Micronutrient malnutrition: Policies and programs for control and their implications

Source: Underwood B.A., and S. Smitasiri, 1999, Annual Review of Nutrition; Vol. 19; p. 303

ABSTRACT

Global progress in social and economic development is occurring, although slowly, in the most needy parts of the nonindustrialized world, where nutritional deficiencies, including micronutrients, remain significant public health problems. Until empowering benefits accrue from development spin-offs, policy guidance for purposeful public health actions can help reduce the unconscionable toll on health and quality of life from micronutrient malnutrition and can interrupt its intergenerational debilitating effects on national development. Narrowly focused control programs including homestead production, plant breeding, fortification, and supplementation are in effect, but in general, they have not been holistically planned and integrated into overall development programs. Such integration is needed to ensure sustainability into the next century. A new paradigm is needed, including a new way of thinking by nutrition scientists and program implementers that includes partnerships with the poor in all aspects of program planning and implementation.

KEY WORDS: iodine deficiency, iron deficiency, vitamin A deficiency, intervention programs, sustainable programs

INTRODUCTION

Micronutrient malnutrition from water-soluble vitamins (e.g. thiamin, riboflavin, and niacin) and minerals (e.g. iodine and fluorine), and from fat-soluble vitamins A and D, which was of concern in the Western World and Europe early in this century, has been virtually eliminated as a public health problem. Other problems (e.g. iron-deficiency anemia) are acceptably controlled. However, the developing world has yet to experience relief from the consequential effects of micronutrient malnutrition, particularly from lack of iodine, vitamin A, and iron, which are recognized global public health problems (99,102,103). It is likely that other micronutrient deficiencies are also highly prevalent, at least seasonally.

Policies and purposeful plans to eliminate or reduce the prevalence of micronutrient malnutrition emerged on a global scale following the 1990 World Summit for Children, the 1992 International Conference on Nutrition, and the 1996 World Food Summit. Over 159 countries and the European Union pledged to virtually eliminate iodine and vitamin A deficiencies by the year 2000 and reduce by one third the 1990 levels of iron deficiency anemia in pregnant women. Participants in these forums reiterated the need for societies to surmount the costs of malnutrition, especially when both scientific knowledge and realizable programs were available (2, 89).

Of the 108 World Health Organization (WHO) member states represented at the conferences, at least 53 with identified micronutrient problems have national nutrition plans of action that specifically address public health micronutrient issues (WHO global data bank: Implementation of the World Declaration and Plan of Action for Nutrition, 1997). In planning new actions, these states have followed advice from internationally generated documents (23, 79, 100, 104) and suggestions made by international consultants. Some countries reexamined their existing national plans and updated their policies in view of long-term goals. Global investment has provided support for assessment and interventions in countries with populations presumed deficient (2).

The objective of the 1990s micronutrient renaissance and its ensuing national policies is to speed progress toward achieving nutritional adequacy, a part of which is micronutrient adequacy. Early impact evaluations indicate variable rates of progress in micronutrient malnutrition control among nations (9 la). If the goal of the 1990s regarding micronutrients were achieved, the livelihood of 2-3 billion people would improve by the dawn of the twenty-first century, including that of an estimated 1.6 billion with iodine deficiency (IDD), 250 million with vitamin A deficiency (VAD), and 2 billion with iron deficiency (ID) (98). The goal for the year 2000 will not be met despite global progress that has occurred with regard to the rapid rate of IDD control, a lower rate of VAD, and an even lower rate of ID and its most severe manifestation of anemia (IDA) (91a).

This review discusses current issues facing micronutrient control programs and factors that have deterred progress and suggests turnkeys for reorienting policy decisions and programs toward incremental, but sustainable, elimination and control of micronutrient deficiencies.

RATIONALE FOR CONTROL POLICIES AND PROGRAMS

Consequences of Micronutrient Deficiencies for Human, Social, and Economic Development

Micronutrient deficiencies alter physiological functions before the deficiencies manifest clinically, and often the true consequences of diets habitually deficient in multiple micronutrients are underestimated. Subclinical forms of IDD, VAD, and ID that occur during fetal and early postnatal life affect physical growth and immunological and cognitive maturation in ways that may be irreversible. Subclinical deficiencies that occur later impede mental performance during the critical school years, impair work performance and earning capacity, reduce disease resistance, and increase risk of severe morbidity and premature death (90). This has impinging effects on the overall quality of life and subsequently slows national development (97a).

The World Bank notes that investment in programs to control micronutrient deficiency are among the most cost-effective of potential health interventions (97b). The Bank's evaluation has encouraged considerable investment in micronutrient interventions by international, bilateral, and other external groups. Yet health ministries in developing countries face multiple needs for their limited budgets. They must balance investment in interventions to control acute infectious disease, as well as micronutrient deficiencies, with long-term investments that will incrementally improve their population's health within a local environment that will smooth and sustain progress toward healthy living. Micronutrient and other intervention programs imposed without consideration of local needs and resources to sustain them can discourage the motivation of local leaders and consequently deter national progress.

Epidemiological Settings Where Micronutrient Problems Occur

The epidemiology of VAD and ID may vary country-wise but bears an overall similar pattern. These deficiencies are mostly prevalent amid poverty, environmental deprivation, and social disparity (76, 88). They take their greatest toll on pregnant and lactating women, infants, and young children, whose needs are elevated to support rapid growth, overcome unphysiological losses from frequent infections, and overcome physiological losses associated with the woman's fertile years (91, 94).

The epidemiology of IDD differs from that of VAD and ID. It is an environmental problem that places the entire population in a given area at risk. Severe deficiency usually occurs in mountainous areas and in frequently flooded, low—lying interior planes where, over time, iodine has been washed out of the soil (32). Severe deficiency in fertile women increases their risk of bearing children with permanent mental and physical retardation (cretins), as well as less severely retarded, deficient, or mentally impaired children (78).

INTERVENTION PROGRAM APPROACHES

Issues in Program Approaches to Increase Dietary Quantity and Quality

National agricultural and animal husbandry policies commonly give priority to increased farm productivity. For impoverished countries lacking food, these policies favor the production of calorie-dense cereals and tubers over micronutrient-rich fruits and vegetables (14). However, maldistribution of bioavailable food sources at global and household levels (and even within households) is likely to account for most micronutrient malnutrition (91a). Many immediate and underlying factors can be identified as potential causes for maldistribution, but those that determine local community and household access to micronutrient-dense foods are most amenable to interventions likely to eliminate VAD and contribute to control of IDA in a sustained manner (8, 10,48).

HOMESTEAD PRODUCTION Based on conventional bioavailability factors, empirical calculations of household production goals to attain micronutrient adequacy indicate that only small plots of land are needed to provide sufficient vitamin A (19, 46) and other micronutrients as well. Furthermore, young children can consume sufficient volumes of micronutrient-rich sources through complementary foods to maintain adequate vitamin A intakes (11, 61). Bioavailability factors from vegetable and fruit sources are now being reexamined and are likely to be modified (7); if so, the preceding calculations will be subject to revision. However, it is evident that when provitamin A sources are consumed regularly at least one to three times weekly, risk of xerophthalmia is reduced (76). This has encouraged several nongovernmental organizations (NGOs) to support local promotion of homestead gardening and, where possible, small animal husbandry (14).

Hesitance to invest public funds in large-scale homestead production for micronutrient control stems from questions regarding efficacy of vegetable sources, particularly leafy vegetables, in combating VAD and ID (96). A recent review dismissed, on the basis of flaws in the study design, the preponderance of supportive epidemiological evidence from 13 positive intervention studies with carotene-rich foods in 16 studies analyzed (16). Two of these studies involved carefully controlled feeding trials that failed to demonstrate biochemical improvement in blood levels of vitamin A or hemoglobin after feeding dark-green leafy vegetables (DGLV) to lactating women (17) or school children (6). Results from these studies were questioned for the following reasons: initial mean serum levels of the population were not notably low; there were heavy worm infections; there was inadequate dietary fat, which could have been limiting; and assessment through relatively insensitive, near—normal serum retinol levels could have masked improvements in whole-body vitamin A status (62). Report of these negative results, however, cast doubt on the expectations for correcting hypovitaminosis A through horticultural strategies (73).

Recent studies, however, provide direct evidence that dietary provitamin A sources can improve vitamin A status. A controlled provitamin A food intervention trial among lactating women in Vietnam resulted in improved serum retinol levels, although the increase was of lower magnitude from DGLV than from other carotenoid food sources (41). A carefully implemented, randomized controlled trial among preschool children in Indonesia reported improved blood levels after deworming when diets contained mixed provitamin A food sources and sufficient dietary fat (36). In addition, controlled feeding trials using isotope dilution to measure total body stores among Filipino (75) and Chinese (107) school children showed that fruit and vegetable diets improved serum levels of retinol and sustained adequate stores of vitamin A, even though a substantial increment in stores did not occur. Nevertheless, the controlled studies raise questions about currently used retinol equivalence from dietary provitamin A carotenoids as part of a meal. This has implications for global estimates of production adequacy (7) and for household estimates of amounts of varied types of vegetables and fruits needed to meet age- and gender-specific requirements (61).

Evaluations of efficiency under program conditions, in addition to efficacy in correcting the problem, are needed for battle-scarred investors of donor and public funds to channel large amounts toward community/homestead horticultural interventions. Biological-impact evaluations are rarely built into large-scale gardening-project designs because of their high cost and requirements for rigorous control to establish cause-effect links. Recently, the NGO-supported household production program in Bangladesh (81), which began on a limited scale and gradually expanded with success (28), reported population-based quantitative evidence of increased intakes of vitamin A-containing foods. This occurred among women and children from participating households who experienced reduction in night blindness and an increase in serum retinol levels (44). Proximity of gardens to the household and diversity of food sources were crucial (6). Participation of small farmers in all phases of program planning, implementation, and evaluation was instrumental in sustaining commitment to homestead production in India (52). Follow-up evaluation of the previously reported successful community promotion of ivy gourd (an inexpensive provitamin A-rich DGLV) in Thailand (71, 68) demonstrated improved status and sustained desirable food-intake behaviors (72). The cited studies and in those from the Philippines (19) strongly link successful household production to supportive, community-based technical assistance (e.g. availability of highquality seeds, fencing, and access to extension-worker advice). Additionally, local government, private sectors, school children and their mothers, and even national and community entertainment figures were actively engaged in creating partnerships to empower the poor to solve their food-based problems (71, 77).

PLANT BREEDING FOR MICRONUTRIENT ENRICHMENT OF DIETARY STAPLES As noted above, national agricultural policies in food-deficient countries are usually oriented toward increased farm productivity of energy-dense staples rather than of micronutrient-rich vegetable crops. In the mid-1990s, plant—breeding research was thus proposed (27) to combine favorable agronomic and nutritional characteristics into cultivars of cereals and other food staples (27), and now this approach is being pursued in several centers of the Consultative Group on International Agricultural Research (CGIAR) (8). The initiative is not based on the premise that enrichment of staple crops can correct existing endemic micronutrient deficiencies. It is based on the fact that once established, it could make a substantial contribution to long-term maintenance of micronutrient adequacy (64).

Most research and development (R&D) work to date has focused on screening rice, wheat, maize, beans, and cassava for iron-, zinc-, and beta-carotene—enriched, high-yielding cultivars (12), and on determining favorable agronomic characteristics (26). Cassava with high carotene content in roots and leaves supports optimistic calculations of the potential for a substantial contribution to micronutrient sufficiency, as well as for caloric adequacy. At the high end (105 mg of beta-carotene/100 g of fresh leaves), as little as 5 g of fresh leaves (2 g of dry leaf flour) would supply an adult male with the daily requirements of vitamin A (i.e. 3-4 mg) or a comparable amount of carotene-dense cassava roots of 200 g (12). Germ plasm screening has also uncovered high-yielding varieties of rice with twice the usual iron and zinc content. These varieties are being evaluated for agronomic advantages of mineral-dense seeds, bioavailability of the additional nutrients in the seed, and the nutritional implications of milling, parboiling, preparation, and cooking (65).

Before seeds with optimal agronomic, nutritional, and organoleptic qualities are available to farmers, several years and substantial resources will be needed to complete the field work necessary for breeding, propagation, bioavailability, and consumer acceptance. Once achieved, however, the recurrent expenditure would be low compared with non-food-based strategies (8). An additional potential deterrent to turning the science of selective plant breeding toward practical situations could be the resistance of governments to developing supportive agricultural policies and financial security incentives that encourage farmers to take the necessary risks, and the resistance of consumers to providing the market demand for micronutrient-enriched dietary staples.

FORTIFICATION Central food fortification that was voluntary, regulated, or, in some cases, legislated provided sustainable control of micronutrient deficiencies in several industrialized countries for over half a century. In part, this sustained success was attributable to early publicizing of population-based research that showed impressive health benefits (e.g. reduction in goiter, pellagra, scurvy, and tooth decay), which sold the concept of fortification to a relatively educated public. Public demand, and hence a stable market for fortified products, was the sustained consequence (50).

Currently, food fortification is strongly advocated internationally as a costeffective intervention for the less-industrialized world. One attraction for supporters of fortification is that community involvement is minimized-an appealing top-down approach (21a). Also, central fortification is becoming increasingly feasible as the food industry develops and as centrally processed foods reach even rural markets (45). National policies supportive of micronutrient fortification have been adopted by some countries and are being considered in several others. Fortification, however, increases product price, albeit marginally. A conclusion reached in Guatemala was that the private sector must be allowed to recover costs, usually through markets rather than from government subsidies, to justify its long-term investments (58).

Cost, rather than humanitarian concern or personally experienced health benefits, can provide the breaking-point that determines choice for producers and poverty-stricken potential beneficiaries (18). The benefits of fortification, therefore, must be convincingly sold to nonsubsidized potential private producers, who risk markets and R&D-investment loss, and to the local undereducated public before fortified products are introduced. That is, involvement of the public-a bottom-up component-is necessary. Government policies that allow placement of a seal of approval on iodized salt, citizens' involvement in monitoring in countries such as India and Bolivia (31), and availability of vitamin A-fortified margarine in the Philippines, coupled to extensive social marketing campaigns (74), represent early attempts to reinforce market choice for fortified, versus unfortified, alternatives.

Country studies documenting health-related or nutritional benefits from appropriately fortified common foods such as sugar, which is fortified with vitamin A in Guatemala (3, 58), and cereal products fortified with iron in Venezuela (43), provide an ambience for creating consumer demand and accommodating producers and policymakers. The benefits from iodized salt engaging with consequent goiter and cretin reduction and increased urinary iodine levels, are well received globally, even in underdeveloped and isolated communities (2, 78, 93, 105).

Some international agencies promote country-level policies and legislation that require universal fortification of food vehicles in order to eliminate the confounding influence of choice, and therefore the need to educate the recipients in making wise food selections. Such legislation may be helpful, but it is unwise to conclude that social marketing to create demand is not necessary to sustain fortification programs in less-developed countries, even though the levels of education among the population are limited (31, 50,102).

Darnton-Hill (15) summarized important lessons learned from past and recent successful experiences with fortification: (a) government expression of political will, support, and willingness to legislate or regulate compliance; (b) private sector understanding and involvement starting at the early implementation stages; (c) willingness on the part of both government and the private sector to enforce quality-assurance programs; (d) public-sector support; and (e) reliable data on consumer patterns and social acceptability of the fortified food, which would imply no significantly undesirable organoleptic properties, and minimal change in cost. Added to this list should be a delivery system designed for the most vulnerable, who often are those hardest to reach. If coverage excludes these, fortification might still be effective in reaching the majority, if targeted support through alternative mechanisms reaches those left out (21). One underlying constraint is a basic conflict between the private sector's profit motivation and the public's willingness to pay for quality. Removing this constraint requires changing the perceptions and attitudes in both sectors.

Not all fortification attempts have been successful, particularly where overall progress in industrial development is slow. Vitamin A fortification of sugar in Guatemala, for example, was temporarily suspended because there was an economic downturn and an increase in international pricing of vitamin A for the premix. Government policy that subsidized some start-up costs had mandated private sector compliance without cost-recovery provisions. Termination of the subsidy for imported vitamin A rendered the program unenforceable among sugar producers, and evidence of VAD reappeared in Guatemala until restructuring occurred some 10 years later. The restructuring recognized that humanitarian goals must be appreciated by industry, and that the government must acknowledge that a stable market and profit margin are crucial to private industry participation (58). Early in 1998, the Guatemalan government, for political reasons, announced suspension of mandated sugar fortification, immediately creating an outcry not only from international groups but also internally. Because the public and private demand for the program had been created, the government quickly rescinded the decision (N Solomons, personal communication).

The efficacy of combating both VAD and ID using doubly fortified sugar, i.e. retinyl palmitate and NaFeEDTA, is reported for Guatemala (95), but the sugar industry has yet to voluntarily assume the additional cost of the fortificant required for double fortification by the national program. A new bioavailable amino acid chelate of iron (54), used to fortify sugar in Brazil and corn and wheat flours and whole milk elsewhere, is said to be a more cost-effective alternative (58). However, the biological factors that regulate absorption of this fortificant are not as fully understood as those regulating absorption from unchelated iron salts.

FOOD-TO-FOOD FORTIFICATION New thinking is emerging concerning fortification and enrichment. Fortification of a micronutrient-poor staple with a concentrated micronutrient-rich food is an underexplored strategy with household/ community-level income-generating and gender-empowering potential (91). Sun-dried fruits and vegetables seasonally available in surplus, or seasonal leafy vegetables dried and then made into inexpensive nutrient-concentrated leaf flours, could be readily incorporated into family soup pots or micronutrient—deficient traditional gruel for complementary and post-weaning diets of children (11). Some traditional household food preservation and preparation practices, such as fermentation (e.g. of fish, soya, and milk products), favor micronutrient retention or enhance bioavailability, particularly of iron, and are important components of a household food-to-food fortification strategy.

Use of Supplements to Increase Intake

LOW-DOSAGE, SINGLE-NUTRIENT SUPPLEMENTS Over-the-counter (i.e. safe—range dosages not requiring prescriptions) vitamin and mineral supplements have played a role in control of micronutrient deficiencies in industrialized countries. In the United States, such supplements are consumed daily by about 25% of the people, and occasionally during the year by 50% of the population (67). Supplements are a routine part of some public programs for low-income children in both the United States and the United Kingdom. Recent national surveys in these two countries do not identify micronutrient deficiencies of iodine and vitamin A as significant health problems, and iron-deficiency anemia (IDA) prevalence is much lower than in most developing countries, presumably due in part to the public and private accessibility of supplements. Unfortunately, in developing countries, suitable single or multinutrient low-dose supplement(s) that are safe and effective for the variable needs at vulnerable ages (6 months to 5 years) and physiological states (pregnancy and lactation) are as yet untested for delivery through community channels outside the health system. Efficiency of weekly delivery of iron pills for prevention of ID, perhaps through community channels, also awaits further experience to ensure compliance.

HIGH-DOSAGE, SINGLE-NUTRIENT SUPPLEMENTS In developing countries where endemic deficiencies of iodine, vitamin A, and iron exist, concentrated supplements are the most important facilitating weapons in combating acute clinical deficiency. Oral (or intramuscular) iodized oil concentrate, high—dose vitamin A, and iron pills-delivered annually, biannually, and by daily ingestion-are provided through ongoing, policy-supported programs in many countries (2). Coverage, however, varies widely by nutrient and country. Many countries have reduced their need for iodine supplements by successful universal salt iodization. To date, however, no country that has initially established large-scale vitamin A supplement distribution has fully replaced dependence on periodic supplements, or consequently on the need for their safe distribution by health workers (25, 87), although more resource-efficient and coverage—effective delivery mechanisms are now used (2, 92).

Iron pills and policies for their use during pregnancy have existed for years, but IDA continues to be the most common micronutrient deficiency on a global scale, and prevalence is not restricted to low-income countries. Supplementation policies for pregnant women exist in many countries but are ineffectively implemented. Lack of compliance at all levels in the health system as well as by potential beneficiaries, for reasons ranging from adequacy of supply and quality of pills to unpleasant side effects and forgetfulness, accounts for slow progress (79). It is not surprising that a mother laden with other critical demands would forget to take a one-a-day pill as part of her daily schedule. A weekly schedule could improve compliance but this would need verification under program conditions. In either case, clearly there is need for social marketing of the short- and long-term individual and societal benefits of prevention and treatment of ID, particularly IDA, among policy and program decision-makers, health workers, and potential beneficiaries.

Because there are such difficulties in overcoming bioavailability problems associated with less-expensive, culturally preferred cereal-based diets, reliance on iron pills is the only likely scenario for treatment of IDA, particularly in resource-poor countries and in countries where enteric and systemic parasitic infections are prominent (23, 79). Pending results from efficiency research in progress, moving from daily to weekly ingestion of iron pills with equivalent dose effectiveness, fewer side effects, and increased compliance may become a future preferred policy for preventive control (94). Publicizing health advantages to high-risk groups among health workers and beneficiaries will be critical in creating a receptive environment for compliance, particularly because mild side effects can be anticipated, such as a transient medicinal taste after ingestion and darkened stools. The former can be troublesome to anemic women who are already suffering from nausea accompanying pregnancy, but for whom the supplement is very important.

One recently completed project in Thailand successfully improved the iron status of women of reproductive age by empowering a core group of community women to go house-to-house selling one-month supplies of iron tablets for weekly consumption. Iron supplements are inexpensive even when a small profit incentive to the seller is allowed (in this case, four pills for about $0.25). Demand was created among the women and adolescents who participated by the improvement in their sense of well-being. Among adolescent schoolgirls, the benefit was borne out by a documented rise in hemoglobin and ferritin levels. Following the initial house-to-house program, older women willingly went to a central community location and continued to purchase the supplements (S Dhanamitta, personal communication).

MULTIPLE VITAM[N/MINERAL SUPPLEMENTS Some argue that supplement distribution should not be characterized as a short-term intervention in developing countries, using as examples the continued public distributions that occur today as part of welfare programs in some developed countries. Furthermore, evidence is growing that in many countries, malnutrition with significant health consequences extends to zinc, vitamins C and D, folate, riboflavin, selenium, and calcium (2), well beyond the three micronutrients to which so much attention is now given. The argument is that supplements are cheap, help overcome obstacles to bioavailability from food sources, and can be tailored to include multiple micronutrients that might be in short supply. The argument is valid where a safe, effective, and frequently taken low-dose (e.g. daily or weekly) supplement could be ensured via bulk delivery to households or community—level outlets. However, there are technical problems in producing inexpensive, stable, multiple vitamin/mineral supplements, especially in incorporating such prooxidant nutrients as iron and iodine with oxidation-sensitive vitamin A. It is technically possible, but at prohibitive costs, to sustain public distribution in most developing countries.

Currently, intensive efforts to reach the goals set for the year 2000 to eliminate and reduce micronutrient malnutrition have channeled resources toward heavy reliance on supplement delivery (2). Policy makers in developing countries, faced with subclinical deficiencies of VAD and ID, must determine whether to rely on high-dosage supplements for sustainable control. It is unlikely that supplement distribution is sustainable, given the health budgets projected for the decade following the year 2000, when interest by international donors is likely to decline. Concern is increasingly expressed as to what achievements of this decade can be sustained into the next century. Undoubtedly, well-targeted supplements will be needed for treatment, as will iron supplements as a preventive measure, to achieve affordable, lasting public health goals.

SUSTAINABLE PROGRAMS FOR MICRONUTRIENT ADEQUACY: KEY ISSUES AND TURNKEYS

A Historical Perspective

Community and household food production were widely promoted and supported in the 1960s as components of applied nutrition programs (ANPs). ANPs focused primarily on reduction of protein-energy malnutrition (PEM)-not on micronutrients-through a series of technical interventions. After several years of implementation, the overall evaluation of the ANPs was that PEM was not reduced (106). The consequence of this evaluation was a cutback in funding for ANP-type activities in favor of focusing on economic development and reliance on a trickle-down effect to influence communities and households. This hypothesis was abandoned when accumulated data revealed that the buck stopped at the top and gave rise to the Primary Health Care (PHC) approach, which represented a new conceptual framework for health and nutrition. Integration was the theme, together with self-reliance and empowerment of the poor, as presented in the Alma Ata declaration of 1978 (101). Implementation of the integrated approach proved to be difficult and slow and caused UNICEF to promote a more focused path in its child survival program, GOBI (growth monitoring, oral rehydration, breastfeeding, and immunizations), which underwent expansion with the addition of family planning and female literacy (GOBI + FF). The global Joint WHO-UNICEF Nutrition Support Programme (JNSP) grew out of commitments at Alma Ata to implement activities that bore directly on the nutritional status of mothers and young children, stressed community participation and empowerment, and at the agency level emphasized day-to-day WHO/UNICEF collaboration (106). Evaluation of the program some years later questioned the success of this project. Nonetheless, household food security (i.e. access to a nutritionally adequate diet), not just the aggregate available food supply, is generally acknowledged to be key to improving family nutrition, and homestead production can substantially contribute to food and nutrition security goals for micronutrients (8, 28, 46).

A New Paradigm for Public Nutrition Programs

The causes of micronutrient malnutrition-like most issues in nutrition-are complex and context-oriented, as well as dynamic in nature (59). To be successful in development of sustainable nutrition programs, including micronutrient improvement, both relevant scientific knowledge and the art of practice are necessary (47). Sustained resolution of micronutrient malnutrition is unlikely through narrowly focused, nutrient-specific public health policies and action programs. Furthermore, policies that bypass at least some level of individual and community participation are unlikely to lead to sustained desirable behavior changes. Apparently simple, specific solutions as reviewed above will need to be recast within a larger development context that incorporates lessons learned from past nutrition programming experiences (80). This will necessitate a new way of thinking among nutrition scientists, policy and program planners, and implementers at all levels to create a closer link between knowledge and knowledge implementation.

The current usual paradigm of food, nutrition, and health institutions must change from a vertical approach to a holistic, flexible, systems approach (13, 29, 37) that includes empowering communities to be involved, as well as monitoring and adjusting the system to the dynamics of local changes (68, 86). UNICEF provided the well-publicized three-tiered conceptual framework for determining causes of nutritional problems-immediate, underlying, and basic factors (39). Recently, Bloem et al (6) applied the model to causes of VAD and suggested entry points for solutions. Howsen et al (35) conceptualized a toolkit for policy makers and health workers to deal with the variation in severity of IDD, ID, and VAD in a dynamic way, as nations and populations move along the continuum from severe, to moderate, to mild and widespread, to mild and clustered deficiencies (35). Mason et al (47) advocates labeling those aspects, excluding laboratory and clinical activities, as public nutrition (47). Combs et al (13,14) broadened the concept to include the interrelationships between food-systems technologies and human health.

In pursuing overall holistic systems approaches, the local context into which the program-system must fit must be understood. It should be viewed as a complete, self-adjusting cycle, progressively moving local situations forward on the continuum toward food and nutrition adequacy (86). In the past, intervention designs were commonly created by outsiders who did not adequately appreciate or have knowledge of local infrastructures and dynamic interrelationships. Participation of local partners from sectors outside the obvious ones of health and agriculture systems was limited (24). In the process of holistic and integrated policy and program planning, however, it is important that the vision of policy and program makers not be clouded by the complexity of local details (see below). Past attempts (noted above) to implement integrated nutrition programming approaches proved to be difficult and slow, causing some organizations to promote more linear programmatic paths (106).

The new paradigm calls for effective participation of actors and players who are able to recognize within these complex systems the entry point(s) that will critically impact the total system and move it toward community-reliant sustained improvements (66). For example, in Thailand, the commonly available green leafy vegetable known as ivy gourd was strategically selected as an entry point for change in the consumption of vitamin A-rich foods, because if this strategy worked, the poor could produce the vegetable without support from others (71). There was no need to provide seeds, and little additional technical know-how was needed to improve production. The project was planned with the belief that in the achievement of a small success, the participants would develop more self-confidence and be prepared to advance to the next steps. The project strategy, therefore, did not require unnecessary initial effort from participants. Rather, it focused on gradually increasing capacity to participate in expanding the community development process (71, 68). This progression from focusing on one specific micronutrient-rich plant to a general category of micronutrient-rich foods is cited because the classical belief is that one must start from the general (56).

Empowering the Poor, Especially Women

Successful processes need to be embedded into an enduring community development context as society progresses into the next century. Lessons learned from successful interventions in developing countries indicate that sustainable solutions are attainable only if all stakeholders are successfully engaged in partnerships that include the poor (24, 35a, 97). The poor, often seen as passive recipients or beneficiaries, can, in fact, become key actors in their own development if they have adequate access to resources, especially to information (37). Empowering the poor means they must be allowed and encouraged to participate in the development process, from which community empowerment follows. Outside development agencies should only work as partner organizations if sustained development is desired (80).

Women in the developing world account for more than half the labor pool required to produce the food consumed (20). They are also the main providers of nutrition for their families, for whom they often sacrifice their own nutritional well-being (33). In South Asia, for example, the shortage of private income and health services, low literacy among females, and fewer opportunities for women to participate in the market economy, as well as aspects of Asian culture with respect to the status and treatment of women, are all important factors in shaping the nutritional status of the population (55). Successful food and nutrition interventions indicate that women's active participation is critical to sustainable progress (60). For women to improve their participation in nutrition interventions, they must have access to the necessary means of production and to intellectual and nutritional resources to solve their own problems. An analysis of the roles of women must be made in order to address nutrition problems in developing countries, and the findings should be specifically included as guides in the formulation of policy (49).

Social Mobilization, Participation, and Commitment Building

In successful and sustainable programs, social mobilization, participation, and commitment building (SMPCB) are essential factors (5, 24, 40, 86). From policy makers to villagers, program approaches must be perceived as economically feasible, politically and socially acceptable, and administratively and technically possible within the setting for which they are meant (51). Approaches that are designed to be contextually appropriate are thus crucial (38). Nevertheless, well-planned approaches by themselves do not automatically initiate SMPCB; facilitating processes need to be created (53). The identification of partners, definition of a mutual agreement, or the formation of a network to develop a shared agenda for improving the micronutrient situation are good starting points to create supportive environments for change (30). SMPCB work should be active not only before and during the intervention but also subsequently, to ensure that the program approach will be integrated into the overall development policies (68, 80).

Proactive Nutrition Education and Communication

To achieve lasting micronutrient adequacy, the target populations must be assisted in acquiring the appropriate knowledge base and attitudes for adjusting both personal and environmental factors in ways that facilitate changed behaviors (4). Providing information, education, and communication (IEC) is one mechanism for stimulating SMPCB and leading toward sustainable change in public nutrition programs. In other words, nutrition education and communication for behavior change, i.e. social marketing, must be tailored to influence actors and players in the entire system-from policy makers to villagers-to think and behave in ways that will improve nutrition (5).

Evaluation of past experiences with IEC approaches indicates some successes, but overall, outcomes have been unsatisfactory; they have not brought about sustained changes in practices. The primary reason identified lies in the fact that the IEC material placed mistaken emphasis on acquisition of general nutrition knowledge and should have focused on a comprehension for behavior-centered actions as the first step to better nutrition (5, 34, 56, 57, 68). Limited success in nutrition education has been attributed to insufficient investment in this approach (5, 34, 68). Donors and other partners participating in micronutrient initiatives should reconsider the cost-effectiveness of investing in comprehensive and systemic mechanisms for stimulating changes through SMPCB and for supporting IEC developed approaches based on the process.

Potential for Change

Unfortunately, policies and programs are usually designed based only on the problems to be solved, and much less emphasis is given to understanding the nature of the problems and those components amenable to change that are also sustainable considering the range of potentially lasting solutions. Consequently, many programs are targeted to the most difficult situations with the least potential for change, unless quick-fix approaches are applied. Campaign-type approaches often require more input (for example, manpower) to achieve desirable changes during a limited program period, and they draw resources away from the initiation of lasting solutions. The consequence is that most quick—fix programs cannot be sustained by local communities beyond the program period. A critical assessment of potential for change in a given context needs significant investment, but this investment is necessary for the development of sustainable programs. A situation-specific assessment, along with science—based information about efficacy and program efficiency of the intervention strategy, including the capacity of the management bodies in the intervention system, must be used in designing and making program decisions. Decisions to implement programs in contexts where potential for change is more favorable can be a more strategic way to create models that can be used to promote further changes through community and social learning processes.

Management and Evaluation

Strong management is critical for the success of nutrition and public health programs (42, 63). Management needs to retain interest in continuously contributing to the program, to be aware of what needs to be done in order to best use program resources to reach expected outcomes, and to create opportunities for integration with other mainstream development activities (68, 70). The more management becomes a participatory management, the greater the likelihood of sustainability (80).

A successful program is a prerequisite for a sustainable program. Valid and reliable evaluation data are needed to evaluate a program's success, justifying investment in monitoring and evaluation methodologies at appropriate intervals. Both outcomes and processes should be monitored and evaluated with appropriate sets of indicators. Quantitative as well as qualitative evaluation methodologies should be applied. Evaluation should not only provide answers to whether and why a program works; it should also identify key program factors that could lead to program sustainability (68, 69).

Capacity Building

Technically speaking, implementing micronutrients for healthier populations is an eminently doable proposition because basic scientific knowledge is available for initiating good programs anywhere in the world (22). The micronutrient renaissance of this decade has, in fact, produced improvements to be proud of in the world populations. Nevertheless, the challenge of the millennium is to bridge the previous successes to more sustainable changes (89). For this, it is necessary to involve people in the target system not as recipients but more as partners in development. The work will, consequently, be more complicated and demanding. Quality staff will be necessary if programs require promoting change in people (5). Specific characteristics needed by the agents of change are an ability to think strategically, an understanding of the population, talent and creativity, knowledge of technology, the ability to interact with others, a willingness to listen to all involved, a desire to make a healthy difference, and being knowledgeable with regard to related issues (68). Priority should be directed toward developing program management skills and building an effective implementation process (63, 70) through broad-based training in nutrition (22). The capacity to develop at various levels more innovative nutrition scientists, policy and program planners, and implementers is urgently needed in order to ensure that collaborative efforts in public nutrition programs really contribute toward micronutrient adequacy in the future (5).

CONCLUSIONS

This review focused on policy and program efforts to control harmful conditions associated with iodine, vitamin A, and iron deficiencies. The complexity of causative factors in developing countries negates sustained resolution of micronutrient malnutrition through narrowly focused, nutrient-specific public health policies and action programs. Holistic planning and systematic implementation that integrate into short- and long-term strategies adapted to the local causative context and the level of resource available are necessary.

Partnerships for micronutrient adequacy at all levels are critical if sustained control is the goal. Therefore, it is unlikely that establishing policies that bypass individual and community participation will lead to significant, long-term desirable changes. The process leading to micronutrient adequacy must enable changes in people's perceptions, motivations, and behaviors regarding lifestyle and diet. Technically focused interventions that ignore empowerment processes and neglect a careful analysis of constraints and potential for change in the local contexts will not help developing countries sustain micronutrient improvement.

Visit the Annual Reviews home page at **Fehler! Verweisquelle konnte nicht gefunden werden.**

Literature Cited

See Ref. 91a

Alnwick DJ. 1998. Combating micronutrient deficiencies: problems and perspectives. Proc. Nutr. Soc. 57:13747

Arroyave G, Aguilar JR, Flores M, Guzman MA. 1979. Evaluation of Sugar Fortification with Vitamin A at the National LeveL Sci. PubL No. 384. Washington, DC: Pan Am. Health Org. 82 pp.

Bandura A. 19x6. Social buntatons of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice Hall. 617 pp.

Berg A. 1993. More resources for nutrition education: strengthening the case. J. Nutr. Educ. 25:278-82 Bloem MW, de Pee S, Darnton-Hill I. 1997. Vitamin A deficiency in India, Bangladesh and Nepal. In Malnutrition in South Asia. A Regional Profile, pp. 12544. Kathmandu, Nepal: UNICEF Reg. Off. South Asia

Bloem MW, Huq N, Gorstein J, Burger S, Kahn T, et al. 1996. Production of fruits and vegetables on the homestead is an important source of vitamin A among women in rural Bangladesh. Eur. J. Clin. Nutr. 50(Suppl. 3):S62-67 Bouis H. 1996. Enrichment of food staples through plant breeding: a new strategy for fighting micronutrient malnutrition. Nutr. Rev. 54:131-37 Bouis HE. 1991. Dietary patterns, income and food prices: an analysis of micronutrient intakes for Philippine farm households. SCN News 7:23-25

10. Bouis HE, Novenario-Reese MJG. 1997. The determinants of demand for micronutrients: an analysis of rural households in Bangladesh. Food Consumption and Nutrition Division Discuss. Pap. No. 12. Presented at Int. Food Policy Res. Inst., Washington, DC. 85 pp.

11. Brown K, Dewey K, Allen L. 1998. Proteins and micronutrients required from complementary foods. In Complementary Feeding of Young Children in Developing Countries: A Review of Current Scientific Knowledge, 4:79-108. Geneva: WHO. 228 pp.

12. Consult. Group Int. Agric. Res. Micronutr. Proj. 1996. Update No. 1. 1997.

Update No. 2. Washington, DC: Int. Food Policy Res. Inst.

13. Combs GF Jr, Duxbury JM, Welch RM. 1997. Food systems for improved health: linking agricultural production and human nutrition. Eur. J. Clin. Nutr. 51:S3233

14. Combs GF Jr, Welch RM, Duxbury JM, Uphoff NT, Nesheim MC, eds. 1996. Food-Based Approaches to Preventing Micronutrient Malnutrition: An International Research Agenda. Summary Report of an International Workshop. Ithaca, NY: Cornell Univ. 67 pp.

15. Darnton-Hill I. 1998. Overview: rationale and elements of a successful food—fortification programme. UNU Food Nutr Bull.19:92-100

16. de Pee S, West CE. 1996. Dietary carotenoids and their role in combating vitamin A deficiency: a review of the literature. Eur J. Clin. Nutr. 50:S38-53 17. de Pee S, West CE, Muhilal, Karyadi D, Hautvast JGAJ. 1995. Lack of improvement in vitamin A status with increased consumption of dark-green leafy venetables. Lancet 346:75-81

18. Florentino RF, Pedro MRA. 1998. Update on rice fortification in the Philippines. UNU Food Nutr. Bull. 19:14953

19. Florentino RF, Pedro MRA, Candelaria LV, Ungson BD, Zarate RU Jr, et al. 1993. An Evaluation of the Impact of Home Gardening on the Consumption of Vitamin A and Iron Among Preschool Children. Rep. No. IN-17. Vitamin A Field Support Project (VITAL). Arlington, VA: Int. Sci. Technol. Inst. 52 pp.

20. Food Agric. Org. 1991. Women and Agriculture Developing. Women in Agriculture Ser No. 4. Rome: FAO. 30 pp. 21. Food Agric. Org. 1998. Guidelines for national food insecurity and vulnerability information and mapping systems (FIVIMS): background and principles. Comm. World Food Secur, 24th Sess., Rome, 2-5 June. 32 pp.

21a. Forum Food Fortif., Int. Dialogue Micronutr. Malnutr. 1996. Sharing Risk and Reward. Public-Private Collaboration to Eliminate Micronutrient Malnutrition. Ottawa, Can.: Micronutr. Initiat. 57 pp.

22. Garza C, Haas JD, Habicht JP, Pelletier DL, eds. 1996. Beyond Nutritional Recommendations: Implementing Science for Healthier Populations. New York: Div. Nutr. Sci., Cornell Univ. 348 pp. 23. Gillespie S, Johnston JI, eds. 1998. Expert Consultation on Anemia Determi

nants and Interventions. Ottawa, Can.: Micronutr. Initiat. 37 pp. 24. Gillespie S, Mason J, Martorell R. 1996. How nutrition improves. ACC/SCN State Art Ser. Nutr Policy Discuss. Pap. No. 15. Presented at UN Admin. Comm. Coord., Subcomm. Nutr. 99 pp.

25. Gopalan C. 1998. Micronutrient malnutrition in SAARC-the need for a food—based approach. Bull. Nutr. Found. India 19:14

26. Graham RD, Senadhira D, Ortiz-Monasterio I. 1997. A strategy for breeding staple-food crops with high micronutrient density. Soil Sci. Plant Nutr. 43:115357

27. Graham RD, Welch RM. 1996. Breeding for Staple Food Crops With High Micronutrient Density. Work. Pap. Agric. Strateg. Micronutr., No. 3. Washington, DC: Int. Food Policy Res.

Inst. 79 pp. 28. Greiner T, Mitra SN. 1996. Evaluation of the impact of a food-based approach to solving vitamin A deficiency in Bangladesh. UNU Food Nutr. Bull.17: 183-205

29. Habicht JP, Pelletier DL, Garza C. 1996. The integration of scientific knowledge for effective action. See Ref. 30, pp. 31119

30. Haglund BJA, Pettersson B, Finer D, Tillgren P, eds. 1996. Creating Supportive Environments for Health. Stories from Third International Conference on Health Promotion, Sundsvall, Sweden. Geneva: WHO. 201 pp.

31. Haxton DR 1996. The process of communicating the message. In S.O.S. for a Billion, ed. BS Hetzel, CS Pandav, 9:163-76. Delhi: Oxford Univ. Press. 466 pp. 32. Hetzel BS. 1996. S.O.S. for a billion-the nature and magnitude of the iodine deficiency disorders. See Ref. 31, pp. 3-29 33. Holmboe-Ottesen G, Mascarenhas O, Wandel M. 1988. Women's role in food production and nutrition: implications for their quality of life. UNU Food Nutr. Bull. 10:8-26

34. Hornik RC. 1985. Nutrition Education. ACC/SCN State of the Art Ser Nutr. Policy Pap. No. 1. Geneva: ACC/SCN 35. Howsen CP, Kennedy ET, Horwitz A, eds. 1998. Prevention of Micronutrient Deficiencies. Tools for Policymakers and Public Health Workers. Washington, DC: Natl. Acad. Sci. 207 pp. 35a. Indep. Task Force Community Action Soc. Dev. 1995. Partnerships for Social Development: A Casebook. Franklin, WV: Future Generations. 128 pp. 36. Jalal F, Nesheim MC, Agus Z, Sanjur D,

Habicht JP. 1998. Serum retinol concentrations in children are affected by food sources of /-carotene, fat intake, and anthelmintic drug treatment. Am. J. Clin. Nutr. 68:623-29

37. Jonsson U. 1991. Community-based development-from a programme towards a movement. SCN News 7:15-22 38. Jonsson U. 1995. Success factors in community-based nutrition oriented programmes and projects. Presented at ICN Followup Meet., Nov., New Delhi 39. Jonsson U. 1997. Malnutrition in South Asia. In Nutrition and Poverty. Pap. ACC/SCN 24th Sess. Symp., Kathmandu, March. ACC/SCN Symp. Rep., Nutr. Policy Pap. No. 16, pp. 53-68.. Geneva: ACC/ SCN. 103 pp.

40. Kachondham Y, Winichgoon P, Attig GA, Tontisirin K. 1992. Reflections on Thailand's food and nutrition situation. See Ref. 97, pp. 227-31

41. Khan NC, West CE, de Pee S, Khoi HH. 1997. Comparison of the effectiveness of carotenoids from dark-green leafy vegetables and yellow and orange fruits in improving vitamin A status of breastfeeding women in Vietnam. In Sustainable Control of Vitamin A Deficiency. Defining Progress Through Assessment, Surveillance, Evaluation. Rep. XVIII Int. Vitamin A Consult. Group Meet., Cairo, Egypt, pp. 54, 92. Washington, DC: ILSI. 139 PP.

42. Kotler P, Roberto EL. 1989. Social Marketing: Strategies for Changing Public Behavior. New York: Free. 401 pp. 43. Layrisse M, Ch5vez JF, Mendez—Castellano H, Bosch V, Tropper E, et al. 1996. Early response to the effect of iron fortification in the Venezuelan population. Am. J. Clin. Nutr 64:972-73 44. Longanathan R, Huq N, Burger S, Krwan MFA, Hye A, et al. 1997. Consumption of green leafy vegetables among children from households with homestead gardens in rural Bangladesh. In Sustainable Control of Vitamin A Deficiency. Defining Progress Through Assessment, Surveillance, Evaluation. Rep. XVIII Int. Vitamin A Consult. Group Meet., Cairo, Egypt, pp. 51, 91. Washington, DC: ILSI. 139 pp.

45. Lotfi M, Mannar MGV, Merx RJHM, Naber-van den Heuvel P 1996. Micronutrient Fortification of Foods: Current Practices, Research and Opportunities. Ottawa/Ontario, Can.: Micronutr. Initiat. 107 pp.

46. Marsh RR. 1995. Household food security through home gardening. Evidence from Bangladesh and Central America.

Presented at Rockefeller Found. Bienn. Meet. Soc. Sci. Res. Fellows, ILCA, Nov. 1994, Addis Ababa, Ethiopia

47. Mason J, Habicht JP, Greaves JP, Jonsson U, Kevany J, et al. 1996. Public nutrition. Am. J. Clin. Nutr. 63:399400 48. Maxwell D. 1998. The Political Economy of Urban Food Security in Sub-Saharan Africa. Food Consumption and Nutrition Division Discuss. Pap. No. 41. Washington, DC: Int. Food Policy Res. Inst. 63 PP

McGiuire .IS, ‘opkn BM. 1990. Helping Women Improve Nutrition in the Developing World: Beating the Zero Sum Game. World Bank Tech. Pap. No. 114. Washington, DC: World Bank. 61 pp. 50. Mertz W. 1997. Food fortification in the United States. Nutr. Rev. 55:4449 Milio N. 1996. Case studies in nutrition policy making: how process shapes product. See Ref. 22, pp. 269-89 52. Niture SK, Joshi RN. 1997. Conservation of carotene in harvested vegetables. In Sustainable Control of Vitamin A Deficiency. Defining Progress Through Assessment, Surveillance, Evaluation, Rep. XVIII Int. Vitamin A Consult. Group Meet., Cairo, Egypt, pp. 52, 92. Washington, DC: ILSI. 139 pp.

53. Norum KR, Johansson L, Botten G, Bjorneboe GE, Oshaug A. 1997. Nutrition and food policy in Norway: effects on reduction of coronary heart disease. Nutr. Rev. 55:S32-39

54. Olivares M, Pizarro F, Pineda O, Name JJ, Hertrampt E, Walter T. 1997. Milk inhibits and ascorbic acid favors ferrous bisglycine chelate bioavailability in humans. J. Nutr.127:1407-11

55. Osmani SR. 1997. Poverty and nutrition in South Asia. In Nutrition and Poverty. Pap. ACC/SCN 24th Sess. Symp., Kathmandu, March. ACC/SCN Symp. Rep., Nutr. Policy Pap. No. 16, pp. 23-51. Geneva: ACC/SCN. 103 pp.

56. Parlato M, Green C, Fishman C. 1992. Communication to improve nutrition behavior: the challenge of motivating the audience to act. Prepared for Div. Food Nutr. Policy/Food Agric. Org. Int. Conf. Nutr. Rome: FAO. 42 pp.

57. Parlato M, Seidel R, eds. 1998. LargeScale Application of Nutrition Behavior Change Approaches: Lessons from West Africa. Arlington, VA: Basic Support Inst. Child Surv. (BASICS). 43 pp. 58. Pineda O. 1998. Fortification of sugar with vitamin A. UNU Food Nutr Bull. 19:131-36

59. Pinstrup-Andersen P.1991. Targeted nu

trition interventions. UNU Food Nutr. Bull. 13:161-69

60. Quisumbing A, Brown L, Feldstein H, Haddad L, Pena C. 1996. IFPRI policy statement, women: the key to food security. UNU Food Nutr. Bull. 17:79-81 61. Rahman MM, Mahalanabis D, Islam MA, Biswas E. 1993. Can infants and young children eat enough green leafy vegetables from a single traditional meal to meet their daily vitamin A requirements? Eur. J. Clin. Nutr. 47:68-72

62. Reddy V, Underwood BA, de Pee S, West CE, Muhilal, Karyadi D, Hautvast JGAJ. 1995. Vitamin A status and dark green leafy vegetables. (Letters to the Editor) Lancet 346:1634-36

63. Roberto EL. 1992. Changing health and nutrition behavior: a social marketing view. In Frontier of Nutrition and Food Security in Asia, Africa and Latin America, ed. NG Kotler, pp. 74-94. Washington, DC: Smithson. Inst./Int. Life Sci. Inst. 171 pp.

64. Ruel MT, Bouis HE. 1998. Plant breeding: a long-term strategy for the control of zinc deficiency in vulnerable populations. Am. J. Clin. Nutr. 68(Suppl.):S488-94 65. Senadhira D, Gregorio GB, Graham RD. 1998. Breeding iron and zinc-dense content of rice. Presented at Int. Workshop Micronutr. Enhancement Rice Dev. Countries, Sept. 3, Rice Res. Ext. Cent., Stuttgart, AR

66. Senge PM. 1990. The Fifth Discipline. The Art and Practice of the Learning Organization. New York: Current Doubleday. 423 pp.

67. Slesinski MJ, Subar AF, Kahle LL. 1995. Trends in use of vitamin and mineral supplements in the United States: the 1987 and 1992 national health interview surveys. J. Am. Diet. Assoc. 95:921-23 68. Smitasiri S. 1994. Nutri-Action Analysis: Going Beyond Good People andAdequate Resources. Salaya, Thailand: Inst. Nutr., Mahidol Univ. 200 pp.

69. Smitasiri S. 1994. Advocating a Multidimensional Evaluation Approach for Comprehensive Nutrition Communication Programs. INMU Spec. Publ. Ser. No. 1. Salaya: Inst. Nutr., Mahidol Univ./ Bangkok: UNICEF East Asia/Pac. Reg. Off. 18 pp.

70. Smitasiri S.1996. On planning and implementing vitamin A interventions: linking scientific knowledge to effective action. See Ref. 22, pp. 203-22

71. Smitasiri S, Attig BA, Dhanamitta S. 1992. Participatory actions for nutrition education: social marketing vitamin

A-rich foods in Thailand. Ecol. Food Nutr. 28:199-210

Smitasiri S, Sa-ngobwarchar K, Kongpunya P, Subsuwan C, Banjong O, et al. 1999. Sustaining behavior change to enhance micronutrient status through community and women-based interventions in Northeast Thailand: I. Vitamin A. UNU Food Nutr. Bull. In press Solomons NW, Bulux J. 1993. Plant sources of provitamin A and human nutriture. Nutr. Rev. 51:199-204 Solon FS. 1998. History of fortification of margarine with vitamin A in the Philippines. UNU Food Nutr. Bull. 19:154-58 Solon FS, Ribaya-Mercado JD, Perfecto CS, Cabal-Barza MA, Tang G, et al. 1998. Improvement in vitamin A status of malnourished schoolchildren with fruit and vegetable intakes. FASEB J. 12:A841 (Abstr.4

76. Sommer A, West K. 1996. Epidemiology of deficiency. In Vitamin A Deficiency: Health, Survival, and Vision, ed. A Sommer, K West, 12:335-54. New York/ Oxford: Oxford Univ. Press. 438 pp. 77. South and East Asia Nutr. Res.-cumAction Netw. Empowering Vitamin A Foods. A Food-Based Process for the Asia and Pacific Region. Bangkok: FAO Reg. Off. Asia Pac./Salaya: Inst. Nutr., Mahidol Univ. 125 pp.

78. Stanbury JB. 1998. Prevention of iodine

deficiency. See Ref. 35, pp. 167-201 79. Stoltzfus R, Dreyfuss ML. 1998. Guidelines for the Use of Iron Supplements to Prevent and Treat Iron Deficiency Anemia. Washington, DC: II.SI. 39 pp. 80. Strachan P, Peters C. 1997. Empowering Communities: A Casebook from West Sudan. Oxford, UK: Oxfam. 88 pp.

81. Talukder A, Khan TA, Baker SK, Zakaria AKM, Bloem MW, Kiess LK. 1997. Home Gardening Activities in Bangladesh. Mapping Report and Inventory. Dhaka, Bangladesh: Helen Keller Int. 127 pp. 82. See 21a 83. See 35a 84. See 97b 85. See 97a

86. Underwood BA. 1983. Some elements of successful nutrition intervention strategies. In Nutrition Intervention Strategies in National Development, ed. BA Underwood, 1:3-11. New York/London: Academic. 419 pp.

87. Underwood BA.1990. Vitamin A prophylaxis programs in developing countries: past experiences and future prospectives. Nutr. Rev. 48:265-74

88. Underwood BA. 1993. The epidemiology of vitamin A deficiency and depletion (hypovitaminosis A) as a public health problem. In Retinoids, ed. MA Livrea, L Packer, pp. 171-84. New York: Marcel Dekker. 648 pp.

89. Underwood BA. 1998. Micronutrient malnutrition. Is it being eliminated? Nutr. Today 33:121-29

90. Underwood BA. 1998. From research to global reality: the micronutrient story. J. Nutr 128:145-51

91. Underwood BA.1998. Prevention of vitamin A deficiency. See Ref. 35, pp.103-65 91a. UN Admin. Comm. Coord., Subcomm. Nutr. 1997. Micronutrients. In Third Report on the World Nutrition Situation, pp. 1940. Geneva: ACC/SCN. 111 pp. 92. UNICEF-Manila, Helen Keller Int. 1996. Sangkap Pinoy. The Philippine experience in massive micronutrient intervention. Manila: UNICEF. 48 pp. 93. Van der Haar F 1997..The challenge of the global elimination of iodine deficiency disorders. Eur. J. Clin. Nutr. 51(Suppl. 4):53-58

94. Viteri FE. 1998. Prevention of iron deficiency. See Ref. 35, pp. 45-102

95. Viteri FE, Alvarez E, Batres R, Torun B, Pineda 0, et al. 1995. Fortification of sugar with iron sodium ethylenediaminotetraacetate (FeNaEDTA) improves iron status in semirural Guatemalan populations. Am. J. Clin. Nutr. 61: 115343

96. West CE, Hautvast JGAJ. 1997. From ‘whither’ to ‘wither’ micronutrient malnutrition? Lancet 350(Suppl. 3):15 97. Winichgoon P, Kachondham Y, Attig GA, Tontisirin K, eds. 1992. Integrating Food and Nutrition Development: Thailand’s Experiences and Future Visions. Salaya, Thailand: Inst. Nutr., Mahidol Univ. 233 PP

97a. World Bank. 1994. Enriching Lives. Overcoming Vitamin A and Mineral Mal

nutrition in Developing Countries. Washington, DC: World Bank. 73 pp. 97b. World Development Report 1993. In Investing in Health, 4:82. Oxford, UK: Oxford Univ. Press. 329 pp.

98. WHO. 1992. National strategiesfor overcoming micronutrient malnutrition. 45th World Health Assem., Agenda Item 21, A45.17, 16 April

99. WHO. 1992. The Prevalence of Anaemia in Women: a Tabulation of Available Information. Geneva: WHO. 100 pp. 100. WHO. 1996. Indicators for Assessing Vitamin A Deficiency and Their Application in Monitoring and Evaluating Intervention Programmes. Geneva: WHO. 66 PP

101. WHO/UNICEF. 1978. Alma Ata Declaration. Geneva: WHO

102. WHO/UNICEF.1995. Global Prevalence of Vitamin A Deficiency. MDIS Work. Pap. No. 2. Geneva: WHO. 116 pp. 103. WHO/UNICEF/ICCIDD. 1993. Global Prevalence of Iodine Deficiency Disorders. MDIS Work. Pap. No. 1. Geneva: WHO. 80 pp.

104. WHO/UNICEF/ICCIDD. 1994. Indicators for Assessing Iodine Deficiency Disorders and Their Control Through Salt lodization. Geneva: WHO. 55 pp.

105. WHO/UNICEF/ICCIDD Jt. Consult. 1997. Review of Findings From 7-Country Study in Africa on Levels of Salt Iodization in Relation to Iodine Deficiency Disorders, Including Iodine-Induced Hyperthyroidism. Geneva: WHO. 44 pp. 106. WHO-UNICEF Jt. Nutr. Support Programme. 1991. Global Evaluation, Vol.1. Rome: Int. Course Primary Health Care Managers Dist. Level Dev. Countries. 155 pp.

107. Yin S, Oin J, Gu SF, Xu OM, Zhao SF, et al. 1998. Green and yellow vegetables rich in provitamin A carotenoids can sustain vitamin A status of children. FASEB J. 12:A351 (Abstr.)

Barbara A. Underwood

International Union Nutritional Sciences, Food and Nutrition Board, Institute of Medicine, NAS, Washington, DC 20418; e-mail: **Fehler! Verweisquelle konnte nicht gefunden werden.**
Suttilak Smitasiri

Division Communication and Behavioral Science, Institute of Nutrition, Mahidol University, Salaya, Thailand; e-mail: **Fehler! Verweisquelle konnte nicht gefunden werden.**