Control and prevention of micronutrient malnutrition

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The importance of micronutrient deficiencies to child survival and to the health and development of nations is universally recognized. Over two billion people, or more than one in three individuals, are at risk of iron, vitamin A and iodine deficiencies. More than 13 million people suffer night blindness or total blindness due to vitamin A deficiency; severe iron deficiency accounts for one in five maternal deaths and one-third of all young children are anaemic; iodine deficiency affects 50 million children and is the greatest single preventable cause of intellectual impairment, as well as a major cause of lost potential and productivity. The World Summit for Children acknowledged that the elimination of the various forms of micronutrient malnutrition would constitute a significant contribution to social, economic and public health development. At the FAO/WHO International Conference on Nutrition held in Rome in 1992, the governments and the non-Governmental Organizations from virtually all nations, together with the international development community, made the elimination of iodine deficiency disorders and vitamin A deficiency important goals to be achieved by the end of the decade, along with a substantial reduction in the levels of iron deficiency anaemia. The United States Agency for International Development established the Opportunities for Micronutrient Interventions in 1993 to help countries achieve these goals by institutionalizing micronutrient activities into other sectoral policies, projects and strategies internationally. An important factor in the recent perceived higher priority for multisectoral micronutrient interventions is the cost-effectiveness of such interventions. The World Bank estimates that a deficiency of vitamin A, iron and iodine could waste up to 5% of the gross domestic product (GDP) of a country, while addressing them effectively would cost only 0.3% of GDP. The three main complementary approaches to controlling and preventing micronutrient malnutrition include food-based strategies such as fortification and diet-based approaches including gardening; supplementation; and related public health interventions.

Key words: micronutrient deficiency, child, iodine deficiency, vitamin A deficiency, malnutrition, iron deficiency anaemia.

Introduction

The elimination of vitamin A deficiency and iodine deficiency disorders, and the substantial reduction of iron deficiency anaemia have been endorsed as achievable goals by 159 countries of the world. This paper will look at why this consensus has been reached, how large is the problem being addressed, and what are the strategies involved. Multiple approaches, including diet diversification, food fortification, pharmacological supplementation and public health measures, can be implemented at the individual, community, national and regional levels to eliminate micronutrient malnutrition. There will also be a brief discussion on integrated approaches, expected impact and sustainability of different approaches, and cost effectiveness.

Micronutrient malnutrition is a serious threat to the health and productivity of more than 2000 million people worldwide despite being largely preventable.[1] Because of their high prevalence and close association with childhood illness and mortality, the three micronutrient deficiencies of greatest public health significance are iron, vitamin A and iodine, often known together as micronutrient malnutrition. Women and children are more vulnerable to micronutrient deficiencies because of their added requirements for reproduction and growth.[2]

Iron deficiency anaemia is said to affect an estimated 42% of women,[3] 58% of all pregnant women[1] and is a major contributor to maternal abnormality.[4] Approximately half the estimated 2000 million people with iron deficiency have overt clinical iron deficiency anaemia.[1] Iron deficiency has recently been re-recognized as an important cause of cognitive deficit in infants and young children with severe anaemia. Anaemia is even more prevalent in preschoolers, reaching 70% or more in sample populations.[3]

Iodine deficiency disorders (IDD) affect 655 million people the world over and another 915 million people live in areas which put them at increased risk.[5] Iodine deficiency disorders are currently a significant public health problem in 118 countries.[1] Iodine deficiency is the commonest cause of preventable intellectual impairment in the world today, as well as having negative effects on women's abilities to reproduce.[6,7]

Deficiency of vitamin A has been identified in 37 countries as a public health problem.[8] Approximately 2.8 million preschool children are at risk of blinding xerophthalmia and each year it is estimated that 250 000–500 000 preschool children go blind from vitamin A deficiency.[1,8] Many more (an estimated total of 251 million) are at risk of subclinical deficiency[1] with its demonstrated relationship to increased child mortality of up to 25–30%.[9]

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Deficiencies of these micronutrients clearly remain major problems in the world today. This was recognized and acknowledged globally in December 1992 at the International Conference on Nutrition (ICN), where representatives of 159 countries agreed to eliminate IDD and vitamin A deficiency as public health problems by the end of the century and to substantially reduce the prevalence of iron deficiency anaemia.[10] In 1990 the World Summit for Children had established broader goals for the health and well-being of children and the nutrition goals agreed to at this forum were echoed to a large extent at the ICN.[11] A year later the Policy Conference 'Ending Hidden Hunger' was held in Montreal and examined the possibility of an integrated approach to the prevention and control of the three identified micronutrients.[12]

Prevention and control approaches

A useful categorization to interventions might be: (i) food-based approaches such as dietary diversification, home gardens, fortification and plant breeding; (ii) supplementary or pharmaceutical approaches (e.g. vitamin A capsules and iron/folate supplements); and (iii) public health interventions such as control of infectious diseases, collaboration with National Immunization Days, promotion of breast-feeding, and so on.

Food-based approaches

With the exception of iodine in certain ecological settings, micronutrients are found abundantly in many plant foods and animal products. In areas where these micronutrients are not naturally available in the soil and thus in food, food fortification and vitamin/mineral supplementation are alternative ways to increase the intake of these essential micronutrients. Fortification of an appropriate food vehicle with specific nutrients has been clearly successful in many countries.[13] Experience in less industrialized countries has not always been encouraging, although Mora and Dary list 17 countries in Latin America which now fortify with at least one micronutrient and sometimes more.[14]

Fortification is often described as a medium-term approach but, based on the experience of industrialized countries, should now be considered a long-term intervention. Where the costs are passed on to the consumer and the food industry routinely fortifies, sustainability is potentially high.

The more sustainable dietary approaches have received lip service in the past, but in fact most countries and programmes have tended to put the majority of resources into supplementation. There is increasing interest in food-based approaches, including horticultural approaches such as home gardens and genetic selection for micronutrient-rich varieties of foods, methods of food preparation and cooking which conserves the micronutrient content, and nutrition education.

When talking of micronutrients, it sometimes appears to be forgotten that nutrients are eaten as food (for the most part). Families who do not have enough to eat are usually poor; their diets are not likely to include much nutrient-rich food and so are likely to be low in vitamins and minerals as well as in energy.[2] Even in populations where a lack of accessibility to appropriate foods or a lack of availability of foods are not the main constraints, there are important dietary habits (such as lack of suitable complementary foods early enough, not breast-feeding, food restrictions at critical points of the life cycle, etc.) that can be modified to enhance micronutrient intakes.

Dietary modification can be addressed by:

(i) behavioural change to improve consumption through communications, social marketing, or nutrition education (IEC);

(ii) breast-feeding: for vitamin A at least, non-breast-fed infants in communities vulnerable to deficiency are particularly at risk;

(iii) home food provisioning: mainly home gardens but including potential animal and fish food sources as in the Vietnamese VACVINA experience;

(iv) food and price policies; and

(v) technology such as food/nutrient preservation, including traditional technologies such as drying and fermenting.

Diets and food behaviours are complex and varied, and attempted solutions to nutrition problems using a food-based approach need to reflect this. It has been pointed out that while the drive to seek food is fundamental, there appears to be no convincing evidence that humans have an innate ability to select foods that supply specific nutrients other than sodium.[2] If micronutrients seem not to be distributed within households according to need, this may not indicate sex or age bias but may simply be that the special needs of children and pregnant women are not being sufficiently recognized.

Supplementation

Pharmaceutical supplementation has conventionally been seen as a short-term measure but in some countries (e.g. Bangladesh, for vitamin A) has now been in existence as an intervention for over 20 years.[15] In countries such as Nepal it is likely these measures will be required for many years yet (KP West, pers. comm., 1995). As a public health measure there is no doubt as to the effectiveness of the supplementation on vitamin A status for those children receiving 200 000 IU capsules,[9,16] although efficacy is still unclear in very young infants.[17] The optimal timing of the dosage (e.g. four monthly or six monthly), and at what time of the year given seasonal shortages, is less clear and may be different in one country from another.

It is clear that coverage with vitamin A capsules is hard to sustain over time and often does not reach the children most at risk.[15,18] Consequently, other approaches are being examined, such as giving a capsule to a mother immediately post-partum and strongly encouraging breast-feeding. Another approach is to be more medically targeted to sick children and the guidelines for this have just been revised.[19] It has become clear that children who are malnourished, children who have repeated diarrhoea or children with measles should be treated. Other innovations have included successful trials with dispensers although this approach has not yet been used routinely in government programmes. A successful strategy has been the distribution of capsules (both vitamin A and iodized oil) during National Immunization Days (e.g. in the Philippines and more recently in Viet Nam and Cambodia).[20,21]

Short-term approaches for iodine have included iodized oil injections. These were extremely successful in the highlands of Papua New Guinea[6] but appears not to have been sustained. Although there are the constraints of injections and sterility, cost, diversion of effort from salt iodization and sustainability, there would seem to be a limited role for remote, unsophisticated populations. The effect appears to last for at least 3 years. Cheaper but less effective is iodized oil taken orally. This is feasible, as seen in the Philippines national immunization days, but efficacy has not been established in public health terms because the effect is only for about 1 year.

Supplementation has been the traditional approach for iron, particularly during pregnancy.[4] It is relatively expensive and coverage is often poor. Compliance is usually blamed but an Administrative Coordinating Committee/Subcommittee on Nutrition of the United Nations review of the topic felt that distribution and logistical problems were every bit as important.[22] Interesting work in a number of centres examining the efficacy of intermittent dosages, once or twice a week, suggests this may be a possibility although not all the results are consistent. However, it does appear that it may be possible to recommend a regimen of one or two times per week, which is presumed will encourage compliance and would certainly reduce costs.[23,24]

Related public health interventions

For maximum impact other public health interventions are essential. These need to include such things as control of infectious diseases, breast-feeding, oral rehydration therapy, intestinal parasite control, measles and other childhood immunization interventions,[25] all of which have an impact on micronutrient status. Control of malaria is a necessary risk factor to be controlled if the goal for anaemia is to be met, especially in much of Africa.[26]

Because of the recognized interaction between infectious disease and malnutrition, addressing only malnutrition or only disease control is unlikely to be successful. It is increasingly accepted that approximately 56% of child deaths in developing countries are attributable to malnutrition's potentiating effects,[27] although the identified cause of the deaths is most often classified as one of the infectious diseases. Malnutrition makes the incidence and the severity of the infectious diseases more likely. Conversely, the infectious disease can have an effect on micronutrient intake, absorption and utilization. Iron deficiency anaemia can affect immune status, and vitamin A deficiency is associated with approximately a 25% increased likelihood of child death, especially from the diarrhoeal diseases.

It has also become clear that governments have a role to play in at least ensuring that legislation is supportive of the public health measures in place or planned. The enthusiastic support of governments both in advocacy and in funds make the essential difference, particularly in the early stages. Legislation or regulations may also be required to ensure that for example all salt is actually iodized and then that there is some sort of on-going mechanism for ensuring the legally minimum levels are complied with.[28] Even in countries with long histories of food fortification and bureaucratic oversight, products do not always deliver what they claim and are mandated by law to contain.[29]

Integrated approaches

Because of the interactions between micronutrients and because micronutrients are generally ingested as part of the daily diet, it appears logical to pursue an integrated approach covering more than one micronutrient. For example, treating iron deficiency anaemia with both iron and vitamin A has a greater effect than either of the two micronutrients alone.[30] However, there are arguments for and against this approach.

Iodine and vitamin A deficiencies tend to be localized rather than distributed widely and theoretically could be virtually eliminated by targeted, sporadic interventions, given reasonable health infrastructure and a high level of political will.[26] Anaemia and protein–energy malnutrition, by contrast, affect much larger numbers of women and require more continuous intervention,[26] and in most cases are unlikely to be permanently resolved until socioeconomic conditions improve.

An integrated food-based approach would seem be more suitable for vitamin A and iron than for iodine, although there needs to be a behavioural component to convince people to include iodized salt in their diets. It should be more convenient and cost effective to target the same populations for all three micronutrients using the same health or social infrastructure and the same workers (e.g. the VADAG approach in the Philippines).[31] Mitigating against this approach is that the age range of the targeted groups is somewhat different; vitamin A deficiency being most common in the second 2 years of life and goitre prevalence being highest in school-aged children. Nevertheless, women and children, and especially those in poverty, are predominantly the most at risk for all three micronutrients.

Sustainability

For all three of the micronutrients, sustainability is clearly a problem for short-term supplementation/pharmaceutical approaches. In most countries in which micronutrient deficiencies are public health problems, the need for programmes to continue over a very long period of time is essential, particularly for iodine and iron but also for vitamin A for poorer populations. As has been seen, supplementation by capsules was originally conceived as a short-term measure but in some countries that need will remain for many years yet. Given the cost to countries, most of which are unable to currently afford it, much less indefinitely, questions of sustainability arise. Countries with the highest prevalences of vitamin A deficiency are those least able to afford supplementation. Although currently being purchased through UNICEF this cannot continue indefinitely, although a parallel to the continuing need for immunization in countries' EPI programmes can be made. In order to address issues of cost and sustainability, there is increased interest in using a more targeted approach to supplementation. However, the issue remains that those who receive the capsules are often not those most at risk. Universal coverage has not proved possible to reach or sustain despite the longevity of some programmes.[18,25]

The need for iodine in iodine-deficient areas, particularly if also poor, and in isolated areas is a long-term need. Given the relatively inefficient bioavailability of iron in most diets characterized by poverty, supplementation of pregnant women and their children will be needed for many, many years to come. The dosages required for infants and small children and how to deliver iron supplements to them are not easily solved at the village level. The medical model does not seem to be an appropriate sustainable approach in these situations. Consequently, there has been a need to look to food-based approaches and hence to agriculture and food science and technology and the food industry for other approaches. In order to increase sustainability there is a need to increase demand for micronutrients and then to work out how to satisfy this demand in a sustainable way. It seems likely that alliances across sectors and greater involvement of the private sector will be needed, both to encourage demand and then to satisfy it. The approach that is currently receiving most attention is the fortification of commonly consumed foods with one or a combination of micronutrients.[13]

Small-scale agricultural approaches including home gardens, and the growing of micronutrient-rich foods are often described as the most sustainable but this too is currently being questioned. Leaving aside the issue of carotenoid bioavailability, the evidence for introduced home gardens being sustainable is not impressive. Finally, nutrition education is seen as an integral part of programme sustainability. However, the beneficial impact of nutrition education on micronutrient or vitamin A status is weak although there are good examples. Education programmes undertaken among rural women in southern India have shown an impact on their knowledge and dietary practices and have resulted in increased use of green leafy vegetables and a reduction in the prevalence of xerophthalmia among preschool children.[32]

Impact

The fact that in vitamin A-deficient populations it is likely that at least 23% of child deaths could be averted suggests that this message is not getting to policy-makers. Likewise the impact of iron deficiency anaemia on maternal reproductive health and infant birth weights and child cognitive development is not being recognized. The impact of iodine on reproductive performance and infant intelligence and its economic impact on communities has been demonstrated beyond doubt.[6] One of the problems mitigating against the more enthusiastic adoption by countries of national programmes to prevent and control micronutrient malnutrition has been a perceived lack of priority (e.g. compared with HIV infection or childhood immunization programmes). There has also been an apparent failure to sell the importance and relative cost-effectiveness to decision-makers, as well as the desirability and the need for adequate micronutrient nutrition to ordinary household consumers and families.

Another problem has been a lack of suitable indicators that are sensitive enough to measure the sort of slow change implied in moderately but endemically deficient areas. Problems policy-makers and planners have experienced in justifying long-term, nutritional approaches include the lack of quick results and measurable nutritional outcomes. However, the home gardens project in Bangladesh of Helen Keller International, using indicators such as number of plant varieties planted etc., has seen some moderately rapid responses.[33]

Lack of documented impact, especially on nutritional status, of nutrition education has also been a factor although this is now being addressed increasingly and a social marketing approach has alerted people to other elements in nutrition and that behaviour change cannot be left to chance.[34] However, communication programme evaluations often focus on assessing changes in knowledge, attitudes and practice (KAP) and not on micronutrient status change. Some interventions are easier to evaluate than others and consequently tend to be done more often. For example, in vitamin A interventions, the largest number of evaluations have been of high dose supplementation and it is therefore important to distinguish between differences in impact detection from programme effect.[25]

Cost effectiveness

The decisions at the Summit for Children in 1990[35] and the International Conference on Nutrition in Rome in 1992[10] were made largely on the basis of humanitarian aspects of alleviating the unnecessary suffering of childhood malnutrition, maternal mortality and diminished personal potentials. However, to translate the decisions into national activities, issues of cost-effectiveness and national productivity need to be highlighted more.

In the document published by the World Bank in 1993, ‘Investing in Health’, micronutrient malnutrition interventions were identified as some of the most cost-effective. There is a degree of oversimplification involved in that the broader benefits, say of nutrition education or home gardens, on strengthening the woman’s role in decision-making in the family were not factored in. Nevertheless, the estimated costs of a child being covered for vitamin A (around \$0.50) compare well with the cost of fully immunizing a child (\$10–\$15).[25] The likely impact of preventing vitamin A deficiency in 6–24 month aged children has been estimated to be one life per 1000, or about 250 000 every year.[25]

Children born in iodine-deficient areas have been estimated to lose the potential of at least 10 IQ points compared with those born in iodine-replete areas (G Maberly, pers. comm., 1995). Calculation of the number of presumed IQ points lost to a country by not fortifying salt, although clearly imprecise, can be a powerful advocacy tool. Similarly, it is possible to make projections concerning the loss to national revenue of decreased productivity caused by iron-deficiency anaemia. Physical work capacity to be reduced even in moderate anaemia. With iron supplementation, gains in productivity and take-home pay have been shown to increase by 10–30%.[36]

It has been stated that the combination of the low cost of fortification with any of the three micronutrients (there are still some technological problems with fortifying with more than one or two simultaneously), and the large potential health gains in populations where deficiencies are prevalent, means that food fortification can be among the most cost-effective health interventions known.[37] From such findings comes the World Bank’s recommendation that micronutrient interventions, including fortification, be included in an ‘essential package’ of public health and clinical services which governments should ensure are available to the entire population and should subsidize for the poor.[26]

Conclusion

There has been wide acceptance of the need to see micronutrient interventions at a national level as a priority. For example, just over 70% (n = 83) of countries affected by IDD already have national salt iodization programmes in place.[38] There is going to be an even greater challenge translating this acceptance into national plans of action, and then, particularly in micronutrients, into the local as well as the national arena. This is especially so in countries moving to more decentralized systems where the importance is perhaps less apparent to the local decision-makers.

There seems a large measure of agreement that although some use of supplements must often be included in order to save lives, this should not be the exclusive approach. Food-based approaches are probably more sustainable and should be commenced early. Innovative approaches involving the food industry, agriculture and governments will be needed. The exact mix and sequencing will become the important questions for each national programme if the goals of the International Conference are to be reached.

A major challenge at present is to make the question of micronutrient elimination more consumer-driven. The supply side is potentially there, particularly in areas of fortification. The challenge is to make sure those most at risk of deficiencies have the knowledge to demand the micronutrients that have the potential to transform their lives and especially the lives of their children. Equally important is the availability and accessibility of the micronutrients in their diets.

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微觀營養素營養不良的預防與控制

摘　要

目前已普遍認識到微觀營養素缺乏對兒童生存和民族健康與發育的重要性。全世界超過 20 億或多於三分之一人口處于鐵、維生素和碘缺乏的危害，超過一千三百萬人由于維生素 A 缺乏而導致夜盲或失明；嚴重的鐵缺乏計有五分之一母親死亡和三分之一幼兒患有貧血；五千萬兒童碘缺乏而引起智能損害。世界兒童高峰會議承認各種形式微量營養素營養不良的消除將對社會、經濟和公共衛生的發展做出明顯的貢獻。 1992 年在羅馬舉行 FAO / WHO 國際營養學術會議上，提出了用十年時間作爲一個重要目標消除碘缺乏和維生素 A 缺乏症，並明顯減少缺鐵性貧血。 在 1993 年美國國際發展代理給予干預試驗幫助這些國家到達該目標。 這些多種微觀營養素的干預試驗中要考慮代價——效果這一重要因素。世界銀行估計克服維生素 A.、鐵和碘的缺乏要花費國家 5%的 GDP 。三個主要補償途徑是：加入缺乏的微量營養素于食物中，膳食和種植的探討。

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