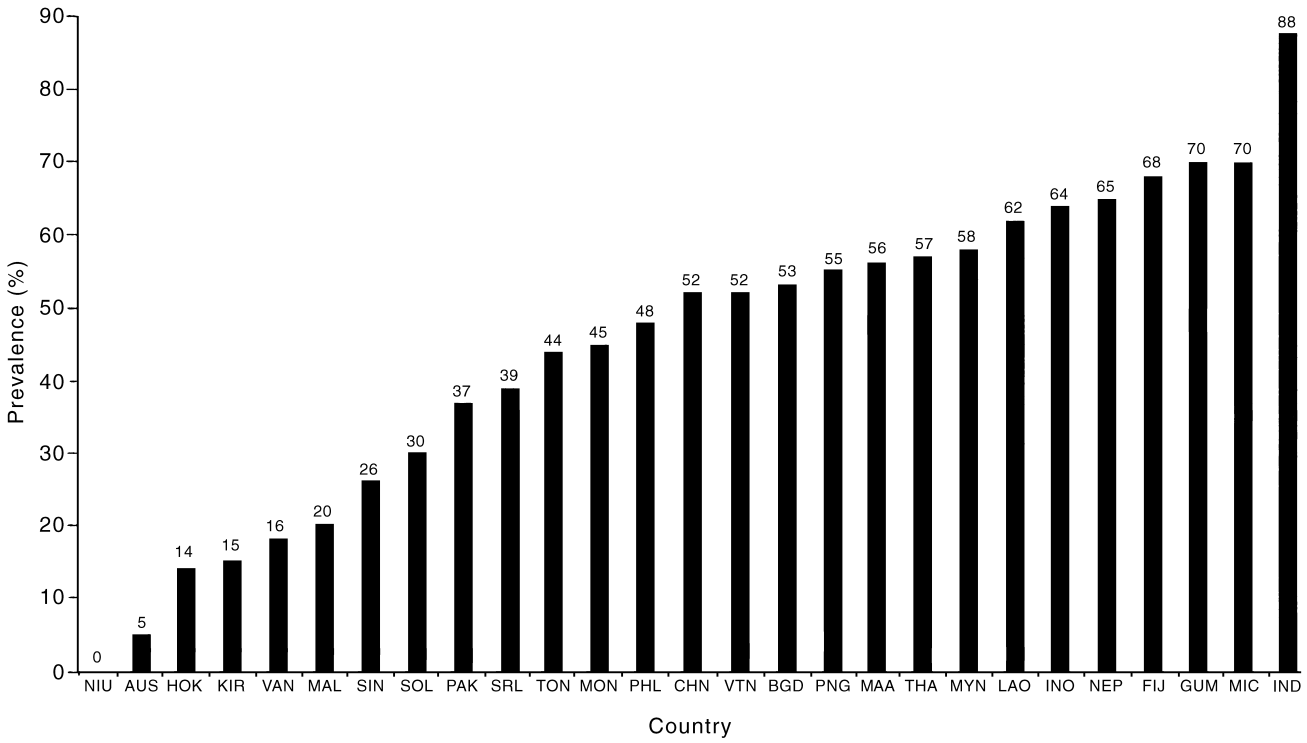

Figure 1. Reported prevalences of iron deficiency anaemia in pregnant women of Asia and the Pacific.[4,30] NIU, Niue; AUS, Australia; HOK, Hong Kong; KIR, Kiribati; VAN, Vanuatu; MAL, Maldives; SIN, Singapore; SOL, Solomons; PAK, Pakistan; SRI, Sri Lanka; TON, (Kingdom of) Tonga; MON, Mongolia; PHL, Philippines; CHN, China; VTN, Vietnam; BDG, Bangladesh; PNG, Papua New Guinea; MAA, Malaysia; THA, Thailand; MYN, Myanmar; LAO, Laos; INO, Indonesia; NEP, Nepal; FIJ, Fiji; GUM, Guam; MIC, (Federated States of) Micronesia; IND, India.

Food-based approaches

With the exception of iodine in certain ecological settings, micronutrients are found abundantly in many plant foods and animal products. However, poor families usually do not have enough to eat: their diets are not likely to include much nutrient-rich food and thus are likely to be low in vitamins and minerals as well as in energy.[7] This low accessibility to food sources is aggravated by low bioavailability and it is poor dietary quality, rather than quantity, that is considered to be the key determinant of impaired micronutrient status.[34] In poorer communities where more than 80% of the diet is of plant origin, as in much of Asia and the Pacific, it appears that dietary diversification may be adequate to prevent vitamin A deficiency but not to cure it.[35] In diets characterised by poverty, iron sources in the diet are unlikely to be adequate during pregnancy.

Nevertheless, improving dietary diversification through increasing variety and frequency of micronutrient-rich food sources through nutrition education and horticultural approaches has been shown to be effective in some settings. Interventions to achieve dietary diversification can include: nutrition education concerning available foods; horticultural approaches such as home gardens; and improved methods of food preparation, preservation and cooking that conserve the micronutrient content. There is also increased interest in the genetic manipulation and breeding of staples and other foods to have higher and more available micronutrient content.[36]

While home gardening is a traditional family food production system widely practised in many developing countries in the world,[37–39] anecdotal experience suggests home gardening (as an intervention method for improving nutrition) has been generally successful at the pilot or local phase, but that it has often not been scaled up successfully. Recent experience in Bangladesh has demonstrated a successful example where it has been successfully scaled up.[38] Where home gardening is traditionally practised, using such an approach to increase micronutrient intake is more likely to be successful. In Indonesia, ownership of a home garden appears to indicate long-term vitamin A intake from plant foods, which explains its relationship with vitamin A status.[35]

Probably the most effective food-based approach to improving nutrient availability and accessibility is fortification. This can be of both staple foods and more processed commercial products. Fortification of an appropriate food vehicle with specific nutrients has been a clear success in many countries.[40–42] Fortification efforts have in the past been less effective, both in terms of start-up and sustainability, in developing countries compared with the more industrialised world. However, in the last few years the experience in many countries of Latin America and Asia suggests the time is now ripe for a considerable expansion of fortification as a prime approach to address micronutrient malnutrition.[42] Micronutrient interventions, and particularly fortification, have been identified by the World Bank as among the most cost-effective of all health interventions and have been a major factor in the control of the micronutrient deficiencies in the industrialised world.[43] Fortification is but one arm of a strategy, but by becoming commercially viable, it can reduce the size of the at-risk population needing other measures such as supplementation (Fig. 3). Where the costs are passed onto the consumer, and the food industry routinely fortifies, sustainability is potentially high.

Supplementation

Iron supplementation has been the traditional approach for iron, particularly during pregnancy,[22] but is relatively expensive and coverage is often poor. Compliance is usually blamed but two reviews of the topic felt that distribution and logistical problems were every bit as important.[44,45] Interesting work is proceeding in a number of centres examining the efficacy of intermittent dosages, once or twice a week, suggesting that this may be a possibility for prevention, although not for treating anaemia in pregnancy. However, it does appear appropriate to recommend a dosage regimen of one or two times per week before pregnancy; for example, to adolescents and young women in schools and factories. It is presumed this approach would encourage compliance and reduce side-effects; it would certainly reduce costs but not logistic requirements, a recognised constraint in many settings.[46,47] With iron supplementation, gains in productivity and take-home pay have been shown to increase 10–30%.[24] Consequently there are important reasons, in addition to the already compelling health, cognitive development and reproduction consequences, to accelerate programmes to prevent and control iron deficiency anaemia.

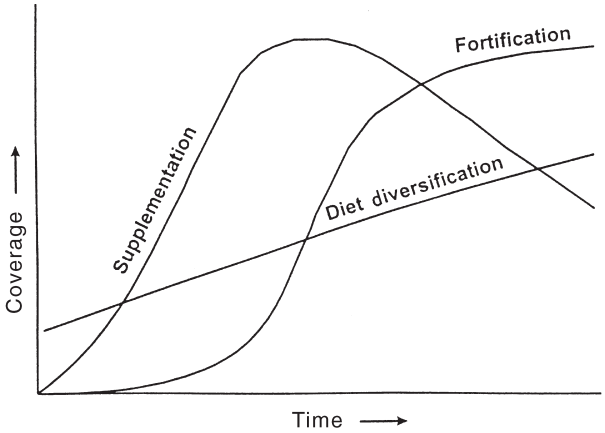

Figure 2. Complementary intervention strategies against micronutrient malnutrition. A diagrammatic time sequence of micronutrient interventions.

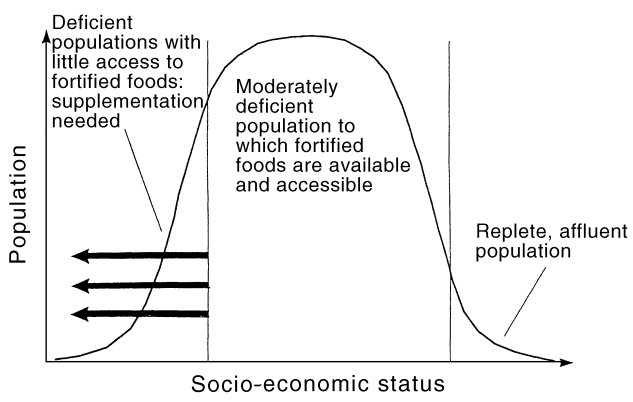

Figure 3. Paradigm for increasing micronutrient intakes in deficient populations. A diagrammatic representation of population approach to micronutrient interventions (Darnton-Hill 1998).[42]

The rationale of supplementation with high doses of vitamin A (retinol) rests on the fact that this fat-soluble nutrient can be stored in the body, principally in the liver. Periodic high-dose supplementation (4–6 months) is intended to protect against vitamin A deficiency and its consequences by building up a reserve of the vitamin for periods of reduced dietary intake or increased needs.[48] National coverage to all preschool children with vitamin A capsules has been hard to sustain over time and often does not reach the children most at-risk,[49–51] although using National Immunization Days has been a successful recent experience. Consequently, other approaches are being examined to reach the most at-risk groups — generally children under five but also pregnant women (e.g. for children to be more medically targeted such as when presenting with measles, malnutrition or diarrhea).[18] The guidelines for supplementation have just been revised.[48] Another approach is to give a capsule to a mother immediately postpartum and strongly encourage breast-feeding.

Short-term approaches for iodine have included iodized oil injections, which were spectacularly successful in the highlands of Papua New Guinea although the programme appears not to have been sustained.[9] Although there are the constraints of injections and sterility, cost, diversion of effort from salt iodization and sustainability, there would seem to be a limited role for hard-to-reach, unsophisticated populations. The effect appears to last for three years at least. Cheaper but less effective is iodized oil taken orally which is feasible, as has been shown in the Philippines.

Related public health interventions

For maximum impact other public health interventions are essential. These include control of infectious diseases, expansion of measles and other childhood immunisation interventions, deworming for intestinal parasites (hookworms), malaria control, promotion of breast-feeding, and proper health care such as oral rehydration therapy, all of which have an impact on micronutrient status.[52]

With the recognised interaction between infectious disease and malnutrition, addressing just malnutrition or just disease control in isolation is unlikely to be successful. Infectious diseases can have an effect on micronutrient intake, absorption and utilization. Vitamin A deficiency and iron deficiency anaemia can affect immune status and vitamin A deficiency is now well recognised as being associated with something like a 25% increased likelihood of child death, especially from the diarrhoeal diseases and measles.[21,53]

Because of the coexistence of multiple micronutrient deficiencies and interactions between micronutrients, and because micronutrients are generally ingested as part of the daily diet, it appears logical to pursue an integrated approach covering more than one micronutrient. For example, treating iron deficiency anaemia with both iron and vitamin A has a greater effect than either of the two micronutrients alone.[54] This clearly has important programmatic and policy implications.

There are, however, arguments both for and against such integrated approaches. It should be more convenient and cost effective to target the same populations for all three micronutrients using the same health or social infrastructure and the same workers; for example, as in the vitamin A deficiency, anemia, goitre (VADAG) approach in the Philippines.[55] A factor mitigating against this approach is that the age range of the targeted groups are somewhat different, vitamin A deficiency being most common in the second and third years of life, iodine deficiency most critical in women of reproductive age, and iron deficiency anaemia being found most commonly in the first 1–2 years of life and in pregnancy. Nevertheless women and children, and especially those in poverty, are predominantly those most at risk for all three micronutrients.

Current programmes: Successes and continuing challenges

Is success in eliminating vitamin A deficiency and the iodine deficiency disorders and reducing iron deficiency anaemia really not far away? Of the three micronutrients being discussed, the elimination of the iodine deficiency disorders are probably closest. This section will look at where the region is, in terms of achieving the ICN goal, for iodine, vitamin A and iron.

The iodine deficiency disorders

The reduction in iodine deficiency is a global success which began to show significant results from 1992.[56] While the universal iodization of salt (USI) has been the overwhelmingly predominant approach, countries have used a variety of programmes to complement this main thrust. These have included:

1. Food-based approaches: social marketing/nutrition education of iodized salt; water supply.
2. Supplementation: oral iodized oil; I/M iodized oil.
3. Fortification: salt iodization (USI); condiments; water pots and other sources.

Salt iodization programmes which began during the middle of this century, and other sources of dietary iodine, have effectively abolished the problem of iodine deficiencies in countries that routinely iodize their salt. This experience has now been extensively adapted to many different local environments: from relatively easy adaptations by major industrial salt producers to providing support for small producers to enable them to iodize salt without losing income.[13,56,57] The United Nations Childrens Fund (UNICEF) estimates that among countries in the world with a recognized IDD problem, all but seven have passed appropriate legislation to ensure universal iodization.[56]

China has had a national programme since 1958 and over 80% of the country is now covered by iodized salt. Whereas a recent evaluation showed that no province had achieved the ambitious goal of greater than 90% of salt iodized at a level of 20 p.p.m., half of all households tested did have iodization at a level of at least 20 p.p.m.[58] Although only two out of 29 provinces had a TGR of < 5%, median urinary levels were higher than they had been in the past, another encouraging indication of potential success. Vietnam has had a control programme since 1970 which now covers over half the country. Cambodia has just completed its first national goitre survey and has in place a national IDD Control Committee. It has the advantage that 80% of its salt is produced in a single place, Kampat Province. The country anticipates USI by the year 2000. Thailand has approximately 90% of its households now consuming iodized salt (USI Update 1997).[4]

India has institutionalised monitoring by the Salt Department and recently reported that over 90% of samples in 12 out of 22 States were being adequately iodized (although in three states less than 25% of salt samples were being adequately iodized).[58] India celebrates Global IDD day on 21 October, organised by the country's Salt Commission. Bhutan had a coverage of 95% in 1992, which then dropped to 82% in 1996 when there was a breakdown in the monitoring system at the community level, indicating the importance of continual vigilance by the government. This drop was reflected in IDD prevalence (as measured by urinary iodine).[58] Pakistan found that less than 30% of households were using iodized salt and only 20% in rural areas (USI Update 1997).[4] Nepal has 75% of the salt that comes into the country from India, iodized before arrival in the country. Half of salt in the markets has been reported to contain at least 20 p.p.m.[58] While in Bangladesh 99% of samples contained iodine, half of these had levels over the national recommended maximum of 50 p.p.m. and 45% had levels < 45 p.p.m.[58]

Myanmar has no legislation yet (there is a law but it has not been enacted), although there are reports of factories being closed for non-compliance (USI Update 1997).[3] Indonesia has an enormous challenge with highly decentralised salt production and is using millions of schoolchildren and teachers to monitor iodization.[56] Adequate levels are being found in nearly 60% of household samples.[58] The Philippines has been disappointing with only 15% of households consuming iodized salt, despite appropriate legislation in place and with over 80% of the population now being aware of the need for consuming iodized salt, as opposed to less than 10% who were aware of this in 1993 (USI Update 1997;[3] ASAP update, Philippines Department of Health, unpubl. data, 1998). The country has the capacity to iodize 70% of its salt.

In the Philippines, all women of child-bearing age are targeted to be given an oral iodized oil capsule during the annual national micronutrient day (ASAP) mass campaign, although effectiveness has not really been established in public health terms as the effect lasts for only about one year. Sustainability may also be a problem, with coverage dropping to 54% at the last campaign (1997), although levels had been sustained at approximately 80% before that. There was also a special problem with supplies.

Vitamin A deficiency

Experience with vitamin A has been very significant in the region, especially for gaining national experience and experiences that have then been transferred to other countries. Indonesia has been declared 'xerophthalmia-free', although it is recognised that a problem of subclinical deficiency persists, especially in the rural areas. Indonesia, Philippines, and Vietnam have all seen national prevalences drop to below levels designated by WHO as constituting a public health problem although pockets of high prevalence exist, particularly in poorer provinces. India, and now Bangladesh, have demonstrated a decline in prevalence, particularly of severe xerophthalmia.

An unexpected problem in the region was recognised in the last decade in the Micronesian island nations which were becoming overcrowded and urbanised, for example, Chuuk in the Federated States of Micronesia and Kiribati. There appears to be a special risk for atoll islands with limited soil capacity and which already import a large amount of food of doubtful nutritional value.[4] These countries have now instituted a variety of vitamin A prevention and control programmes.

The different food-based approaches that have been used in current programmes towards the elimination of vitamin A deficiency (VAD) include:

1. Dietary diversification: home gardening; nutrition education.
2. Fortification: flour; margarine and edible oils; noodles; condiments.
3. Supplementation: national distribution to all preschool children; National Immunization Days through health system centres; with EPI ; post-partum supplementation.

For two decades now at least four countries in the region (Bangladesh, India, Indonesia, and Vietnam) have had programmes implementing universal supplementation of vitamin A capsules, one of the most cost effective of health interventions, according to the World Bank. A successful strategy has been the distribution of capsules during mass campaigns such as National Immunization Days, as in Bangladesh and the Philippines and more recently in Cambodia, Laos, Mongolia, Myanmar and Vietnam and as part of the United Nations Expanded Programme of Immunisation (E.P.I.).[15,59] Coverage has been consistently maintained in several countries at over 80% for over 3 years now. Currently 12 countries in Asia and three countries in the Pacific have been successfully providing vitamin A capsules during National Immunization Days or other mass campaigns.[15]

In Nepal, supplementation has been consistently expanded through delivery by community health workers, and has now been extended to 32 districts with a coverage of 90%. Indonesia has been able to show a coverage, through health centres, of approximately 60%. These are important examples as more countries move towards decentralised health systems. India has had a long history of vitamin A supplementation through the Integrated Child Development Services programme which has been delivering vitamin A to children under 5 years of age as part of its comprehensive activities since 1975, but which appears to have had a relatively small effect on subclinical vitamin A deficiency.[60]

Since 1994, vitamin A supplementation coverage in South Asia has increased from 52 to 75%, and in East Asia and the Pacific from 25 to 86%.[15] Of countries with a VAD problem, 83%[5,6] in South Asia have vitamin A supplementation policies and 89%[8,9] in East Asia and the Pacific have vitamin A supplementation policies: for countries with populations of less than one million (as in much of the Pacific) it is 60%.[15] In just seven States of India, supplementation for one year (provided there was sufficient coverage) could save the lives of 175 000–250 000 children.[60] Ten countries (Bangladesh, Bhutan, Cambodia, India, Indonesia, Laos, Myanmar, Nepal, Philippines, and Vietnam) have policies of giving postpartum high dose vitamin A to mothers within 8 weeks of birth (6 weeks if not breast-feeding).

Vitamin A fortification has been important in reducing deficiencies of vitamin A, especially in Latin America with regard to the fortification of sugar. Other vehicles have included fats and oils, tea, cereals, flour, monosodium gluta-

mate and instant noodles, as well as milk/milk powder, whole wheat, rice, salt, soybean oil, and infant formulas.[41] Margarine, for example, is currently fortified with vitamin A in the Philippines, and its effectiveness has been demonstrated.[61] In India, red palm oil is added to other edible oils and Malaysia has done much work with retaining the β-carotene content of palm oil during processing.[62] Fortifying commercially available produced foods and flours with iron and B vitamins, including more recently folate, has been successful in much of the industrialised world in reducing levels of IDA.[63] There is currently work under way in the Philippines testing the efficacy of vitamin A in a wheat flour product, pandesal, and the technology of fortification with both vitamin A and iron.[64] Work, supported by USAID/OMNI, is on-going in Sri Lanka to test the effectiveness of an iron-fortified wheat flour intervention.

Currently, Bangladesh, India, PNG and the Philippines are looking at fortifying sugar with vitamin A. China, India, Pakistan, Philippines and Thailand (condensed milk) are fortifying dairy and vegetable oil with vitamin A. Philippines is seriously considering fortifying flour. Noodles (or the accompanying sauce) are increasingly being fortified with vitamin A and a recent assessment of Indonesian households found 29% of households, even in rural Sulawesi to be using fortified noodles (HKI, Indonesia, unpubl. data, 1998).

Iron deficiency anaemia

Iron deficiency anaemia (IDA) remains as probably the most prevalent nutritional problem in the world. Although UNICEF supplied 2.7 billion iron/folate supplements to 122 countries from 1993 to 1996, many pregnant women enter pregnancy already anaemic and thus, a majority of women in Asia are anaemic at some stage of their pregnancy. Iron for anaemia remains the micronutrient that needs the most acceleration, but ICN goals are unlikely to be reached in most countries. Current programmes towards the reduction of iron deficiency anaemia (IDA) include:

- Food-based: dietary diversification.
- Fortification: flour, commercial foods (also combined with other fortifiers such as vitamin A and B vitamins).
- Supplementation: clinic-based to pregnant and lactating women; clinic-based to infants and children; private sector; factory workers; school-aged adolescents; intermittent versus daily.

There is a lot of work in the region on enhancing delivery of iron/folate supplements through innovative approaches, including the private sector, as in Indonesia.[64] Compliance issues and different regimens are also starting to move beyond research into operational research and programmes. In Malaysia, weekly supplementation over several months resolved the anaemia in over 80% of adolescent girls in a community where anaemia was highly prevalent,[65] and similar results have been reported from other countries such as Indonesia.[66] Fortification of foods with iron has increased and will have an effect on anaemia levels, particularly as commercial food companies begin to fortify. At the same time, it is being increasingly recognised that other factors must be addressed concurrently; for example, deworming and malaria through impregnated bednets.

Next steps and on-going constraints

In countries of the Asia Pacific region, all three micronutrient deficiencies have been problems of public health significance and in many cases remain so, although there has been tremendous progress in improving iodine and vitamin A deficiency levels. There has been a period of rapid social and economic change. At the national level, most countries do not have a food security problem, but problems of household dietary deficit and individual malnutrition are still common among low-income populations, while social inequalities in nutrition and health experience persist.[67,68]

Iodine deficiency disorders

The most recent State of the World's Children has described the reduction in iodine deficiency as a global success by any standard.[56] Something like 60% of all salt is now being fortified, meaning that 1.5 billion people are now consuming iodized salt for the first time[56,69] (Fig. 4). Although 19 countries continue to have significant iodine deficiency, iodized salt has gone from 10% to > 50% in South-east Asia and to

Figure 4. Percentage of households consuming iodized salt (1992–1996). A diagrammatic world map of countries with iodization of salt (UNICEF 1997). (⊠), Less than 50%; (⊡), 50 to 89%; (■), 90% or more; (■), no data. Source: IDD data from UNICEF. *Report on Progress Towards Universal Salt Iodization*, 1994. Salt iodization data compiled UNICEF, 1997. Note: The boundaries shown on this map do not imply official endorsement or acceptance by UNICEF.

> 70% in China. This has had a significant effect on the goitre rate in the region. Over 12 million infants each year are being protected from mental retardation. The amount of intellectual potential saved must run into the millions of IQ points. The number of cretins being born has halved in the last decade (from approximately 120 000 to 60 000 annually).[56]

Constraints to complete success include: lack of adequate coordination and communication between sectors; a continuing need for advocacy, communications and training at all levels, insufficient quality assurance and monitoring; and a remaining need to stimulate public demand.[58] A review by van der Haar[12] quoted as critical the need for increased advocacy, legislation, regulations and enforcement; improved communications, information and management; strengthened laboratory management; and international collaboration and private sector involvement. In some countries, price differential and poor accessibility remain constraints (USI Update 1997).[4] Dunn adds an inattention to costs and to sustainability.[13]

The next steps include strengthening of quality assurance/quality control (QA/QC); accelerating existing programmes; eliminating pockets of IDD in unreached populations; and ensuring sustainability of current programmes.

Vitamin A deficiency

The United Nations Childrens Fund has estimated that there has been a 40% decline in prevalence of vitamin A deficiency over the last 10 years[15] (Table 5). Vitamin A supplement coverage has increased, on average in the region, from approximately 33% only 4 years ago (1994) to over 80% today. The rate of decline of vitamin A deficiency 'is about 70% of the global rate required to eliminate clinical vitamin A deficiency by the year 2000'.[15] If the current rates are maintained, clinical VAD would be eliminated in South Asia by 2007, and there has been a higher rate of improvement in South Asia than the global average. The subclinical goals would be reached in 2012. Other countries in Asia and the Pacific may well reach the year 2000 goal.

A mix of interventions will give governments the chance to shift from a subsidised vitamin A capsule programme to more sustainable, non-subsidised consumer-funded vitamin A interventions. In an appreciable number of countries, supplementation with vitamin A will be a necessity for some years to come. Nevertheless, governments are seeking guidelines for phasing out the VAC programme when fortification and other approaches emerge as complementary effective alternatives.

Table 5. Trends (number of children and percentage change) in prevalences of clinical and subclinical signs of vitamin A deficiency calculated from instances where multiple surveys have been reported[15]

UNICEF Region	No. children (millions)					
	Clinical			Subclinical*		
	1985	1995	Δ%/10 years	1985	1995	Δ%/10 years
South Asia	2.67	1.58	–47%	27.7	19.2	–22%
East Asia and the Pacific	0.66	0.40	–42%	11.8	9.1	–23%

* Serum retinol < 0.7 μmol/L.

The next steps include transition to a mixture of fortifications, other food-based approaches and targeted supplementation; high dose vitamin A to mothers within 8 weeks of delivery; addressing women's status, leading to a life-cycle approach; form and dosage regimens of supplements (retinol or β-carotene, smaller intakes weekly or 200,000 IU six-monthly); assessing whether there is a role in HIV transmission reduction; and assessing whether there is a role in malaria prophylaxis.

Iron deficiency anaemia

Although the most prevalent of the three deficiencies, this has been the least successful, despite the goal being the most modest. The Standing Committee on Nutrition of the UN system has drawn attention recently 'to the lack of progress in tackling iron deficiency anaemia which affects the health and development of tens of millions of children and women in spite of the availability of practical low-cost interventions'.[69] Constraints are multiple, starting with the fact that it is a harder problem to tackle programmatically. However, it has been of lesser priority (perhaps because it affects mainly women and children?); logistics are complicated; compliance is often low; bioavailability in the diet, especially in the diets of the poor, is low and further reduced in many largely vegetarian diets; and the status is worsened by coexisting conditions of parasite infection and malaria.

The next steps include greater emphasis on IDA as the other two micronutrients show progress; a life-cycle approach targeting adolescents; using other delivery mechanisms such as schools and factories; administering weekly versus daily dosing; logistics; fortification; emphasis on cost-effectiveness and productivity increasing effects of interventions.

Fortification and the private sector

One of the biggest trends is likely to be in the increased fortification of staples such as wheat flour, rice and oils, as well as the completion of the universal iodization of salt. Involvement of the private sector in processed foods, such as noodles, will increase. Nevertheless a strong governmental role will remain an essential ingredient for success. A further development here is likely to be a regional approach to fortification in terms of exports and imports, a harmonization of standards and common legislative approaches, building on the common ground of *Codex Alimentarius*, especially in an environment of economic globalisation. There will also be more involvement of the private sector in the sale of supplements. There will be some emphasis, particularly with donor encouragement, on using the private sector as the avenue for supplements, as in the recent pilot experience in Indonesia. A recent survey in the Philippines found that while approximately 90% of people said they would be willing to buy supplements, most would not spend more than 20 pesos (approximately 5 cents US) on iodized oil or vitamin A supplements, citing a lack of money and a feeling that it was the Government's responsibility.

Multi-micronutrient approaches

The poor diets that women in developing countries often consume due to poor availability and limited consumption of micronutrient-rich foods lead to deficiencies of iron, vitamin A, zinc, folic acid, B6, B12 and other vitamins and minerals.

Such deficiencies have important consequences for women's own health and pregnancy outcomes, as well as for the health and nutritional status of their breast-fed children.[70] Current efforts are testing the benefits to women of combining iron/folic acid and zinc, zinc and vitamin A, as well as several multiple vitamins and minerals into a single tablet. A study of pregnant Indonesian women showed that 100% of those who were anaemic were cured by a combination therapy of vitamin A with iron, in contrast to vitamin A alone (40%) and iron alone (60%).[71]

Preliminary impressions are that a postpartum approach is of limited value. This is probably because of limited coverage and a relatively narrow time-frame, usually 8 weeks postpartum, when the evidence suggests that longer time periods are needed. In addition, because developing country diets are limited in many other essential vitamins and minerals, and given the need to factor in micronutrient interactions, effectiveness may be limited even if programmes are successful in increasing supplement use among the target population.[70] Nevertheless, supplementation (commenced before pregnancy), and fortification, with a range of micronutrients, are likely foreseeable trends.

Sustainability

Three factors have been identified as essential for sustainability: efficacy, appropriateness, and demonstrated feasibility.[28] In a report from the United States Institute of Biology of the Academy of Science, the authors point out that sustainability has two components: (i) process, that is, the continuity of a successful intervention; and (ii) outcomes, that is, the continuation of a significant, positive impact on the intended beneficiaries. For example, the Indonesian vitamin A programmme is an excellent example of an intervention that evolved over a 20-year period from 100% donor support to the current programme, which is entirely funded by government money.[28]

Pharmaceutical supplementation is of proven efficacy but effectiveness over time remains a challenge for public health micronutrient programmes. Nevertheless, supplementation with iron, especially for pregnant women, and probably infants, currently has no alternative, and is of confirmed efficacy, although 'it has proven ineffective in practice in most developing countries'.[46] Vitamin A supplementation has been in existence as a public health intervention for over 20 years; for example, in Bangladesh.[49,51] In countries with pockets of vitamin A or iron deficiency, supplementation will be required for many years to come; however; methods of targeting, enhancing delivery, ensuring supplies, encouraging demand and compliance will continue to be streamlined and adapted to local circumstances. Although vitamin A supplements are currently being purchased or donated through UNICEF, this cannot be continued indefinitely. However, a parallel to the continuing need for the purchase of immunisation in countries' E.P.I. programmes can be made.

To address issues of cost and sustainability, there has been increased interest in the use of a more targeted approach to supplementation through healthcare facilities and other channels likely to reach groups at risk: such approaches include using the private sector, and expanding on the recent success of National Immunisation Days (NID). These have usually been with the mass polio campaigns and while high levels of coverage have been achieved and maintained, the polio initiative is due to finish over the next few years. National measles immunisation campaigns are a possible alternative for a first vitamin A megadose. Seroconversion does not appear to be affected.[72] Another factor is the need for a follow-up day on which a second vitamin A capsule can be given, approximately 6 months later. This has been successfully handled, with so far good sustainability, in Bangladesh during National Vitamin A Weeks; on 2 days in April and October each year in Nepal using the Female Community Health Volunteers (with > 80% coverage sustained over three years); the *Araw ng Sangkap Pinoy* on World Food Day in the Philippines (which has also had over 80% coverage, although the most recent coverage dropped from 88% to 78% (HKI, unpubl. data, 1998). Constraints are seen as health worker fatigue with the campaign approach, lack of supplies on the day, the need for continued promotion and greater consumer demand.

The need for iodine in iodine deficient areas, particularly if such areas are also poor and isolated, is also a long-term requirement. Fortunately, the fortification of salt with iodine has now had the experience of almost half a century in some countries and is clearly sustainable when there is government commitment, and where monitoring systems are in place. In Europe IDD re-appeared in Germany when the programme was not ensured by the Government,[9] and more recently prevalence increased again in Bhutan.[58]

Nutrition education and the increased knowledge of both consumers and policy makers are seen as integral parts in the sustainability of any programme. However, the beneficial impact of nutrition education on micronutrient status has not been well documented in the past, except for limited efforts to increase consumption of food sources of β-carotenes; for example, in Thailand.[73] Analyses of both the Bangladesh and Vietnam experiences show that the reduction in vitamin A deficiency in those countries has been mainly an effect of the VAC supplementation programme, and that the underlying cause of lack of vitamin A in the diet (through fortification or through foods in the diet) has still not been solved.[18] Again, it would appear that when taken together, the complementary approaches of nutrition education, fortification, dietary diversification, and supplementation, where needed, are most likely to ensure sustainability.

Conclusions

The elimination of vitamin A deficiency and the iodine deficiency disorders, as well as the substantial reduction of iron deficiency anaemia, have been endorsed as achievable goals by virtually all countries of the world. There has been wide acceptance in the countries of Asia and the Pacific of the need to see micronutrient interventions at a national level as a priority. The cost effectiveness of most micronutrient interventions still needs to be advocated to policy makers: overall, it has been estimated that for 'less than 0.3% of their GDP, nutrient deficient countries could rid themselves of these entirely preventable diseases, which now cost them more than 5% of the GDP in lost lives, disability and productivity'.[27]

Most countries of the Asia Pacific region are ideally placed to tackle the issue of micronutrient malnutrition, having national infrastructures in place, a recognised need, and

an improving socio-economic status. As this paper has demonstrated, there has been considerable progress made in alleviating mirconutrient malnutrition, especially in addressing the iodine deficiency disorders and vitamin A deficiency, and to a lesser extent with iron deficiency anaemia. Increased cooperation between governments, communities, the food industry, agriculture and academia will be needed. The exact mix and sequencing of interventions, and when to modify these, will become the important questions for each national programme. A major challenge at present is to make the elimination of micronutrient malnutrition more consumer driven.

The recent economic problems of the Asia Pacific are likely to set back the general nutrition improvement that has been taking place and that accompanies, at least for deficiency diseases, socio-economic success. However, given the recent success of many such programmes in Asia and the Pacific, the chance of achieving the goals of the International Conference on Nutrition seem possible for the iodine deficiency disorders and vitamin A deficiency. Iron deficiency anaemia will continue to be a challenge.

Acknowledgements. This publication was made possible through support provided by the Office of Health and Nutrition, Bureau for Global Programs, Field Support and Research, U.S. Agency for International Development, under the terms of Contract No. HRN-5122-C-00–3025–00. The opinions expressed within are those of the author and do not necessarily reflect the views of the U.S. Agency for International Development. The authors would like to acknowledge the support of USAID, especially Dr Frances Davidson; Dr Martin Bloem, Regional Technical Director of HKI for Asia and Country Director for Indonesia; and Dr L Tommaso Cavalli-Sforza, the Nutrition Adviser of the Western Pacific Region of WHO; and Dr Sultana Khanum, the Nutrition Adviser for the South-East Asia Region of WHO.

References

1. WHO. Nutrition. Highlights of recent activities in the context of the World Declaration and Plan of Action for Nutrition. Nutrition Programme. Geneva: World Health Organization, 1995.
2. FAO/WHO. World Declaration, Global Plan of Action. International Conference on Nutrition, Rome, 1992.
3. Black R, ed. Zinc for child health. Child health research project special report. Baltimore: Johns Hopkins School of Public Health, 1997; 1: 1.
4. Darnton-Hill I, Cavalli-Sforza LT, Volmanen PVE. Clinical nutrition in East Asia and the Pacific. Asia Pacific J Clin Nutr 1992; 1: 27–36.
5. Cavalli-Sforza LT, Xu W, Wu K, Lu F, Liu Q, Siri E, Ferro-Luzzi A. Anaemia, rickets and protein–energy malnutrition during the weaning period in a rural community of the People's Republic of China. 1991: 1–7.
6. Welch RM *et al.* Mineral status in relation to rickets in Chakaria, Bangladesh [Abstract]. Proc Ann Mtg International Centre for the Control of Diarrhoeal Diseases, Bangladesh, Dhaka, 1998 (in press).
7. Calloway DH. Human nutrition: Food and micronutrient relationships. International Food Policy Research Institute. Agricultural Strategies for Micronutrients. Working paper 1, 1995.
8. West CE, Hautvast JGAJ. From 'whither' to 'wither' micronutrient malnutrition? Lancet 1997; 350 (Suppl. III): 15.
9. Hetzel BS. The story of iodine deficiency: An international challenge. Oxford: Oxford Medical Publishers, 1989.
10. Bleichrodt N, Born MPH. A meta-analysis of research on iodine and its relationship to cognitive development. In: Stanbury JB, ed. The damaged brain of iodine deficiency. New York: Cognizant Communication Corporation, 1994; 195–200.
11. Cobra C, Muhilal, Rusmil K, Rustama D *et al*. Infant survival is improved by oral iodine supplementation. J Nutr 1997; 127: 574–578.
12. van der Haar F. The challenge of the global elimination of iodine deficiency disorders. Eur J Clin Nutr 1997; 51: 53–58.
13. Dunn JT. Seven deadly sins in confronting endemic iodine deficiency, and how to avoid them. J Clin Endocrinol Metab 1996; 81: 1332–1335.
14. WHO/UNICEF/ICCIDD. Global prevalence of iodine deficiency disorders. MDIS Working paper 1, 1993.
15. Sethuraman K, Dalmiya N, Mason J, Lotfi M, Alnwick D. Progress in controlling vitamin A deficiency [Draft]. UNICEF/Tulane University/Micronutrient Initiative, 1997.
16. WHO/UNICEF. Global prevalence of vitamin A deficiency. Geneva: WHO, MDIS Working paper 2. WHO/NUT/95.3, 1995.
17. Long F, Yang Y, Wang S. Untouched land: A report on the vitamin A deficiency situation in the minority areas of Southwest China. Sight Life Newsletter 1998; 1: 28–30.
18. Bloem MW, de Pee S, Darnton-Hill I. New issues in developing effective approaches for the prevention and control of vitamin A deficiency. Food Nutr Bull 1998; 19: 137–148.
19. Semba RD, Miotti PG, Chiphangwi JD *et al.* Maternal vitamin A deficiency and mother to child transmission of HIV-1. Lancet 1994; 343: 1593–1597.
20. West KP, Khatry SK, Katz J *et al.* Impact of weekly supplementation of women with vitamin A or beta-carotene on fetal, infant and maternal mortality in Nepal. XVIII IVACG Meeting. Sustainable control of vitamin A deficiency. Cairo, Program and Abstracts 1997: 28.
21. Sommer A, West KP. Vitamin A deficiency, health, survival and vision. New York: Oxford Press, 1996.
22. DeMaeyer EM, Dallman P, Gurney JM, Hallberg L, Sood SK, Srikantia SG. Preventing and controlling iron deficiency anaemia through primary health care. Geneva: World Health Organization, 1989.
23. Singh K, Fong YF, Arulkumaran S. Anaemia in pregnancy – a cross-sectional study in Singapore. Euro J Clin Nutr 1998; 52: 65–70.
24. WHO/UNICEF/UNU. Indicators and strategies for iron deficiency and anaemia programmes. Report of a WHO/UNICEF/UNU Consultation. Geneva: WHO (in press) (Draft: May 1994).
25. ACC/SCN. Second report on the World Nutrition Situation, Volume 1. Geneva: Administrative Coordinating Committee/Subcommittee on Nutrition of the United Nations, 1992.
26. Draper A. OMNI/USAID/PCD. Child development and iron deficiency. Oxford Brief developed from a consultation held by the Opportunities for Micronutrient Interventions Project of USAID and the Partnership for Child Development. Arlington: JSI, 1997.
27. McGuire J, Galloway R. Enriching Lives. Overcoming vitamin and mineral malnutrition in developing countries. Washington: World Bank, 1994.
28. Howson CP, Kennedy ET, Horwitz A, eds. Prevention of micronutrient deficiencies: Tools for policy makers and public health workers. Summary and key elements. Committee on Micronutrient Deficiencies, Board of International Health, Food and Nutrition Board of the Institute of Medicine, National Academy of Sciences. Washington: National Academy Press, 1998.
29. Scholz BD, Gross R, Schultink W, Sastroamidjojo S. Anaemia is associated with reduced productivity of women workers even in less-physically-strenuous tasks. Br J Nutr 1997; 77: 47–57.
30. World Bank. Health, nutrition and population. Sector strategy of the Human Development Network. World Bank: Washington, 1997.
31. Gopalan C. Child care in India – emerging challenges. NFI Bulletin 1993; 14: 3.
32. Csete J. Importance of understanding the aetiology of anaemia. Research in Action. New York: UNICEF, 1997; 7.
33. UNICEF. World declaration on the survival, protection and development of children. The World Summit for Children, New York, September 1990.
34. Allen LH, Ahluwalia N. Improving iron status through diet: The application of knowledge concerning dietary iron bioavailability in human populations. USAID/OMNI. Arlington: JSI, 1997.
35. De Pee S, Bloem MW, Gorstein J *et al.* Reappreciation of the role of vegetables for vitamin A status of mothers in Central-Java, Indonesia. Am J Clin Nutr (in press).
36. Welch RM, Combs GF Jr, Duxbury JM. Toward a 'greener' revolution. Issues in Science and Technology 1997; Fall: 50–8.

37. Talukder A, Bloem MW. Home gardening activities in Bangladesh. Dhaka: HKI, 1992.
38. Bloem MW, Huq N, Gorstein J *et al.* Production of fruits and vegetables at the homestead is an important source of vitamin A among women in rural Bangladesh. Eur J Clin Nutr 1996; 50 (Suppl.): 62–67.
39. Marovatsanga L *et al.* Food-based approaches to the control and prevention of micronutrient malnutrition. Opportunities for Micronutrient Interventions (OMNI) /USAID. Arlington: JSI, 1998.
40. Nestel P. Food fortification in Developing Countries. USAID/VITAL. New York, 1993.
41. Lotfi M, Mannar MGV, Merx RJHM, Naber-van den Heuvel P. Micronutrient fortification of foods: Current practices, research, and opportunities. The Micronutrient initiative/International Agricultural Centre. MI/IDRC/IAC. Ottawa, 1996.
42. Darnton-Hill I. Overview: Rationale and elements of a successful food fortification program. Food Nutr Bull 1998; 19: 92–100.
43. World Bank. Investing in Health. World Development Report 1993. The International Bank for Reconstruction and Development/The World Bank. New York: Oxford University Press, 1993.
44. Gillespie S, Kevany J, Mason J. Controlling iron deficiency. UN Administrative Committee on Coordination/Subcommittee on Nutrition. ACC/SCN State-of-the-Art Series. Nutrition Policy Discussion Paper no. 9, 1991.
45. Galloway R, McGuire J. Determinants of compliance with iron supplementation: Supplies, side effects, or psychology? Soc Sci Med 1994; 39: 381–390.
46. Viteri F. Supplementation for the control of iron deficiency in populations at risk. Nutr Rev 1997; 55: 195–209.
47. Schultink W, Gross R, Gliwitzki M, Karyardi D, Matulessi P. Effect of daily vs twice weekly iron supplementation in Indonesian preschool children with low iron status. Am J Clin Nutr 1995; 61: 111–115.
48. WHO/UNICEF/IVACG. Vitamin A supplements: A guide to their use in treatment and prevention of vitamin A deficiency and xerophthalmia. Geneva: World Health Organization, 2nd edn, 1997.
49. Darnton-Hill I. Vitamin A deficiency in Bangladesh. Health Policy Planning 1988; 3: 205–213.
50. Darnton-Hill I, Sibanda F, Mitra M *et al.* Distribution of vitamin A capsules for the prevention and control of vitamin-A deficiency in Bangladesh. Food Nutr Bull 1988; 10: 60–70.
51. Reddy V. Control of vitamin A deficiency and blindness: The Indian experience. In: Darnton-Hill I, ed. Vitamin A deficiency in Bangladesh: Prevention and control. Dhaka: HKI, 1989; 124–9.
52. Gillespie S, Mason J. Controlling vitamin A deficiency. ACC/SCN State-of-the-Art Series. Nutrition Policy Discussion Paper no. 14. ACC/SCN of the United Nations, Geneva, 1994.
53. Beaton GH, Martorell R, Aronson KJ *et al.* Effectiveness of vitamin A supplementation in the control of young child morbidity and mortality in developing countries. ACC/SCN State-of-the-Art Series. Nutrition policy discussion paper no. 13, 1993.
54. Bloem MW. Interdependence of vitamin A and iron: An important association for programmes of anaemia control. Proc Nutr Soc 1995; 54: 501–508.
55. Solon FS. Vitamin A deficiency, anemia and goiter (VADAG) control handbook. Manila: Nutrition Center of the Philippines, 1985.
56. UNICEF. The state of the world's children. Oxford: Oxford University Press, 1998.
57. Hetzel BS, Pandav CS. S.O.S for a billion: The conquest of iodine deficiency disorders. Delhi: Oxford University Press, 1997.
58. Mannar MGV. Monitoring IDD in Asian countries – lessons learned. International Council on the Control of Iodine Deficiency Disorders (ICCIDD). IDD Newsletter 1997; 13: 42–45.
59. DOH/UNICEF/NNC/HKI. Sangkap Pinoy: The Philippine experience in massive micronutrient intervention. Department of Health, Republic of Philippines/UNICEF/National Nutrition Council/Helen Keller International, 1994.
60. Mesite JP. Children in the dark: Four decades of vitamin A supplementation in India and vitamin A deficiency is still a public health problem. MHS treatise. Johns Hopkins School of Hygiene and Public Health, 1997.
61. Solon F, Latham MC, Guirrieo R, Florentino R, Williamson DF, Aguilar J. Fortification of MSG with vitamin A: The Philippine experience. Food Technol 1985; 39: 71–7.
62. Ong ASH. Nutritional aspects of palm oil: An introductory review. Asia Pacific J Clin Nutr 1994; 3: 201–206.
63. Hurrell RF. Preventing iron deficiency through food fortification. Nutr Rev 1997; 55: 210–222.
64. OMNI. Annual report: Project year 4. Opportunities for micronutrient interventions – a fully USAID funded Project managed by John Snow Inc. Arlington: JSI, 1997.
65. Tee ES, Cavalli-Sforza LT, Kandiah M *et al.* A study of the effectiveness of weekly iron supplementation in adolescent secondary schoolgirls in Malaysia: Preliminary findings [Abstracts]. 7th Asian Congress of Nutrition, 1995: 127.
66. Gross R, Angeles-Agdeppa I, Schultink WJ, Dillon D, Sastroamidjojo S. Daily versus weekly iron supplements: Programmatic and economic implications for Indonesia. Food Nutr Bull 1997; 18: 64–70.
67. Cavalli-Sforza LT, Rosnan A, de Boer AS, Darnton-Hill I. Nutritional aspects of changes in disease patterns in the Western Pacific Region. Bull World Health Organ 1996; 74: 307–318.
68. Darnton-Hill I, Coyne ET. Feast and famine: Socioeconomic disparities in global nutrition and health. Publ Health Nutr 1998; 1: 23–31.
69. ACC/SCN statement. Nepal. Administrative Coordinating Committee of the United Nations/Subcommittee on Nutrition. ACC/SCN. Geneva, 1997.
70. Huffman SL, Baker J, Shumann J, Zehner ER. The case for promoting multiple vitamin/mineral supplements for women in underdeveloped countries [Draft]. LINKAGES Project/USAID. AED/PSI. Washington, DC, 1998.
71. Suharno D, West CE, Muhilal. *et al.* Supplementation with vitamin A and iron for nutritional anaemia in pregnant women in West Java, Indonesia. Lancet 1993; 342: 1325–1328.
72. Benn CS, Aaby P, Bale C *et al.* Effect of vitamin A supplementation on antibody response to measles vaccine in Guinea-Bissau, West Africa. XVIII IVACG Meeting. Cairo, Egypt. Abstracts. 1997: 36.
73. Smitasiri S, Attig GA, Valyasevi A, Dhanamitta S, Tontisirin K. Social marketing vitamin A-rich foods in Thailand. UNICEF/Institute of Nutrition. Bangkok: Mahidol University, 1993.