Designing effective programmes to prevent and control iron deficiency anaemia

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Iron deficiency anaemia is a global public health problem as compelling and harmful as epidemics of infectious diseases. It affects hundreds of millions of people around the world, most of them women and young children.

Defining the problem

Iron deficiency anaemia (IDA) is the most severe degree of iron deficiency and occurs if the haemoglobin concentration falls below a threshold level. For every case of IDA in a population there are thought to be at least two cases of iron deficiency.

Prevalence

More than two billion people worldwide are iron-deficient. In sub-Saharan Africa an estimated 42% of women aged 15 - 45 years are anaemic and the prevalence is more than 50% during pregnancy. At least 20% of maternal deaths during pregnancy are associated with anaemia. Children aged 1 - 2 years are also extremely susceptible to anaemia.

Causes

IDA is largely caused by: (*i*) an insufficient dietary intake; (*ii*) poor bio-availability of iron consumed — related to a low consumption of absorption enhancers and high consumption of absorption inhibitors; (*iii*) increased requirements at certain stages in the life cycle, notably during pregnancy and rapid early childhood and adolescent growth; (*iv*) blood loss due to menstruation and childbirth among women; and (*v*) parasites, most importantly hookworm.

In addition, chronic and recurrent infections such as diarrhoeal disease, malaria and HIV can contribute to severe anaemia. In fact, anaemia in Africa tends to have multiple aetiologies including malaria, deficiencies of iron, folate, protein and possibly other micronutrients such as vitamin A and riboflavin, and infections such as sickle-cell disease and AIDS.

Consequences

One of the greatest dangers posed by iron deficiency is that it diminishes the ability to fight infection, and thus increases vulnerability to transmissible diseases. Anaemic expectant mothers face the risk of death resulting either from spontaneous abortion, the stress of labour or other delivery complications. A recent review of anaemia and maternal mortality showed that at least 20% of African women who die in childbirth each year do so because of the effects of anaemia. Even in developed countries 18% of pregnant women suffer from iron deficiency anaemia. Maternal anaemia almost always leads to infant anaemia. The babies of severely anaemic mothers suffer from low birth weight and have a greater than average risk of early death. Mental and motor development is impaired in anaemic infants and children and apathy, inactivity and significant loss of cognitive abilities can occur. The effects on a child's development can be irreversible. Work capacity and hence in many cases earning capacity of adults is considerably reduced by anaemia. The potential effect of anaemia on the national economic output can be substantial.

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Strategies to address the problem

Anaemia is more complicated than other micronutrient deficiencies because it is only partly caused by dietary insufficiency of nutrients. In many countries malarial and helminth infections and AIDS are also important causes of anaemia. In these cases food-based interventions alone will be insufficient. The challenge is to develop a policy based on knowledge of multiple aetiologies of anaemia and to mobilise support for effective interventions.

Combating IDA most often requires a combination of approaches. National programmes that include iron supplementation for certain well-defined groups, food fortification, nutrition education, promotion of exclusive breast-feeding for up to 6 months and social marketing for improved available iron in the diet may all be part of the solution. Experiences with each of these interventions and ways to strengthen their effectiveness are discussed below.

Supplementation

Pharmaceutical iron supplementation involves the provision of iron (usually as ferrous sulphate) in capsule, tablet or elixir form. The great majority of iron supplementation programmes are focused on correcting pre-existing IDA, i.e. one of therapy or correction rather than prevention. In iron-deficient women who become pregnant food-based strategies to raise iron status will not be enough to respond to the increased iron requirement. However, despite proven biological effectiveness or efficacy, few large-scale supplementation programmes have been found to be operationally effective. The main operational constraints are: (*i*) inefficient and irregular supply of supplements; (*ii*) low accessibility and utilisation of antenatal care by pregnant women; (*iii*) inadequate training and motivation of front-line health workers; (*iv*) inadequate counselling of mothers; and (*v*) low compliance with the supplementation regimen by the intended beneficiaries .

Effectiveness can be improved by addressing all of these identified constraints. In summary:

1. Awareness and demand need to be generated, aimed at both women and men. Communications need to derive from an understanding of local terms, perceptions, beliefs, traditions and

perceived obstacles to compliance, including side-effects.

2. Programme functionaries must be community-based, motivated, well-trained, approachable and supportive. They must be able to explain the nature of the problem and how it can be tackled successfully, including other diet-based approaches. Supplements should be promoted positively as health-promoting rather than negatively as disease-curing. Community leaders should be involved.

3. Population coverage must be high and targeted to at-risk groups (e.g. pregnant women and adolescent girls) and at-risk areas (endemic malarial or hookworm-infested areas).

4. Supplementation must be initiated early in pregnancy.

5. Delivery systems should be functionally integrated within but not limited to existing channels, e.g. schools, traditional birth attendants through the expanded programme for immunisation (EPI) outreach. Supplements could also be made available at retail stores either free, at cost or in exchange for a coupon from the health centre.

6. The procurement process must be well organised and the supply regular and timely. Supplements must be of good quality, stability and shelf life, and acceptable to the local population.

7. Monitoring must be simple but effective at all levels, from supply through coverage and consumption to measuring biological impact.

Dietary modification

Dietary modification is primarily a strategy for improving either the amount of food iron ingested in the diet or its bio-availability. Absorption of iron is influenced by four dietary characteristics: dietary iron content, physicochemical form of the food, other dietary constituents and food processing techniques. The higher the level of the iron to which the intestinal mucosal cells have been exposed, the lower the relative efficiency of iron absorption. Dietary iron exists either as haem iron (in meat, poultry and fish) or non-haem iron (in milk, eggs, cereals, vegetables and fruits). These two forms are absorbed by different pathways and with different degrees of efficiency. Haem iron is 20 - 30% absorbed in normal individuals. However, only the main proportion of dietary iron in developing countries in the non-haem form is derived from cereal-based diets. Non-haem iron absorption may be as low as 5% and varies over a wide range of 1 - 40%.

Inhibitors such as phytates and polyphenols decrease overall solubility and absorption of iron in the meal. Enhancers such as ascorbic acid and citrates form soluble complexes with iron and increase its absorption. Wet heat processing and any enzymatic process that results in high phytase activity, e.g. soaking, malting, germination, lactic acid fermentation and leavening of bread with yeast increases absorption. Phytates may also be physically removed through extraction and dehulling of grains although this will also remove some of the iron.

Dietary iron intake is closely related to energy intake. Even with an adequate food intake the extent of absorption required to ensure sufficient iron through the diet would be far higher than can be realistically expected from cereal-based diets especially for infants, young children and women.

The main behavioural actions to improve dietary iron adequacy would include a combination of: (*i*) exclusive breast-feeding of children for the first 6 months of life followed by complementary feeding with iron-rich foods; (*ii*) increased intakes of absoption enhancers, e.g. meat, fresh fruit and vegetables; (*iii*) reduced intakes of inhibitors, e.g. coffee, tea, phytates in some cereals; (*iv*) germination, malting and fermentation to enhance iron absoption; and (*v*) intakes of complementary nutrients, particularly vitamin A, folate, riboflavin and vitamin B_{12}.

Unfortunately, there are few clearly documented examples of successful approaches to dietary modification through behavioural change. Often even successful communication projects are difficult to sustain. This points to the need for more positive reinforcement through regular and sustained interpersonal and mass media communications. This calls for a reliable pre-existing cadre of community-based health workers or another network of potential communicators. Training of community-based workers (of several sectors, not just health) should incorporate approaches to counselling and participatory information, education and communication aimed at increasing and diversifying dietary intakes. This would require an understanding of local cultural traditions and taboos and appropriate support and feedback throughout the process of change.

Food fortification

Fortification is the process of adding vitamins and/or minerals to food to increase its overall nutritional content. Fortification, when imposed on existing food patterns, may not necessitate changes in the customary diet of the population and does not call for individual compliance. It could often be dovetailed into existing food production and distribution systems. For these reasons, fortification can often be implemented and yield results quickly and be sustained over a long period of time.

The primary objective of iron fortification of foods is to prevent iron deficiency or sustain adequate iron status of a population over the medium to long term. Food fortification with iron makes sense only if iron deficiency is related to low iron intake, low iron bio-availability or both. If successful, fortification can over time facilitate a rightward shift in a population's distribution of iron status that would result in lower proportions slipping from iron deficiency into frank anaemia. In developed countries where there is a high dependence on processed foods and industries are streamlined and automated, food fortification has played a major role in the health of the populations at large over the last 40 years and several nutritional deficiencies have been eliminated. If fortification and supplementation are undertaken concurrently in an area then the prevalence of IDA may be reduced faster than would be possible with supplementation alone.

While iron has the potential for use in more food vehicles than iodine or vitamin A, fortification with iron is technically more difficult than with other nutrients, since iron reacts with several food ingredients. The biggest challenge with iron is to identify a form that is adequately absorbed and yet does not alter the appearance or taste of the food vehicle. The buff-coloured insoluble iron phosphate compounds are stable under a variety of storage conditions but are poorly absorbed. The soluble iron salts like ferrous sulphate are well absorbed but easily discolour by reacting with food ingredients. In addition to the general fortification criteria, iron fortification needs to take into account certain specific considerations:

1. The vehicle should be a component of all meals because absorption varies inversely with the iron content of the meal.
2. It should not require prolonged storage, particularly under hot and humid climatic conditions, since this could cause organoleptic problems.
3. Vehicles that are dark in colour or have a strong taste or odour permit the use of more reactive iron compounds.
4. Segregation of iron should not occur during mixing or storage.

Examples of foods fortified with iron include processed cereals (such as wheat, maize and rice), salt, sugar, cookies, condiments (curry powder, fish sauce, soy sauce). Wheat flour and bakery products have had significant success as vehicles for iron in developed countries like the USA, Sweden and Canada. More recently Venezuela, Ecuador, Brazil and several other Latin American countries have implemented universal fortification programmes for wheat and corn flour with iron, vitamin A, thiamin, riboflavin and niacin. Recent work at the University of Toronto supported by the Micronutrient Initiative (MI) has shown the feasibility of double-fortifying salt with iodine and iron. It uses a dextrin encapsulation technique that provides a barrier between the iron and iodine compounds and thus improves stability. The salt is currently being field-tested in Ghana for efficacy and consumer acceptability. The successful testing and large-scale application of available technology for the double fortification of salt could represent a major breakthrough for combined iron and iodine delivery. Several condiments have been tested as carriers for iron. In Thailand fish sauce fortified with NaFeEDTA has shown good haemoglobin response. Curry powder used by the Indian population in South Africa has been fortified with NaFeEDTA with successful results. In China the feasibility of using soya sauce as a carrier for iron is being examined. However, all these studies have been only pilot trials and are yet to be expanded into large-scale programmes.

There is a growing trend in several developing countries to use processed foods such as noodles, breakfast cereals and soup cubes as vehicles for iron. Weaning foods for children are also becoming popular. In Chile, chocolate cookies have been fortified with dried haemoglobin for distribution as part of a school lunch programme. In Mexico chocolate milk powder is fortified with iron. In Tanzania a fortified orange beverage drink has been effective in improving iron and vitamin A status among schoolchildren. Barring such programmes with a defined target population, it is not expected that processed foods or beverages could serve as a mainstay for food fortification programmes in the developing countries. While fortifying such foods, it must be kept in mind that it is virtually impossible to ascertain the effect of any one product on iron balance in the population and that it is difficult to regulate the level of iron supplied to the population. Unlike iodine or vitamin A, a realistic level of iron fortificant in a single food vehicle could only provide 20 - 40% of a person's iron requirement based on expected consumption.

Iron fortification of complementary foods for infants and young children after 6 months should be explored where iron deficiency is common. This is the most common form of targeted fortification for which a clear effect has been shown. A recent South African study showed a significant effect of iron-fortified soup on the iron status of 6 - 8-year-old children after 5 months. A recent review in South Africa has concluded that iron fortification will not lead to the development of iron overload among normal individuals because there is a very efficient system of down-regulation of dietary iron absorption and an actual blocking at certain iron store thresholds.

In addition to the choice of food vehicle and iron source there are other operational prerequisites that relate to relationships between public and private sectors, legislation, financial support, incentives and management information systems. Commitment and active collaboration between many sectors, both public and private, will be critical to getting a fortification programme off the ground. Government sectors, private industry, the scientific community, media, non-governmental organisations, consumer groups and donors are all likely to have important roles to play and responsibilities to fulfill.

Parasite disease control

Public health measures for disease control, including helminth control, are complementary to other approaches and additive in their effect. Although as far as possible they should be initiated regardless of any proven benefit to iron status, they should be integrated with other approaches and intensified in areas where IDA is strongly associated with high prevalence of hookworm or other parasites. Schoolchildren are usually a priority target group. Periodic supervised deworming one to three times a year should be undertaken through the primary health care and school systems. Deworming should be carried out among pregnant women after the first trimester when it is safe.

PROGRAMMING FOR EFFECTIVE ACTION AND IMPACT

An overall strategy for control of IDA should derive from an understanding of the nature, extent and severity of IDA and its causes as far as possible. If the problem is found to be related to low dietary intake or low bio-availability of iron or both, then fortification is an option and a feasibility study should be undertaken. If the various technological prerequisites for fortification relating to the vehicle and fortification are then found by the industrial sector research and development to apply and operational and financial feasibility is felt to exist, then fortification should be pursued. Linkages would then need to be developed with other intervention strategies such as dietary modification to exploit complementary activities or practices, particularly with regard to communications and education. The strategy would also need to address 'who does what' with regard to production, distribution, budgeting and sources of financial and technical support, management structures and enforcement mechanisms — including incentives and legal sanctions. Disruptions to existing systems of production and distribution should be minimised. The means of monitoring at all levels, from industrial compliance with regulations to iron concentrations in the product throughout the distribution chain, right down to the ultimate outcome of reduced prevalence of IDA, would need to be clearly articulated in the strategy. A specific component of training for assessment, quality control and monitoring would be required along with a time-bound work plan for strategy implementation — decided and agreed upon by all those involved.

Conclusions

Anaemia programmes need to be founded on a sound understanding of the multiple aetiologies of anaemia in a given situation rather than focusing solely on iron deficiency. The web of multiple interacting causes of anaemia demands strategies of prevention and control that act complementarily at different stages of deficiency and across different aetiologies.

There is no one single intervention to be universally advocated. Deciding what to do out of an array of possibilities is not an 'either/or situation' but an 'and-and' one. Supplementation of at-risk groups, fortification, dietary modification, parasitic disease control and overall education of policy makers, professionals and the public all have their place. Their relative prerequisites, costs, constraints and opportunities all need to be explored in any given situation to determine the appropriate intervention mix. In the wider picture technological problems are not nearly as serious as operational ones related to making programmes work in communities where iron-deficient people live. The human aspects of advocacy, communications, social mobilisation, participation and behavioural change will remain integral to progress. Other priority needs include minimal monitoring and evaluation, pertinent local-level education of both beneficiaries and community-based workers and greater community participation. Many of these needs interact and are mutually reinforcing. Adequate process and outcome monitoring and documentation are paramount within any approach so that both obstacles and opportunities can be made apparent and others can learn from the experience. A budget line for operational research should also be built into large-scale programmes. Recent evidence that vitamin A, beta-carotene and zinc can help reduce maternal morbidity and mortality gives reason to consider the development of a multiple micronutrient-based approach to combat the whole spectrum of micronutrient deficiencies. Finally, in addition to public demand and community ownership, the sustainability of programmes will require maximal integration of approaches into existing systems as well as transdisciplinary coalitions between different sectors in both public and private spheres and an attack of the problem at all levels — immediate, underlying and basic.

Bibliography

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