Overview: Rationale and elements of a successful food-fortification programme

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Abstract

Over 2,000 million people, or more than one of three individuals throughout the world, are at risk for iron, vitamin A, or iodine deficiency. The three main approaches to addressing micronutrient deficiencies are fortification, supplementation, and dietary diversification. Although fortification of staple foods has played a significant role in the nutritional well-being and health of the more industrialized nations, it has not been considered an option for less developed countries because of the lack of centrally processed foods and poorly developed food-marketing systems. As food markets expand, however, fortification options are becoming increasingly available. This paper identifies past and present successes and failures, as well as the facilitating factors and constraints that need to be addressed. Based on recent experience and the lessons learned, successful programmes require at least the following: political will and support and the willingness to legislate or regulate; private-sector involvement; public-sector support; willingness of both sectors to enforce quality assurance programmes; good data on consumption patterns; social acceptability of fortified food, implying no change in organoleptic properties; and minimal change in cost.

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 more than 159 countries [1]. This paper will look at one of the main strategies being used to address this problem: fortification and the elements of a successful programme. Other complementary approaches to prevent and control micronutrient malnutrition include diet diversification, pharmacological supplementation, and public health measures, such as immunization and control of infectious diseases.

Extent of the micronutrient problem

Micronutrient malnutrition is a serious threat to the health and productivity of more than 2,000 million people worldwide, even though it is largely preventable [2]. Because of their high prevalence and close association with childhood illness and mortality, the three micronutrient deficiencies of greatest public health significance are those of iron, vitamin A, and iodine. Women and children are more vulnerable to micronutrient deficiencies because of their added requirements for reproduction and growth, respectively [3].

Fortification as a prevention and control approach

Fortification is defined by the Codex Alimentarius as “the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups” [4].

Micronutrient interventions, and particularly fortification, have been identified by the World Bank as among the most cost-effective of all health interventions [5]. There is a wealth of experience in fortifying foods, and it has been a major factor in the control of micronutrient deficiencies in the industrialized world [6]. It is now being extended in some of the wealthier nations to provide preventive action against deficiencies of nutrients that are not in real shortage in the diets of the general population. For example, in Australia thiamine is added to wheat flour to address the relatively high levels of cerebral degeneration (which

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Mention of the names of firms and commercial products does not imply endorsement by the United Nations University.

are seen, however, in less than 1% of the population) associated with diets low in thiamine and high in alcohol (Wernicke-Korsakoff syndrome) [7]. In the United States flour is fortified with folate to prevent congenital malformations of the spinal cord (neural tube defects, including spina bifida), which affect approximately 2 in every 1,000 pregnancies [8].

Until recently it was presumed that fortification was not a suitable intervention in the less industrialized countries, since previous experience in developing countries has not always been encouraging [9]. However, there are now enough successful examples to suggest this is no longer true. Mora and Dary* list 17 countries in Latin America that now fortify foods with at least one micronutrient and sometimes more.

Requirements for effective fortification in food-aid programmes will not be discussed, although the issue is very important and is currently receiving a lot of attention. For the purposes of this review, it suffices to mention that fortification of food aid for displaced persons and refugees was endorsed at the International Conference on Nutrition (ICN), which included the recommendation that "donor countries and involved organizations must… ensure that the nutrient content of food used in emergency food aid meets the nutritional requirements if necessary through fortification, or ultimately supplementation" [1].

Fortification programmes

Some experiences with fortification, especially in developing countries, will be examined below.

Vitamin A

Fortification has been important in reducing deficiencies of vitamin A, especially in Latin America where sugar is fortified with it. Other fortification vehicles have included whole wheat, monosodium glutamate and instant noodles, rice and other cereals, tea, fats and oils, milk and milk powder, rice, salt, soya bean oil, and infant formulas [10].

Sugar

The fortification of sugar with vitamin A is actually a success story but does offer a couple of lessons. Despite demonstrated success in the Guatemalan programme in the early 1970s, with increases in the status of recipients' vitamin A levels and, indirectly, haemoglobin levels, the programme faltered in the 1980s [11]. This was because of a lack of continuing government commitment, indifference from the producing sector, economic limitations, and, presumably, a lack of self-sustainability (in terms of passing on costs, etc.), so that it could not continue without some public-sector involvement. It has now been revitalized, although some technical improvements are still needed. In a start-up programme in Bolivia, involving a partnership among government, donors (US Agency for International Development and UNICEF), and a commercial firm, sustainability has yet to be assured, although there are currently plans for scaling up nationally by the private sector. However, this is happening for reasons of economic scale and before all the technological problems have been clearly resolved. For instance, a recent evaluation of the levels of vitamin A in fortified sugar has shown them to be quite low. Ecuador had moved along the path towards fortification, but after a meeting on sugar fortification in Guatemala early in 1996, the government decided that the technical problems were still too unresolved for the country to commit to such a programme. Nevertheless, sugar has been fortified with vitamin A in Costa Rica, El Salvador, Guatemala, Honduras, and Panama. Other countries, such as the Philippines in Asia and Uganda in Africa, are also interested.

Wheat

An interesting programme using whole wheat was developed in Bangladesh with technical assistance and support from the US Agency for International Development through Helen Keller International. Because wheat is the less preferred staple, the fortification programme would have been automatically targeted to the poor. It became, however, an example of a technically feasible, properly developed programme that failed politically because it did not adequately involve the policy makers and those most affected [9, 12]. The Philippines is currently testing vitamin A fortification of wheat flour.

Monosodium glutamate

The project to fortify monosodium glutamate (MSG) with vitamin A was also technically feasible and had been properly developed by consumption, taste, and impact trials in both Indonesia and the Philippines [13, 14]. There are several reasons why it failed at the time. Some of the technological developments were released too early and subsequently found not to have been resolved, e.g., yellowing of the MSG in a product that sold itself as "pure white" [9]. Key government policy makers were not convinced of the safety of MSG, despite statements by the Food and Agriculture Organization/World Health Organization (FAO/WHO) regarding its safety, and there was a further lack of conviction on the part of the private sector in the programme's cost-effectiveness. It is possible that it may still go ahead in Indonesia as a purely private-sector initiative. How-

*Mora JO, Dary O. Strategies for prevention of micronutrient deficiency through food fortification. Lessons learned from Latin America. Presented at the 9th World Congress of Food Science and Technology, Budapest, Hungary, 1995.

ever, in the Philippines the programme seems permanently stalled, and other vehicles are now being investigated.

Rice and other cereals

Again, although technically feasible as a pilot, the fortification of rice with vitamin A has not proceeded to the national level in any country. Both the Dominican Republic and the Philippines have attempted to fortify rice with vitamin A [6]. In the Philippines the 15% to 20% losses from water washing were considered unacceptable [9]. A feasibility trial of a fortified rice premix is under way in Indonesia, but the government has made known its lack of enthusiasm for fortifying the national staple. In Brazil the programme is still at the stage of testing bioavailability [10]. In Venezuela, on the other hand, pre-cooked corn flour, which is used to make *arepas*, a staple food in the national diet, has been successfully fortified with vitamin A, thiamine, riboflavin, niacin, and iron [15].

Tea

In three countries, India, Pakistan, and Tanzania, technically feasible programmes to fortify tea with vitamin A have not proceeded, although they have been properly developed and tracked [10].

Fats and oils

In developed countries, fats and oils have been the main vehicles of vitamin A fortification, often with other micronutrients such as vitamin D. The production of a variety of vegetable oils is high throughout the world, and consumption is increasing, especially among the low socio-economic sectors of the population. Thus, oil represents an ideal fortification vehicle to reach these groups [10]. An important example of cooperation among the food industry, government, and academics has been the relatively successful fortification of Star Margarine with vitamin A in the Philippines, which has led to the fortification of canned sardines. Programmes of fortifying margarine with vitamin A are currently ongoing in Brazil, Chile, Colombia, El Salvador, Mexico, and other countries around the world, especially developed countries. In India, red palm oil is added to other edible oils, and vitamin A–fortified soya bean oil is being tested in Brazil [16].

Summary of vitamin A—fortification programmes

Success in vitamin A fortification has depended on sustained political commitment (both in-country and by donors), persistence with technical development of fortificant technologies to overcome problems, increased awareness of the health consequences of vitamin A deficiency by governments, and involvement of the private sector. Fortification programmes have been shown to be effective in a variety of settings [11, 15, 17].

Iron

Compared with other strategies used for correcting iron-deficiency anaemia, with which relatively little progress has been made worldwide, iron fortification is the cheapest to initiate and maintain, reaches the largest number of people, guarantees sustainability [18], and lacks the side effects and logistical problems that have often affected iron-supplementation programmes. Long implemented in developed countries, iron fortification is now being adopted in several Latin American and Caribbean countries in accordance with government regulations. In developed countries, wheat flour and cereal-based foods have had significant success as vehicles for iron. Other vehicles include infant weaning foods, salt, sugar, rice, curry powder, fish sauce, soy sauce, bakery products, beverages, biscuits and cookies, low-fat milk, chocolate milk, maize flour, margarine, and water [4, 10].

Rice

There has been extensive commitment to fortify rice with iron by the Filipino government, which, unlike the Indonesian government, recognizes the good sense in fortifying the national staple. However, technical problems with discolouration, the multitude of rice-milling factories, and a lack of demonstrated success in a pilot trial promoting the idea of buying sachets of fortified rice grains to add to unfortified rice (which people picked out after the rice was washed) indicate that this programme has not proceeded as expected, despite government support. Iron-fortified rice may have a role in government-subsidized rice stabilization programmes, but in this case, the programme's sustainability would become more problematic.

Other cereals

Programmes to fortify other cereals with iron have generally been successful, although, given the inhibitory effect of cereals on iron bioavailability, cereal fortification may not be the most efficient way to reduce iron-deficiency anaemia [10]. However, it has been useful in many countries and has been found to be cost-effective [6, 10]. Chile has used animal blood as a convenient and cheap source of iron for fortification programmes [10]. Venezuela has fortified pre-cooked corn flour, to which other micronutrients, including vitamin A, have been added. Wheat flour (without vitamin A) has also been fortified with iron successfully on a national basis [15]. The OMNI Project is currently working with the Sri Lankan government to test the efficacy of the fortification of wheat flour with iron for tea plantation workers, with the intention of scaling up to a larger programme when its efficacy has been established. The private sector in Indonesia and other Asian countries is developing instant noodles fortified with iron and other nutrients, aiming initially at a middle-income more than a low-income market.

Salt and other products

Fortification of salt with iron has been implemented on a limited scale in India and Thailand, but although it appears to be technically feasible, it has not, at this time, been adopted more widely [10]. Iron-fortified salt may have a greater role in double fortification (see below). Other vehicles of fortification include rice flour (Argentina and Chile), fish sauce (Thailand), curry powder (South Africa), and such products as barley sprout flour, coffee, grain amaranth cereal, maize meal, potato starch, and wheat flour noodles, all of which are currently being investigated and developed; however, their future on a large and sustainable scale remains uncertain [10]. In Brazil there is an experimental project in some day-care centres to fortify water-filtration systems with iron.

Summary of iron-fortification programmes

Success with iron fortification has involved finding appropriate iron fortificants and food vehicles in terms of organoleptic properties, getting government commitment (often by legislation as a political act), and increasing awareness of the extent of the problem of iron deficiency as well as the fact that other interventions have not been particularly sustainable or successful. Fortification with iron has also been shown to be effective, e.g., in Chile and Venezuela [15, 19].

Iodine

Iodine has been most vigorously pursued as a fortificant of salt for a variety of reasons, especially those factors which lead to or contribute to successful programmes: consumption in fairly consistent amounts by all sectors of society, consumption at roughly consistent levels throughout the year, and technological feasibility and cost-effectiveness. It has also had the advantage of strong international and government commitment and an international experience that has been freely shared. Countries with effective iodized salt programmes have shown sustained reductions in the prevalence of iodine-deficiency disorders [6, 10, 20]. However, sustainability has not always been ensured, and the populations of countries like China, Germany, and Switzerland showed increases in the prevalence of iodine deficiency where commitment to the programme was not maintained.

Another problem has been the assumption that fortification could be imposed from the top without the involvement or commitment of consumers and, sometimes, policy makers. This has led, in some cases, to consumer groups suing governments for the right to consume non-iodized salt, e.g., in India, and to both consumers and government not being aware of the importance and significance of iodization in terms of national health and economic productivity. It is essential that people know why their salt is iodized and what the associated benefits are, so that the programme ensures sustainability through consumer demand. It has also been shown that all salt (including salt intended for animals and industry) must be iodized to ensure the success and sustainability of these programmes [10, 20].

Other vehicles of iodization have included bread, sweets, milk, flour, sugar, and condiments. Fortification of animal feeds can be useful in increasing the iodine content of animal products [4]. Dietary intake of iodine can be increased by adding iodine to drinking water (as in schools in Thailand) or to the local water supply (as in China), or by using a commercial attachment to water pumps with slow-release resins, which is currently under trial.

In summary, the success with iodization has been due to its relative technological straightforwardness, much international experience, proven efficacy, and enormous support and advocacy from the international donor community, such as UNICEF and the International Council for the Control of Iodine-Deficiency Disorders (ICCIDD)[20].

Multiple fortification

Multiple fortification of foods is a possible way of addressing deficiencies of two or more micronutrients at the same time in a cost-effective manner, although some organizational, technical, and micronutrient-interaction constraints need to be addressed in developing countries. Nevertheless, progress is being made, e.g., in double fortification of salt with iodine and iron [21]. Multiple fortification has been successful in the more developed countries, particularly in fortification of cereals and infant-weaning foods [10]. In some cases, fortification with two micronutrients (e.g., iron and vitamin A or iron and vitamin C) would enhance the effects of fortification on micronutrient status [6, 22].

Nevertheless, it is important to remember that although scientific and engineering advances have resulted in an increasing number of options regarding the choice of fortificant compound and processing procedures, there is a limit to the possibilities of new technologies. For example, multiple fortification of certain food vehicles may result in substantially increased cost and reduced bioavailability [23]. Changes in the sensory or organoleptic characteristics of the food can also be a problem. For example, encapsulation of micronutrients may not be cost-effective in some countries, even though the technology is theoretically available.

Other micronutrients

The focus of the international community has been on the three most prevalent micronutrient deficiencies (vitamin A, iron, and iodine). Clearly, other micronutrients, such as vitamins D, E, and C and the B-complex vitamins, are also likely to be important in many settings and are used as fortificants in many countries in different combinations. There is mounting evidence that zinc deficiency may be important in many population groups. However, for focus, and reflecting current international priorities, this paper has only addressed vitamin A, iron, and iodine.

Constraints to successful programmes

Factors involved in constraining the development of successful programmes might be categorized as technical, socio-economic, infrastructural, and political.

Technical constraints

Technical problems must be considered, such as the installation and maintenance of new machinery, the stability of added micronutrient fortificants in the food, and, sometimes, the need to develop new technologies, such as adding vitamin A to MSG. Innovative fortificant development does not appear to have been a major constraint; for example, wheat grains have been coated with a clear, vitamin A–containing shellac. However, some have yet to be fully overcome, such as double fortification of salt with iron and iodine. Technical constraints to successful fortification programmes include the purity of salt needed for effective iodization, the presence of phytates and other substances that affect the bioavailability of non-haem iron fortificants, and the storage conditions necessary for vitamin A–fortified foods [4, 6, 10]. The long time periods and high costs required for the development of new combinations of fortificants and vehicles must be considered when planning fortification activities [9].

Socio-economic constraints

Socio-economic constraints include the facts that fortification relies on a centrally processed and marketed food vehicle and that only those purchasing and consuming the food, who may not be the very poor, will benefit [6, 24]. Also, such foods may not be available or accessible in less developed countries, particularly to the more at-risk, poorer rural segments of society. The transfer of the costs of fortification to the consumer, even when slight, can deter the very poor from purchasing such foods. Setup costs can also be an inhibiting factor at the start of a fortification programme. The demand that programmes make on foreign exchange may represent another constraint, unless it is feasible to manufacture the fortificant or the fortified foods at the local or regional level [6].

Infrastructural constraints

Experience of the public and private sectors working together is often limited, although such cooperation is essential. Cooperation of the food industry has often not been ensured at an early enough stage in programme development. Linkages between the health care system and the private food sector are usually weak. A background paper for a recent FAO consultation concluded that active government participation must continue for food-fortification programmes to succeed in developing countries [25]. Other infrastructural constraints in a country may affect quality assurance and regulation, suggesting that the lack of adequate food-control systems could constrain the success of food-fortification programmes. Distribution can be affected by poor roads, inadequate storage and delivery systems, etc., particularly in rural areas. This lack of infrastructure has meant that the time lag between starting a programme to retailing fortified food has tended to be longer than anticipated. Lack of adequate political, financial, and technical support for an efficient monitoring and surveillance system is often a cause of programme failure as well [4].

Political constraints

Political support may be lacking for a number of reasons. Nutrition and health are relatively low priorities in national budgets when there are many competing demands. Furthermore, the lack of good programme evaluations in the past has failed to provide a convincing body of data for policy makers [6], although this is changing. There is often a concern about start-up costs and the costs of regulation. A simple lack of awareness of the magnitude of micronutrient malnutrition and its economic and health costs is frequently an underlying constraint. Political and financial incentives can be offered in the form of tax exemptions; import licences and loans for equipment and raw materials; initial subsidies to procure fortificants; assistance in developing an in-process quality control system; training of production, administrative, and marketing personnel; training of the wholesale and retail sector; and prohibition of illegal imports. However, these incentives are rarely offered. Mandatory quality assurance and control can be ensured through legislation and regulations [10], but industry still needs to comply. Care needs to be taken that special provisions given to one firm do not distort incentives for other companies, as happened in the Philippines, when one company was given the concession of an extended monopoly that effectively inhibited competitors from fortifying salt.

Other constraints

A major overall constraint on fortification is the lack of an obvious food vehicle that can reach the targeted recipients. In many cases, identification of suitable vehicles is made difficult by the absence of reliable information on the dietary habits of the target population [4]. The major problems involved in fortifying foods include the identification of suitable vehicles, selection of appropriate fortificant compounds, determination of technologies to be used in the fortification process, and the implementation of appropriate monitoring mechanisms to determine whether the goals of the programme are being met [4].

Facilitating factors in successful programmes

Technical facilitating factors

There is a minimum set of requirements that a fortified food must have to be successful (table 1). Innovations in appropriate technology, especially in small-scale salt iodization, village-level mixers in Thailand, and small mechanized and relatively cheap machines manufactured in Bangladesh, China, and India, have proven important facilitating factors. Newly emerging markets in less industrialized countries are encouraging the development of more stable fortificants and the fortification by the private-sector food industry of their own commercially sold foods, e.g., margarine in the Philippines. Consumer acceptance through the testing of fortified food, which must be done at several locations and under varying cooking conditions in the country in which fortification will take place, must also be ensured. Where consideration has been given to problems potentiated by increasing production activities from the pilot level to industrial scale, success has been more likely.

Socio-economic facilitating factors

Fortification is largely socially acceptable and does not require active consumer participation or changes in cooking or eating habits if organoleptic properties are maintained. When the different sectors of society participate actively as partners, successful programmes are more likely to result. These should include relevant government institutions, the food industry, trade organizations, consumer organizations, academic and research facilities, marketing specialists, and interested international organizations and agencies [9, 26]. For example, the overall responsibility for quality control inside the country often rests with the Public Health Department, but consumer organizations can and should be involved. Schools and industry are both involved in the monitoring of salt-iodization programmes in Ecuador [27], a relationship that has recently been proposed in Eritrea. In India non-governmental organizations in Uttar Pradesh are involved in monitoring salt for iodization at the retail and household levels, and local politicians are involved to the extent that they point out inadequacies to the provincial and national parliaments [10].

TABLE 1. Requirements for a fortified food

» Commonly consumed by the target population
» Constant consumption pattern with a low risk of excess consumption
» Good stability during storage
» Relatively low in cost
» Centrally processed with minimal stratification of the fortificant
» No interactions between the fortificant and the carrier food
» Contained in most meals. with the availability unrelated to socio-economic status
» Linked to energy intake

Source: ref. 4.

Infrastructural facilitating factors

A major infrastructural advantage is the existence of a commercially processed food with a widespread distribution system, thus making the introduction of the micronutrient-fortified food relatively easy. Effective fortification needs to be supported by suitable legislation and regulations; however, legislative measures are more likely to allow for successful programmes when they do not make fortification practices cumbersome or restrict communication about the availability of the fortified food. This has been avoided by including extensive consultation with the scientific community, industry, consumers, and other relevant interested parties in the legislative process [4]. When good quality assurance and quality control exist, particularly as a partnership between government and industry (e.g., in the development of the Sangkap Pinoy quality seal in the Philippines), proper fortification of some commercial foods through successful programmes is ensured.

Political facilitating factors

Increased awareness of the health, developmental, and economic consequences of micronutrient malnutrition is important, especially for sustainability. Political advocacy of fortification is sometimes more direct in developing countries, as exemplified by the endorsement of programmes to prevent micronutrient malnutrition at the highest levels in the Philippines, Thailand, and some other countries. The relative cost-effectiveness of fortification is a strong incentive for governments if they can be convinced. Finally, fortification has high sustainability [6, 11].

Conclusions

The concepts of what constitutes a successful programme and what fortification with micronutrients attempts to achieve have undergone something of a paradigm shift over the last few years. Previously the intention was to target those most at risk by programmes in the public sector with donor support. In government-subsidized programmes, sometimes with a political agenda, equity aim, or intentions for very specified groups such as refugees, this is still appropriate. However, there is now a strategy to move the targeted population to the left of a distribution curve (fig. 1) so that a larger portion of society will be addressed by the private sector. Where these foods are not able to reach or be bought by the poorest or those generally most at risk, these more vulnerable populations may need to be addressed by other initiatives, such as targeting with supplements or with feeding programmes [24]. In Western countries, for example, fortified foods were bought initially by the middle classes primarily, and then became more and more the foods that are bought by all. Even in countries such as the United States, there are less advantaged groups needing special programmes, such as the Women, Infants, and Children (WIC) programmes.

The main lesson up to this point has been that although simple nutritional and technological solutions to the problems of micronutrient malnutrition exist, these are often complicated by economic, social, and political factors [4, 6, 10]. Following from the above, conditions necessary for the success of food-fortification programmes include the following:

» political will and support, which must be maintained from the developmental stage through quality assurance and control;
» understanding of the problem by having adequate data on the magnitude of the nutritional problem being addressed;
» adequate data on food-consumption patterns;
» industry support with involvement of local industry and the private sector;
» adequate technical expertise, sufficient time for the development of the food, and adequate testing under a range of real field conditions;
» a multisectoral approach in establishing a programme, including key governmental organizations, the food industry, trade organizations, the scientific community, consumers, marketing specialists, and other relevant interested parties, early in the process;
» adequate application of legislation and regulations, including those for external quality assurance;
» facilitative rather than punitive regulations; i.e., guidelines should not be so restrictive as to impede the provision of high-quality fortified foods nor hinder communication on fortification between relevant parties;
» human resource training at the industry and marketing levels and of public health and food-safety personnel;
» appropriate fortification levels evaluated and adjusted according to the bioavailability of the nutrient in the diets of the target population;
» good bioavailability of the compound and no constraints on procurement of the micronutrients;
» no inhibitory effect of the common diet (and in the case of iron-deficiency anaemia and vitamin A deficiency, complementary control of parasitism, infectious diseases, and other non-dietary causes);
» intensive and appropriate investment in information, education, and communication about the problem and the fortification approach, to ensure consumer acceptability and also to ensure that there are no cultural or other objections against fortified foods;
» minimal cost increases to the consumer;

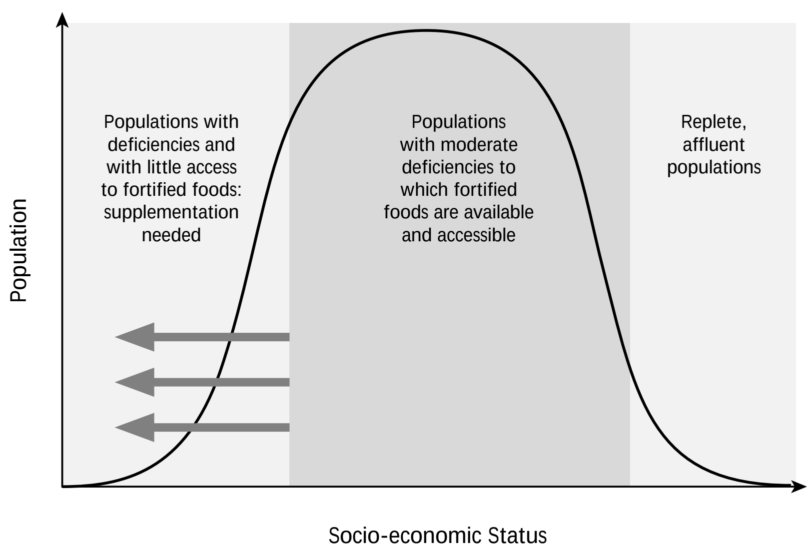

FIG. 1. Paradigm for increasing micronutrient intakes in populations with micronutrient deficiencies

» relevant nutritional information available through adequate labelling to help ensure consumer involvement, commitment, and understanding of the advantages of fortifying foods.

Summary

From recent experience and the lessons learned from it, it is clear that the attributes of a successful programme require at least the following: political will and support and the willingness to legislate or regulate; private-sector involvement; public-sector support; willingness of both sectors to enforce quality assurance; good data on consumption patterns; social acceptability of the fortified food, implying no change in organoleptic properties; and minimal increase in cost. The current situation and the existing resources and constraints need to be assessed in each country. However, fortification has clearly become a viable and cost-effective intervention for countries to adopt in their efforts to control and prevent micronutrient malnutrition.

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