

Animal Source Foods to Improve Micronutrient Nutrition and Human Function in Developing Countries

Interventions for Micronutrient Deficiency Control in Developing Countries: Past, Present and Future¹

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ABSTRACT There has been an evolution in our understanding of the causes of undernutrition and of the nutrition intervention programs that should be prioritized. This article discusses why nutrition programs have shifted their primary emphasis from control of protein deficiency, to energy deficiency, and now to micronutrient deficiencies. It has become recognized by the nutrition community that micronutrient malnutrition is very widespread, and is probably the main nutritional problem in the world. The most commonly used strategies for micronutrient deficiency control are supplementation and fortification, because they are cost-effective and to some extent, relatively easy to deliver. They have important limitations, however. Relatively little emphasis has been placed on food-based approaches to control micronutrient malnutrition. Evidence from several past studies, including the Nutrition Collaborative Research Support Program (N-CRSP), indicated a strong positive association between animal source food (ASF) intake, micronutrient status, and many human functions. This association motivated the intervention studies supported by the Global Livestock CRSP and described in this supplement, which found benefits of increasing ASF intake. In contrast to the common assumption that increasing consumption of ASF in poor communities is infeasible, and will only cause environmental problems, the articles in this supplement show the potential economic benefits of animal ownership in poor communities, and provide examples of innovative programs that have increased local production and consumption. Much more communication is needed among the nutrition, agriculture and development communities to achieve improved dietary quality for poor populations. *J. Nutr.* 133: 3875S–3878S, 2003.

KEY WORDS: • *micronutrients* • *supplementation* • *fortification* • *animal source foods*

This article provides an overview of the evolution, current situation and future prospects for micronutrient deficiency control, including the role of animal source foods (ASF)³. The focus of nutrition interventions evolved from control of protein deficiency, followed by concern about protein-energy deficiency, to the prevention and treatment of micronutrient deficiencies. These changes in focus required different approaches to the delivery of lacking nutrients, and our understanding about optimal delivery systems is still evolving. As part of this continuing evolution of thought and practice, the efficacy and effectiveness of food-based approaches, including increasing the intake of ASF, for the delivery of micronutrients are only now being documented. A major

objective of the articles in this supplement is to gather evidence for the importance of ASF as a source of micronutrients for people in developing countries, where micronutrient malnutrition is common and ASF intakes are normally quite low. At the same time, the intake of ASF should ideally fall within a range that supplies sufficient amounts of nutrients, especially micronutrients, without causing risk of excessive intakes of other dietary constituents such as energy and saturated fat.

The evolution of focus on specific nutrient deficiencies

As part of a joint World Bank-UNICEF planning activity, we reviewed the evolution of investment in control of protein deficiency, control of protein-energy deficiency and control of micronutrient deficiency (1). The history of this evolution was obtained by merging “nutrition narratives”, which were based on interviews with many scientists and program planners who have been involved in the recognition and control of micronutrient deficiencies over the past 30–40 y.

Starting in about the 1930s, nutrition intervention programs for developing countries predominantly focused on filling the perceived “protein gap.” At that time, kwashiorkor and severe malnutrition were reported in Africa, in part because of the low protein content of starchy complementary foods. The official view until the 1960s was that protein deficiency was the main nutrition problem in the world. This viewpoint was also

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³ Abbreviations used: ASF, animal source foods; N-CRSP, Nutrition Collaborative Research Support Program; CNP, Child Nutrition Program.

advocated by the United Nation's Protein Advisory Group, which was formed in 1955 to "help WHO advise FAO and UNICEF on the safety and suitability for human consumption of new protein foods". Around 1960, Jelliffe suggested that "protein-calorie malnutrition" was probably the main problem, recognizing that protein deficiency was not the only cause of malnutrition. Nevertheless, throughout the 1960s research worldwide tended to be focused on the effects of interventions to increase protein intake.

In 1974, McClaren wrote "The Great Protein Fiasco" in which he stated the view that the role of protein deficiency as a cause of child malnutrition had been overstated, and that more attention should be paid to energy deficiency (2). Around the same time, Joy and Payne supported this viewpoint by showing that the available protein content of diets in most countries was sufficient to meet requirements—not least because estimates of protein requirements had been lowered successively over time. Waterlow and Payne, in their article "The Protein Gap," insisted that the concept of a worldwide protein gap was no longer tenable (3).

In the late 1970s the majority of nutrition intervention programs focused on breastfeeding, and maternal and child malnutrition including complementary and supplementary feeding. UNICEF developed its "GOBI Initiative" (growth monitoring, oral rehydration therapy, breastfeeding and immunization) to improve child health and survival. Although the consequences of severe micronutrient deficiencies, especially those of vitamin A, iodine and iron deficiency, were known throughout these decades to be harmful to health and development, there was little understanding that milder forms of deficiency were so widespread or that they could also have harmful effects. As a result, at this time there was relatively little interest in developing programs in micronutrient deficiency control.

The World Food Study and Nutrition Collaborative Research Support Program

In 1977 the National Research Council in the United States conducted a "World Food Study" to discuss and prioritize the international agriculture and food research agenda. The study team in charge of nutrition concluded that the highest priority at that time was to determine if mild-to-moderate malnutrition had an adverse effect on human function. Globally, the main cause of malnutrition was now believed to be energy deficiency, due to lack of sufficient food. The functions that the team hypothesized would be affected most adversely were growth, psychological development and behavior, immune function and morbidity, reproductive outcomes including pregnancy and lactation, and social competence. To investigate these hypotheses the U.S. Agency for International Development funded the Nutrition CRSP in 1980.

The development and data collection phase of the Nutrition CRSP lasted from 1980 to 1986, although it took until the early 1990s to complete most of the data analysis and publications. The Nutrition CRSP was an observational, nonintervention study conducted in parallel in Egypt, Kenya and Mexico (4). The main independent variable for prediction of functional outcomes was intended to be the energy intake of ~100 of each of the following types of individuals: pregnant women (then followed through 6–8 mo of lactation) and their infants, preschoolers (between 18 and 30 mo), schoolers (for 12 mo between the age of 7 and 8 y), and adult men and nonpregnant/nonlactating women (for 12 mo). Outcomes were the functions listed above that had been hypothesized by the National

Research Council study to be those most affected by the energy deficit.

The results of the Nutrition CRSP have been published in detail elsewhere (for example, references 4–13). Those of most relevance to the present topic of documenting the importance of ASF, and micronutrient deficiencies as a cause of impaired human development are as follows: 1) growth stunting started at birth (or before) and was complete by 18–24 mo; 2) protein intakes and protein quality were adequate in all three locations as were energy intakes except when a famine occurred in Kenya; and 3) ASF intake was the strongest predictor of functional capacity (such as growth, lactation outcome and cognitive function) (Table 1). For example, in Kenya, consumption of ASF was the second strongest predictor of cognitive performance after duration of schooling (9) and ASF intake measured between 18 and 30 mo of age was the strongest predictor of cognitive performance measured later at 5 y of age.

There was a high prevalence in all three locations of inadequate micronutrient intakes and of deficiencies when measured (4,7). The highest predicted prevalences of inadequacy were for iron, zinc, calcium (except in Mexico where maize is prepared with added calcium), riboflavin, vitamin B-12, retinol and vitamin E. ASF are the main and/or most bioavailable source of these micronutrients in most diets, and the inadequate intakes in the Nutrition CRSP were due to the low intakes of animal products. The contribution of ASF to micronutrient intakes in these and other situations are reviewed elsewhere in this supplement (14). The percent of total energy from ASF was only 18% in Egypt, 8% in Kenya and 12% in Mexico.

The overall findings of the Nutrition CRSP were reviewed in a "Feasibility and Planning Activity" in 1992 (15). The conclusions of this activity were as follows: 1) the most important findings of the CRSP were that faltering in height and weight of children occurs early and was not caught up later in life; and 2) the *quality* of food (specifically ASF and micronutrient content) was a much stronger determinant of nutritional status than was the *quantity* of food. At that time, the findings were "recognized as being on the cutting edge of modern nutrition science". Another conclusion was that links should be forged between the Nutrition CRSP (which ended in

TABLE 1

Examples of functional outcomes related to animal source food variables in the Nutrition Collaborative Research Support Program¹

Outcome	Egypt	Kenya	Mexico
Pregnancy outcome	+	+	+
Infant cognition	+	+	+
Infant growth	+	+	+
Preschooler growth	—	+	+
Preschooler cognition	+	+	+
Preschooler activity	—	+	+
Schooler growth	+	+	+
Schooler cognition	—	+	+
Schooler activity	+	+	+

¹ This table is an over-simplification of the CRSP results in that it simply records the presence of any positive associations between animal source food intake of the mother (in pregnancy and lactation) or child (preschoolers and schoolers) and any function in the defined categories. Details of the actual analyses are provided elsewhere (for example, references 4–15).

1992) and other CRSP projects, to find ways to improve micronutrient status and nutrient bioavailability. It was perceived that food systems should be developed that integrate production of agricultural commodities and ASF, because in many poor countries dietary inadequacy is caused by a precarious balance between the quantity of agricultural production and its quality. Sadly, relatively little attention was paid to these suggestions perhaps because the NCRSP was a non-intervention study. Interestingly, if it had been, the intervention would probably have been wrong (increasing protein and/or energy intake). However, the results of the Nutrition CRSP provided a strong rationale for the Global Livestock CRSP Child Nutrition Program (CNP) in Kenya, which is featured in this supplement to *The Journal of Nutrition*. To validate the findings of the nonintervention Nutrition CRSP, the CNP tested the effect of controlled ASF interventions.

Strategies for improving micronutrient intake

Although the Nutrition CRSP findings further supported the importance of dietary quality, animal source foods, and micronutrients for human development and function, other research was particularly important in bringing the attention of the development community to the need to focus on micronutrient interventions—and indeed, on the demonstrable benefits of doing so. For example, in the mid-1980s, there was a renewed interest in iodine deficiency control, based on the recognition that iodine deficiency affected a wide range of functions resulting in the syndrome “iodine deficiency disorders”. Importantly, even marginal iodine deficiency had adverse effects. Moreover, salt iodization appeared to be an option for essentially eliminating the global problem of iodine deficiency. More attention was directed to vitamin A interventions after the mid-1980s, when it was demonstrated that vitamin A supplementation of preschoolers lowered their mortality by 34% (16). A meta-analysis of additional studies in other locations confirmed this result (17).

These and other findings led to global agreements at several major international meetings including the World Summit for Children, which set goals related to the elimination or reduction of iodine, vitamin A and iron deficiencies by the year 2000 (1). The goals provided a major impetus for much of the action of international, bilateral and national agencies during the past decade, and were since renewed. As a result, of the 130 countries affected by iodine deficiency, ~98 have legislation that requires salt iodization and 68% of households have access to iodized salt. About half of the countries in the world have programs that deliver vitamin A supplements to children under 5 y of age and to women during the first six weeks postpartum. Some reasons for the relative success of the programs to control iodine deficiency disorders and vitamin A deficiency include the following: 1) the programs can show a clear impact on health and provide known multiple benefits; 2) many people can benefit; 3) the interventions are practical; 4) there are strong advocates for these programs including consultative groups on iodine and vitamin A deficiency; 5) there is strong financial support from donors; and 6) there is substantial academic involvement (especially in vitamin A research). Iron deficiency anemia control has been less effective and less well supported, because these program success predictors are weaker in the case of iron, and iron supplementation is needed on at least a weekly basis (compared to once every 4–6 mo for high dose vitamin A). An additional problem is that effective iron fortification of staples is relatively difficult due to adverse interactions between available iron and food constituents.

Each of the main categories of micronutrient intervention (supplementation, fortification and dietary improvement) has its advantages and disadvantages. Supplementation is most useful for targeting larger doses of micronutrients to specific individuals (such as iron for pregnant women) and can have a relatively rapid impact. However, it often fails to supply all necessary nutrients, individuals in nontargeted groups are usually neglected, and compliance is poor especially when the supplements need to be taken very frequently and for extended periods of time. High dose supplements of vitamin A improve body stores for only a few months. In addition, supplementation programs are a “top-down” approach to solving nutrition deficiency problems that have diverted attention from more sustainable food-based approaches. Food fortification programs (mass fortification) can increase the intake of multiple micronutrients simultaneously and provide a cheap sustainable supply of these nutrients. Obviously, the fortified foods must be consumed in adequate amounts by all those in the population who need the additional micronutrients and this is often not the case, because poorer and undernourished segments of the population are more likely to produce their own food and purchase fewer fortified products. There are also some substantial technical barriers to fortification including adverse effects on the sensory qualities of foods, nutrient-nutrient interactions, poor bioavailability of some fortificants and the difficulty of fortifying some food staples such as rice.

From some perspectives, increasing micronutrient intake by improving dietary quality is the ideal approach. Consumption of more high quality foods, including ASF, has the benefit of increasing the intake of many nutrients simultaneously. Some of these nutrients, as well as other bioactive constituents of foods, would not be provided in either supplementation or fortification programs. All household members could benefit from improved household dietary quality, unlike supplementation programs, which are usually confined to women and young children, and fortification programs that may not reach the most needy population groups.

Is it realistic to influence the production and consumption of animal source foods?

The majority of nutritionists are well aware of the nutritional advantages of increasing ASF intake where dietary quality is poor. This is also the case for some nutrition planners and program providers, although it has been generally less true for the agricultural community and development agencies. Nevertheless, nutrition scientists and those responsible for nutrition policy and programs tend to readily discard the option of increasing ASF intake, due to the pervasive belief that poor populations all lack the necessary capital, land and other resources to be successful in animal production, and due to the potential for ecological harm. Several articles in this supplement, however, point out the potential economic benefits and sustainability of programs to increase ASF production and intake (18–22). In some cases, the programs have been relatively novel and provide useful examples that might be replicated in other locations (19–21). Although sociocultural and other household factors probably do not impede ASF consumption as often as cited (23) these do have an impact especially on intrahousehold distribution of ASF. Religious doctrines and beliefs are certainly a barrier to ASF consumption in many communities. Appropriate education about the health benefits of ASF can be effective for increasing the consumption of specific ASF, as demonstrated in a community intervention in Lima, Peru (24) and in Thailand (25). The agricultural sector can certainly improve ASF production, with the VAC

program in Vietnam providing one of the best examples (26). Preservation of ASF is often a constraint to local consumption, and one innovative and economically viable solution to this problem is described in this supplement (27). More need to be developed. Finally, data are provided in this volume to document the rapidly rising global production and consumption of ASF in many developing countries, which is a largely uncontrolled and unguided phenomenon (22, 27–29). This raises concern about the potentially adverse effects of high ASF on the health of populations undergoing the nutrition transition, largely due to the increasing intakes of saturated fat (29).

The long-term objective of programs concerned with ASF production and consumption, therefore, becomes ensuring that populations with currently inadequate intakes—especially the most vulnerable groups such as women and children—attain access to more adequate quantities of these foods, while reducing the risk of excessive intake by other groups. The development of better validated indicators of dietary quality, as described by Ruel in this supplement (30) would greatly assist our ability to proscribe and attain a healthy *range* of ASF intake for different population groups. Such indicators must be used routinely by policy makers and programs at the local, national and global levels to influence the production and consumption of ASF through various policies such as: 1) the provision of seed money and subsidies; 2) access to the best animal stock; 3) programs to support production and preservation; and 4) education about the need to include ASF in the diet in some populations and to avoid excessive saturated fats where appropriate. Poverty reduction programs will also increase ASF consumption. We must change from our present vision of ASF production and consumption as being difficult to either increase in some regions, or to control in others, to one that better manages the situation. It is important to view adequate dietary quality as a human right. Many articles in this supplement show that this can be done, even in poor communities that were the main focus and concern in this symposium.

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