Micronutrients and health

Nutri*view*

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Nutri*view* 2001/3

Contents in brief:

■ **Nutri***view* is a quarterly newsletter on the role of micronutrients in nutrition and health. It is published by Roche Vitamins Europe Ltd, Basel, Switzerland, as a service to health-care professionals and science communicators. The findings, interpretations and conclusions expressed in **Nutri***view* are those of the authors, and are not necessarily shared by the Publisher.
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Editorial:
Too much of a good thing?

Are we doing enough to eliminate micronutrient malnutrition in the world? Or are we doing too much? Judging by ancient medical records, micronutrient malnutrition has been around for thousands of years. For more than a century we have known that these often fatal disorders are caused by vitamin and mineral deficiencies. Food fortification has been used to correct micronutrient deficiencies since 1923 (start of salt iodization in Switzerland). And since 1992, when delegates to the International Conference on Nutrition in Rome agreed to a plan of action aimed at eliminating malnutrition and hunger in the world, there has been a veritable "explosion" of activities. Yet the problem is still with us. Why?

I recently received a copy of a report, published in the Food and Nutrition Bulletin, on dietary approaches to vitamin A deficiency as discussed at a workshop held in Korea in 1999[1]. I was amazed to read how much creativity is being invested into finding ways to improve the nutritional quality of people's diets. It seems like hundreds (or perhaps even thousands) of researchers want to make an innovative contribution: original ideas for fortifying staple foods that are not centrally processed; new, refined forms of cooking oils with high levels of bioavailable carotenoids; new, nutrient-reinforced breeds of sweet potato, cassava, rice, wheat and other staples; new methods of food processing to maintain nutrient levels after storage; new cooking recipes to reduce levels of antinutrients and enhance availability of nutrients; revival of traditional, more nutritious, cooking methods; nutrient-dense snack foods as novel supplements; ways to produce affordable foods at home; new communication techniques to gain the support of the target groups. Even this short, incomplete, list shows that the nutrition research community has got the message, and is making exceptional efforts to find a solution to the problem.

But is this knowledge being used on a wide scale to benefit affected communities? Is research finished after it has been published? When has enough research been done to convince those who need to implement it? Who needs to convince whom?

Agreed, an intervention cannot be started on a national scale without careful planning and preparation. The person who agrees to use public funds for such a project needs to be fairly sure that it will be successful. Nevertheless, I would have thought we already have more than enough evidence to show that supplementation, food fortification and dietary diversification are affordable measures that can reduce micronutrient malnutrition below the level of a public health problem if implemented wholeheartedly.

The VIGNETTE in this issue puts available strategies against micronutrient malnutrition into perspective, and lists the key criteria for successful interventions. I hope it will help to get more good things done. – *A. Bowley*

1. Special issue on dietary approaches to vitamin A deficiency. Food Nutr Bull 2000; 21: 115–246.

Feature:
Guidelines for iron fortification of cereal food staples

Fortification of milled, refined cereals is a convenient way to deliver vitamins and minerals to deficient populations. Iron should be always be included in cereal fortification programs where iron deficiency anemia is widespread.

In September 2000, SUSTAIN (Sharing United States Technology to Aid in the Improvement of Nutrition) convened a workshop in Monterrey, Mexico, to help resolve long-standing concerns about the bioavailability of elemental iron powders in cereal fortification. Based on the recommendations made at the workshop, SUSTAIN has now prepared a document that helps program planners to select and use iron fortificants.

These guidelines are based on over fifty years' experience with iron enrichment of cereals, and current knowledge of iron fortificants. They have been written with the goal of optimizing bioavailability, cost-effectiveness and consumer acceptance of the fortified product, and have been reviewed and endorsed by a panel of experts in the field. While they represent the best information currently available, these guidelines should only be considered interim and may change as more information becomes available.

The report below presents the main recommendations from the guidelines. For more details, please see the original document[1].

Selection of iron fortificant

Ferrous sulfate: Because of its high bioavailability and low cost, FCC-grade dried ferrous sulfate is often the best choice. It can be used in bakery flour, semolina and other types of low extraction wheat flours, which are normally used within 1–2 months. Only dry powders with a fine particle size should be used, because large particle sizes and hydrated ferrous sulfate can cause color and spotting problems.

Ferrous fumarate: FCC-grade ferrous fumarate has a bioavailability similar to that of ferrous sulfate. It is insoluble in water and therefore causes fewer organoleptic problems than the more soluble ferrous sulfate. However, it usually costs more than ferrous sulfate.

Elemental iron: Elemental iron powders may be considered as potential iron sources if unacceptable changes in color, flavor or storage properties of the fortified food prevent use of either ferrous sulfate or ferrous fumarate. At the current state of knowledge, *electrolytic iron* is the best choice among the elemental iron powders. It is about half as bioavailable as ferrous sulfate. Its physical properties and dendrite structure should be the same as the product formerly supplied under the trade name Glidden A131. Not enough is known about the bioavailability of the other elemental iron powders to offer specific recommendations. Whatever type is selected, preference should be given to the 325 mesh (<45 microns) rather than the 100 mesh specified for reduced iron in the current FCC guidelines.

Foods with high levels of inhibitory factors (phytic acid or polyphenols) significantly reduce iron absorption, limiting the impact of fortification. In such cases, it may be necessary to add an iron-absorption enhancer or reduce the amount of inhibitor in the food. Where permitted, use of *sodium iron-EDTA* or *disodium EDTA* plus *ferrous sulfate* as fortificants should be considered. Other options include dietary change, fortification of a food that is consumed separately from the main inhibitory meals, and iron supplementation.

Determining the addition level

In planning a fortification strategy, the optimal level of iron fortification will depend on a number of factors, including the prevalence of iron deficiency, the nature of the diet, the distribution of cereal foods, and the bioavailability of the added iron.

To restore the original level of iron found in whole-wheat flour (35 ppm), at least 25 ppm (as ferrous sulfate or ferrous fumarate) must be added to white flour. Higher levels may be required for populations with iron deficiency whose consumption of flour is low.

Elemental iron powders have a lower bioavailability than soluble iron salts. Because of this, twice the amount of fortificant is needed (e.g. 50 ppm iron as electrolytic iron is equivalent to 25 ppm iron from ferrous sulfate.

In most countries, flour fortification is generally regulated by setting a minimum iron level in the enriched flour, to include both the added and native iron, rather than specifying the exact quantity of iron fortificant to be added.

Iron is usually added along with other micronutrients in a premix of vitamins and minerals formulated to meet the specified enrichment standards. The shelf life of the premix is determined by the vitamins in it, not the iron. This is because most iron fortificants are more stable than the vitamins.

Conclusion

It is important to note the limited data related to the bioavailability of elemental iron powders. Given the high prevalence of iron deficiency anemia in developing countries, and the wide use of elemental iron powders in food fortification programs, a thorough evaluation of these powders is highly recommended. ■

Source

1. SUSTAIN, May 2001. Guidelines for Iron Fortification of Cereal Food Staples. www.sustaintech.org

■ Conference report:

Forging effective strategies to combat iron deficiency

In May this year, 200 research scientists, public health professionals and representatives of the food industry from 45 countries met in Atlanta, Georgia, USA, to reach an agreement on which is the best way to control iron deficiency. The 3-day conference was jointly sponsored by the International Life Sciences Institute Center for Health Promotion, the Centers for Disease Control and Prevention, the Micronutrient Initiative and Emory University. Here is a summary of the main findings of the meeting (source: ILSI press release). The full texts will be published in a major nutrition journal. Information relating to iron deficiency prevention and control, as well as the session abstracts is available on a CD from the ILSI office.

Globally, more than two billion people are iron deficient. In some countries, more than half the population, in particular pregnant women and infants, are affected. Iron deficiency not only causes anemia. It also reduces people's capacity for learning and working, and so slows a nation's economic growth. Because of this, expanded efforts to reduce iron deficiency are urgently needed.

Such efforts include interventions at the national level, communication strategies, new alliances between the public and private sectors, and targeted interventions to accelerate food fortification and improve supplementation strategies. By adopting a goal to substantially reduce the prevalence of anemia and iron deficiency by the end of the decade, the United Nations General Assembly Special Session on Children could help to reinforce global efforts.

Iron deficiency can be controlled

A strategy to control iron deficiency can benefit significant proportions of the population and should be implemented without further delay.

"Children who have iron deficiency anemia in infancy are at risk for long-lasting developmental disadvantage as compared to peers with better iron status" said Dr Stanley Zlotkin, Professor at the University of Toronto Departments of Pediatrics and Nutritional Sciences and The Hospital for Sick Children, Toronto, Canada.

Evidence from the United States shows that iron-fortified infant foods can reduce iron deficiency anemia in infants of low-income families. There has also been a significant reduction in iron deficiency in Venezuela following fortification of cereal flours there.

Studies from Vietnam and China

indicate that iron-fortified condiments (fish sauce and soy sauce respectively) can reduce iron deficiency anemia. Dr Nguyen Cong Khan from the National Institute of Nutrition in Hanoi, Vietnam, reported that iron-fortified fish sauce reduced iron deficiency by 33% within 6 months.

Integrated approach is best

After reviewing the impact of food fortification and supplementation interventions in developed and developing countries, and discussing the related technical and practical barriers, participants agreed that a strategy combining several appropriate interventions has the best chances of success. Even though additional research and expansion of national monitoring and evaluation systems may be needed, there is already significant programmatic and technical knowledge and experience from around the world to support such an approach. An appropriate program includes:

- fortification of staple foods (e.g. cereals) or condiments;
- multimicronutrient fortification of infant foods;
- micronutrient supplementation for vulnerable individuals (e.g. infants and pregnant women);
- dietary education;
- control/treatment of parasites (malaria, worms).

Setting a realistic goal

Experts at the meeting made five key recommendations aimed at reinforcing efforts to reduce iron deficiency and iron deficiency anemia in the near future:

1. Governmental and nongovernmental organizations, international and bilateral agencies, the private sector and civil society need to recognize how much iron deficiency negatively affects a population's health and economic status; they should prioritize an appropriate strategy as a major public health initiative and allocate adequate resources.
2. Effective, affordable measures to prevent deficiencies of iron and other vital micronutrients are available. National governments have an economic, social and moral obligation to support and implement them. Pilot efforts are insufficient; only a full-scale implementation can make a difference.
3. Strategies must use culturally appropriate interventions and be multifaceted, integrating fortification of cereal flours and other foods with preventive multimicronutrient supplementation of vulnerable groups, and complemented by dietary diversification and other public health measures.
4. Control programs for iron, folate and other micronutrients should be implemented in all developing countries. Emphasis should be placed on the most cost-effective combination of food fortification (cereal flours fortified with bioavailable iron) and supplementation of infants, children, adolescent girls and women of childbearing age, especially during pregnancy.
5. The outcome document of the United Nations General Assembly Special Session on Children (*A World Fit for Children*) should include the following goal: "Reduce by one third the prevalence of anemia, including iron deficiency, by 2010, and accelerate progress towards reduction of other micronutrient deficiencies, through food fortification and supplementation". ■

■ Conference report:

Homocysteine: A potential health risk

A workshop held at the University Hospital of Vienna on March 23, 2001 brought together a group of specialists from Europe and the USA to discuss the role of high blood levels of homocysteine as a risk factor for cardiovascular disorders and congenital malformations. There was widespread agreement that measures to correct deficiencies of folic acid, vitamin B_6 and vitamin B_{12} can lower homocysteine levels, and might be a worthwhile preventive strategy. The report below summarizes the information communicated at the meeting.

Hyperhomocysteinemia (excessive amounts of homocysteine in the blood) is a common finding in patients with coronary artery disease, thrombosis, stroke, senile dementia or Alzheimer's disease. It is also a feature of pregnancies affected by complications associated with placental underfunction or the congenital malformations known as neural tube defects (NTD). It has been suggested that hyperhomocysteinemia represents an independent risk factor for these disorders, and should be treated. Elevated blood levels of homocysteine can be normalized by ensuring adequate intakes of folates, vitamin B_6 and vitamin B_{12}. While this has been shown to prevent numerous pregnancy complications, convincing evidence that it reduces cardiovascular morbidity and mortality is still lacking.

The case against homocysteine

The relationship between hyperhomocysteinemia and cardiovascular disorders was recognized more than thirty years ago in children with enzyme defects who prematurely developed fatty plaques in their arteries. The link was confirmed by inducing hyperhomocysteinemia in animals, which resulted in lesions similar to those found in affected children.

These genetic defects of enzymes involved in homocysteine metabolism are quite rare. Hyperhomocysteinemia, on the other hand, is widespread. One possible reason for this is that many people have suboptimal intakes of folates, vitamin B_6 and vitamin B_{12}. Other factors that might be involved include renal insufficiency, use of drugs that interfere with vital enzyme reactions, and inefficient enzyme forms (polymorphism) that need higher substrate levels to function properly.

It is still not clear how homocysteine damages the blood vessel walls or causes congenital malformations. Altered homocysteine metabolism appears to be involved in all the main pathophysiological abnormalities that characterize vascular disease. This means that excess homocysteine could be a direct cell toxin. It might also affect blood clotting mechanisms or oxidize circulating lipids, making them more likely to accumulate as fatty plaques.

Recent studies conducted in Austria found that:

- hyperhomocysteinemia increased the risk of recurrent venous thromboembolism threefold;
- an increased risk for deep venous thrombosis or stroke was not associated with polymorphism of the enzyme methylene tetrahydrofolate reductase;
- patients with severe coronary artery disease and high blood levels of homocysteine had the least accumulation of homocysteine in the coronary arteries, while healthy hearts (from heart donors) showed the most extensive arterial enrichment;
- children with morbid obesity (but no familial history of premature cardiovascular disorders) had significantly elevated homocysteine levels, while non-obese children from families with such a history did not.

A worthwhile preventive strategy

From the available evidence it seems that many Europeans do not have enough folates in their diets (and maybe not enough vitamin B_6 and vitamin B_{12}) to ensure proper methionine metabolism. Various research groups have determined that a daily intake of 400 µg folic acid, 2 mg vitamin B_6, and 6 µg vitamin B_{12} is needed to maintain homocysteine at a normal level in most cases. Most young people could easily obtain such amounts through an appropriate choice of foods. Alternatively, authorities might consider food fortification.

For groups at a high risk for cardiovascular disorders or pregnancy complications, regular intake of a nutritional supplement containing these B-vitamins might be worthwhile.

Source

1. Homocystein: Ein Risikofaktor für Atherosklerose und Fehlbildungen. Workshop organized by the Children's Hospital of the University of Vienna, the Austrian Academic Institute for Nutritional Science, and the Ministry of Education, Science and Arts. March 23, 2001.

News in brief:

New method shows efficiency of beta-carotene conversion

To estimate the bioefficacy of β-carotene (= the efficiency of absorption and conversion to retinol) van Lieshout et al.[1] have developed a method that requires only three blood samples. They gave Indonesian children a supplement (160 µg retinol+160 µg β-carotene in oil, each specifically labelled with a stable carbon isotope) daily for up to ten weeks, and measured how long it took to reach a plateau in isotope enrichment in the serum. They calculated the extent of conversion from the degree of labelling of retinol with the different isotopes, and the amounts of supplement administered.

Isotope enrichment reached a plateau by day 21. It took 2.4 µg β-carotene in oil to form 1 µg retinol in the body. There was a 22% interindividual variation in bioconversion. The authors conclude that this method can be used to measure the bioefficacy of carotenoids in foods with high precision, and uses fewer subjects than other methods.

In an editorial in the same issue, Solomons and Russell[2] welcome this initiative, expecting that the technology will encourage international collaboration. It should help to solve the dispute about what is the correct conversion factor to use. They also mention the possible use of high doses of β-carotene in oil as a low-risk substitute for retinol in supplements.

1. Van Lieshout M, West CE, Muhilal, et al. Bioefficacy of β-carotene dissolved in oil studied in children in Indonesia. Am J Clin Nutr 2001; 73: 949–958.
2. Solomons NW, Russell RM. "Appropriate technology" for vitamin A filed research. Am J Clin Nutr 2001; 73: 849–850.

Maternal night blindness increases mortality risk

Christian et al.[1] examined the relationship between maternal night blindness and the risk of the infant dying within the first six months of life in 10,000 Nepalese women who participated in a controlled trial of supplementation with vitamin A, beta-carotene or placebo.

For women who were not night blind, infant mortality was 63/1000 live births independent of supplement used. In night-blind women given placebo, infant mortality was significantly higher (99/1000 live births). Vitamin A supplementation reduced mortality in infants of night-blind women to 74/1000, but beta-carotene supplementation had no effect (91/1000).

These findings confirm the importance of identifying night blindness during pregnancy, which indicates an increased mortality risk for mother and child that can be lowered by supplementation with vitamin A.

1. Christian P, West Jr KP, Khatry SK, et al. Maternal night blindness increases risk of mortality in the first 6 months of life among infants in Nepal. J Nutr 2001; 131: 1510–1512.

World malnutrition situation reviewed

Stephenson et al.[1] review what is known about protein-energy malnutrition, as well as deficiencies of iron, iodine, vitamin A and zinc in terms of their global and regional prevalence, the groups affected, the clinical and public health consequences, and recent progress achieved in their control.

They mention the following as some of the most important recent conclusions from nutrition research:

- Child mortality is directly linked to protein-energy malnutrition. More children die from mild-to-moderate malnutrition than from severe malnutrition.
- Malnutrition is the most common cause of immunodeficiency worldwide.
- Micronutrient supplementation can reduce mortality and morbidity significantly.

Numerous tables summarize the key data.

1. Stephenson LS, Latham MC, Otteson EA. Global malnutrition. Parasitology 2000; 121: S5–S22.

Vitamin D deficiency: A problem in sunny countries

Vitamin D deficiency, the cause of rickets in children and osteomalacia in adults, also impairs health in other ways. It has been associated with an increased risk of hyperparathyroidism, hypertension, cancer and inflammatory disorders such as rheumatoid polyarthritis.

A research team in Lebanon[1] has examined the global prevalence of vitamin D deficiency and found that it is more common in those parts of the world with lots of sunshine than in those with little. The lowest prevalence is found in countries that fortify foods with vitamin D. Vitamin D deficiency occurs at all ages, not just in the elderly. In Lebanon, up to 84% of young women are deficient in winter.

Besides low dietary intakes of vitamin D, the main reasons for the high prevalence are insufficient sun exposure due to dark skin, traditional dress that covers the face and arms, use of sun protecting products, and air pollution in the cities.

Until adequate public health measures can be introduced, the authors recommend that people should take a vitamin D supplement and increase skin exposure to the sun.

1. Gannagé-Yared MH, Tohme A, Halaby G. L'hypovitaminose D, problème mondiale majeure de santé publique. Presse Med 2001; 30: 653–658.

Fewer NTD since start of food fortification with folic acid

Since 1992, the US Public Health Service has recommended that all women who are capable of becoming pregnant should consume 400 µg folic acid daily. It was estimated that about a third of the target group followed this advice and took a supplement. Addition of folic acid to enriched grain products began in 1996, and became mandatory in 1998. The chosen level was expected to add 100 µg folic acid to the average daily diet, so that about half of the targeted women would have a daily intake of 400 µg folate from all sources.

To evaluate the impact of food fortification with folic acid on the prevalence of neural tube defects, Honein et al.[1] compared US birth certificate reports before (10/95–12/96) and after (10/98–12/99) the introduction of mandatory fortification.

Prevalence of neural tube defects (NTD) fell from 37.8/100,000 live births before fortification to 30.5/100,000 in the second period. This represents a decline of 19%.

The authors conclude that fortification might not be the only reason for the decline. Other factors (use of supplements, number of affected fetuses aborted) might have influenced the result, but not significantly.

1. Honein MA, Paulozzi LJ, Mathews TJ, et al. Impact of folic acid fortification of the US food supply on the occurrence of neural tube defects. J Am Med Ass 2001; 285: 2981–2986.

Micronutrient deficiencies increase cancer risk

Ames[1] presents evidence supporting the hypothesis that deficiencies of micronutrients contribute to DNA damage and so initiate the development of cancer.

A deficiency of the vitamins B_6, B_{12}, niacin, folic acid, C and E, as well as iron and zinc, mimics radiation by damaging chromosomes. This is a strong predictive factor for cancer. Surveys have shown that between 2% and 20% of the US population consumes less than half of the recommended amounts of these nutrients. Eighty percent of young US Americans (and 68% of adults) do not eat the amounts of fruits and vegetables recommended by the National Cancer Institute and the National Research Council. Consumption is lowest among the poor. Cancer incidence is twice as common among the 25% of the population with the lowest intake than among the 25% with the highest intake.

This situation could be remedied at low cost, leading to a major improvement in health and lifespan.

1. Ames BN. DNA damage from micronutrient deficiencies is likely to be a major cause of cancer. Mut Res 2001; 475: 7–20.

South Asia region supports food fortification

Following the South Asian Conference on "Micronutrient Fortification of Foods: Nepal Perspective" in October 2000, a document calling for steps to promote and facilitate food fortification, "The Kathmandu Declaration", was presented to the Vice Chairman of the Nepal National Planning Commission for consideration and action. The Declaration, together with a summary of the conference presentations, has now been published[1].

The document recognizes the economic importance of health problems caused by micronutrient deficiencies, and recommends food fortification as an effective, low-cost solution. Ten vital steps are listed for the facilitation of fortification. These include:

- Creation of public awareness about the benefits of fortification
- Provision of fortified foods through public distribution systems
- Reformulation of food regulations conform to international standards
- Favorable treatment of fortified foods with respect to taxation
- Special efforts by industry to reach rural areas, and to develop new fortification technologies
- Government support to help small companies participate in fortification programs
- Upgrading of analytical laboratories
- Constitution of partnerships to deal with arising issues.

Further details can be obtained from the meeting organizers (International Life Sciences Institute, The Micronutrient Initiative or Federation of Nepalese Chambers of Commerce and Industry).

1. South Asian Conference on Micronutrient Fortification of Foods: Nepal Perspective. 20–21 October 2000, Kathmandu, Nepal. Executive Summary. International Life Sciences Institute, Washington, DC 20036-4810, USA.

Strategies against micronutrient malnutrition

Micronutrient malnutrition occurs when an individual's diet does not contain enough vitamins, minerals and trace elements for optimal health. It is a global problem, affecting more than a third of the world's population in industrialized as well as developing nations.

Reasons for acting now

No country with micronutrient malnutrition can afford not to take action. The main reasons for doing it without delay are:

- Infants with severe micronutrient deficiencies have a high mortality rate. More than half of child deaths in developing countries are due to malnutrition. Many of the children who survive are severely handicapped physically or mentally.
- Deficient mothers are more likely to experience severe complications during pregnancy and childbirth.
- Micronutrient malnutrition impairs immune function, making people more susceptible to infections, and reducing their chances of survival.
- Even mild to moderate deficiencies reduce learning and working capacity, and may be responsible for increased morbidity in later life.
- Micronutrient malnutrition impedes economic development. World Bank specialists estimated that up to 5% of a nation's Gross Domestic Product can be wasted as a consequence.
- The benefits (significant improvements in health, school achievement and work performance) that can be expected from improved nutrition greatly outweigh the costs of the intervention.

The combined use of supplementation, food fortification and dietary diversification may be the best solution for the control of micronutrient malnutrition.

Choice of methods

An overview of the three internationally accepted strategies for eliminating micronutrient malnutrition is shown in Table 1.

For the best results, depending on prevailing conditions, a combination of measures may be necessary. It might also be preferable to gain experience in a pilot intervention before seeking a comprehensive solution on a national scale.

Contributing factors

When choosing a strategy, it is important to understand the reason(s) why people become malnourished in the first place. These factors need to be addressed to achieve a sustainable result:

- *Income*. Malnutrition is usually associated with poverty. Increasing income alone, however, is not enough. It has been shown that a family's priorities for spending available resources have a greater influence on dietary habits than the absolute level of poverty. Women will spend more on food, if given the opportunity. If the woman of the household works away from home, leaving less time for preparing and cooking food, nutritional quality tends to suffer.
- *Social standing*. Levels of malnutrition may vary within the same household depending on the individual's social standing. Women, female children and elderly are more likely to be undernourished, even when the head of the household and male children are adequately fed.
- *Ignorance*. Lack of schooling makes it difficult for people to understand nutritional concepts. Nevertheless, a knowledge of how nutrition affects health is not enough to change dietary habits. To create a demand for healthy foods, education efforts must convince recipients of the social and economic benefits.
- *Religious and cultural taboos*. It is best to avoid solutions that interfere with long-standing traditions involving specific food choices.
- *Food security*. Food-based solutions require that an acceptable and affordable selection of nutritious foods is available all year round. In areas regularly affected by flooding or droughts, and where space for gardens is limited, this can cause problems. Many traditional ways of processing food for later use do not preserve micronutrients adequately.
- *Health and hygiene*. Unsanitary living conditions, shortage of clean drinking water, and widespread infections aggravate the effects of an inadequate diet. Many diseases impair appetite, reduce nutrient uptakes or increase requirements. Because of this, basic healthcare services are an important prerequisite for the success of nutritional interventions.

Criteria for success

Three key conditions must be fulfilled to achieve a sustainable result with a minimum of setbacks:

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Editor: A. Bowley, ABCommunications.

- *Perseverance*: It is human nature to resist change, and to forget things that are not part of our routine. Project leaders therefore need to maintain an optimistic outlook even when everything seems to be going wrong, and be ready at all times to help other stakeholders understand what is needed from them, and to encourage their full participation.
- *Partnership*: Any intervention that requires a change in behavior, or increases workload or spending, must have the support of all stakeholders. This is more likely when they are involved as partners from an early stage of the project, and participate in the identification and solving of problems.
- *Control*: Clearly defined objectives and an efficient system of quality control and monitoring are needed to ensure that everybody is aware of and maintains the standards required, and to allow an accurate estimate of the costs and benefits.

Further reading

1. United Nations Administrative Committee on Coordination/Sub-Committee on Nutrition. Fourth Report on the World Nutrition Situation. January 2000.
2. Blum M. Food fortification: A key strategy to end micronutrient malnutrition. Nutriview Special Issue 1997.
3. The Micronutrient Initiative. Joining Hands to End Hidden Hunger. 2nd Edition 1997.
4. Food and Agriculture Organization of the United Nations/International Life Sciences Institute. Preventing Micronutrient Malnutrition: A Guide to Food-based Approaches. 1997.
5. Lotfi M, Mannar VMG, Merx RJHM, Naber-van den Heuvel P. Micronutrient Fortification of Foods. Current practices, research and opportunities. The Micronutrient Initiative/International Agricultural Centre. 1996.
6. McGuire J, Galloway R. Enriching Lives: Overcoming Vitamin and Mineral Malnutrition in Developing Countries. A World Bank Publication. 1994.

Table 1: Interventions to improve micronutrient intakes

Intervention	Features	Strengths and weaknesses
Supplementation	Use of single or multiple micronutrients in a pharmaceutical dosage form (tablets, capsules, syrup, injection).	First choice for rapid correction of deficiencies and for people with small appetites (elderly, sick). Low cost. Relatively high risk of non-compliance. Needs funding to ensure long-term sustainability.
Food fortification	Addition of single or multiple micronutrients to staple foods (fats, oils, cereals, milk, sugar, salt) or processed foods, including snacks, beverages and condiments.	First choice when a centrally processed staple consumed by the majority of the target population can be fortified. No change of diet needed. Lowest cost. Highly sustainable when supported by government and food industry, and efficiently monitored. Still some problems associated with choice of iron fortificant and technology for rice fortification. If no suitable staple is identified, alternatives (addition of nutrient premix locally, distribution of fortified drinks and snacks at schools, seasoning of meals with fortified condiments such as glutamate, bouillon cubes, soya or fish sauce) may have a similar effect on nutrient status. However, they require education of the target population or helpers, and a corresponding change of dietary habits. They also involve a higher risk of non-compliance.
Dietary diversification	Extension of food choices to provide a balanced diet with adequate amounts of micronutrients. Modification of food preparation and processing methods to enhance the content and bioavailability of nutrients. Community/household production of small livestock, fish, fruits and vegetables. Use of fertilizers, plant breeding and genetic engineering to enhance the content and bioavailability of micronutrients.	The most "natural" solution. Once adopted, is the most sustainable choice, provided that the necessary foods are available at affordable prices. Requires considerable education and social marketing efforts to change behavior. These are relatively expensive and labor intensive, and may take months/years to accomplish. Dietary diversification alone cannot increase nutrient levels enough to restore normal status in deficient individuals. Creation of "home gardens" could make more nutritious foods available at a reasonable cost. Only possible when there is enough space and willing labor to ensure cultivation and harvesting. Relatively high risk that producers will sell their crops rather than using them to improve the family's nutrition. Iron and zinc content of plant foods can be increased by applying appropriate fertilizers to the soil or foliage. Requires education of the farmers, but no change in food choices. Various new varieties of plant foods have been developed that contain higher levels of provitamin -A carotenoids. These may look different from traditional varieties, causing them to be rejected unless efforts are taken to educate the consumers. Genetic engineering is a technology that carries some promise for the future. There is, however, considerable opposition in many countries to its introduction.