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Brief: Food-Based Approaches to Address Anemia

Anemia is a multi-factorial condition; successfully addressing it demands an ecological approach that recognizes internal (biology, genetics, health) contributors and external (social/behavioral/demographic and physical) environments. As highlighted in the USAID Advancing Nutrition Anemia Task Force (ATF) report,[1] using this approach to develop and implement context-specific equitable, safe, and effective interventions will improve assessment and implementation of programs, policies, and standards of care of patients and populations. An appreciation of systems biology will support the development and translation of nutrition-sensitive and nutrition-specific assessment methodologies and interventions, and improve clinical and public health outcomes.

The ATF emphasizes that assessment and interventions need to target both nutritional and non-nutritional cause(s). Although iron deficiency remains a major contributor to anemia, it is not the only one, and is not only due to low iron intake or low dietary iron bioavailability, but also because of infection and inflammation. To support decisions about which intervention might be most effective in a particular context, include other potential nutrition-related causes of anemia when exploring nutrition-specific approaches. A summary of available nutrition-specific options to address anemia with a focus on low- and middle-income countries (LMICs) follows.

Food Systems and Diet Quality

Food systems represent another critical aspect of the anemia ecology. Multiple factors that can negatively impact diet quality affect food systems, and ultimately an individual or populations' nutritional status (and probability of developing anemia). These include economics, sustainable agricultural practices, the physical environment (and the impact of climate change), and ingrained cultural practices.

Key Messages

- Food-based approaches to enhance iron intake and absorption include increasing dietary diversity, biofortification, the addition of animal source foods, and food processing, as well as food fortification.
- Food fortification approaches include mass fortification and targeted fortification.
- Primary products for targeted food fortification include fortified blended foods (FBF) and complementary food supplements (CFS).
- Lipid-based nutrient supplements (in medium and large quantities) are a type of CFS. Two essential LNS are ready-to-use therapeutic foods (RUTF) and ready-to-use supplementary foods (RUSF), which treat severe and moderate acute malnutrition, respectively.

The state and shape of food systems influences dietary diversity. Ruel (2003) defines dietary diversity as the number of individual food items or food groups consumed over a given period. It is usually assessed by counting the number of food groups—rather than food items consumed—and is reflected by a computed dietary diversity score. Factors contributing to low dietary diversity include production and consumption patterns rooted in social, behavioral, cultural, and economic factors.

Particularly in populations in LMICs, an over-reliance on plant-based foods such as pulses and whole cereals often limits the quality, diversity, and bioavailability of minerals in diets (Soares et al. 2019).

[1] Several manuscripts are being prepared on the content of the ATF report. The plan is to publish them in a peer-reviewed journal.

Although plant-based foods are rich in many essential nutrients, several features of relevance to anemia characterize them, including—

- incomplete profile of essential amino acids
- less bioavailable forms of certain minerals and vitamins (e.g., zinc, iron, vitamin A) or their absence (e.g., vitamin B_{12} or vitamin D, with the exception of certain mushrooms, which are not plants, but are commonly present in plant-based diets)
- interfering compounds (e.g., phytic acid and polyphenols) which reduce nutrient (in most cases mineral) absorption (Popova and Mihaylova 2019).

For these reasons, consider diets that are diverse and include some animal source foods, which are rich in bioavailable sources of nutrients limited in plant-based diets (i.e., zinc, iron, vitamins A and D, and vitamin B_{12} and B_2) where feasible, sustainable, and culturally acceptable.

Food-Based Approaches to Enhance Micronutrient Intake and Absorption

Approaches to enhance [micro]nutrient intake include—

- **Improving dietary diversity** is an important component of efforts to strengthen food systems, diet quality, and nutrition and is a potentially critical intervention strategy to combat micronutrient deficiencies; however, study results show a high variability (Thompson 2007).
- **Biofortification** increases the micronutrient content or bioavailability of commonly consumed staple crops via breeding or modification of cultivation practices (WHO 2006 and 2019).
- **Adding animal-source foods**, as iron is predominantly present in the highly absorbable heme form. Animal source foods are also rich in zinc, and improve the absorption of non-heme iron, the form predominantly contained in plant-based food sources such as legumes and dark green leafy vegetables (Kontoghiorghe, Kolnagou, and Kontoghiorghes 2016; Kontoghiorghes and Kolnagou 2005).
- **Food processing** to improve iron bioavailability and food quality:
  - Traditional household-level food preparation techniques such as dehulling, peeling, soaking, drying, germination, and fermentation improve food quality and safety and continue to receive research attention. The presumed benefits arise from the activation of enzymes that aid digestion and hydrolysis of anti-nutrients including—
    - amylase, an enzyme that helps with starch digestion
    - phytase, which helps break down indigestible phytic acid to digestible phosphorus, and also improves mineral bioavailability (Nkhata et al. 2018).
  - Other approaches to improve bioavailability include the addition of exogenous phytase or organic acids (e.g., vitamin C, also known as ascorbic acid). However, evidence for improved bioavailability for most food processing techniques is based on *in vitro* experiments with no efficacy trials in humans.
- **Food fortification** refers to the addition of one or more essential nutrient(s) to an industrially produced food (SPRING 2018). Different fortification strategies can be used to reach the targeted consumer(s).
  - **Large-scale food fortification or mass fortification** entails improving the nutrient content of regularly consumed staple foods and condiments during the industrial processing

stage in formal and centralized facilities (USAID 2022), such as commonly consumed food vehicles like salt, cereal staples, oil, milk, and sugar (WHO 2006).

— **Targeted fortification** involves adding micronutrients to—

- foods consumed by specific population/age groups (e.g., concentrated RUTF formulations that stimulate recovery for individuals who are severely wasted)
- foods in social programs (e.g., fortified blended cereals and legume flours, and complementary food supplements, such as ready-to-use supplementary foods).

Food Fortification

Fortification strategies have a long history of successfully addressing priority nutrient challenges. Prominent examples include the large-scale fortification of salt with iodine, which has led to the constant and effective control of iodine deficiency in many parts of the world (Andersson, Karumbunathan, and Zimmermann 2012) and the reduction of neural tube birth defects due to fortification of flours with folic acid (Keats et al. 2019).

Vehicles, Nutrients, and Contents

Fortification requires equipment to add the nutrients to processed food and adequately blend them together prior to packaging. Commonly used fortification vehicles include wheat and maize flour, milk, oil, rice, salt, and sugar (Mkambula et al. 2020; López de Romaña, Olivares, and Pizarro 2018). The vehicle choice often depends on the commonly consumed staples in the country, and processing them in centralized and formal factories. Factors that influence the selection of nutrient(s) to add to a fortified food include the nutritional needs of the population, the cost of adding the nutrient to a particular food, and the feasibility of adding the nutrients without compromising the acceptability of the food (WHO 2006). Food fortification uses staples and condiments as vehicles of micronutrients, which enables increased intake without changing the dietary habits or promoting the consumption of these products.

Types and Bioavailability of Fortificants—Example of Iron

The bioavailability of iron compounds depends on their inherent properties and their interaction with the diet. Water-soluble iron compounds such as ferrous sulfate are more bioavailable than compounds soluble in dilute acid such as ferrous fumarate; however, they frequently cause undesirable effects on the stability and sensorial properties (e.g., color, flavor) of the foods. Water-insoluble compounds, such as reduced iron or ferric pyrophosphate, are more compatible with the food matrixes but have the lowest bioavailability (WHO 2006). Adding sufficient bioavailable iron to foods remains a challenge.

Considerations for Mass Fortification

Although mass fortification complements the nutritional value of diets, practitioners may need to implement other interventions to correct micronutrient gaps in all population groups. Successful mass fortification requires efficient quality control and assurance procedures for the manufacturing industry, as well as government regulation and enforcement. An existing production facility and ongoing production process and supply chain enable easy and cost-efficient industrial production and trade of the fortified product.

Targeted Fortification: Fortified Blended Foods and Complementary Food Supplements

Evidence suggests that targeted fortification was associated with 47 percent reduction in anemia (Tam et al. 2020). Two primary types of products are used for targeted populations: FBF and CFS. Typically, FBF are used in humanitarian settings where there is either inadequate or no production capacity to carry out mass fortification and/or a functioning market does not exist to meet the macro- and micronutrient needs of the target population. They are mixes of cereal flours with legume flours. Development settings may also employ FBF to supplement the nutrient intake of the population. Complementary food

supplements include lipid-based nutrient supplements (LNS), such as RUTF, and RUSF which we describe below.

Lipid-Based Nutrient Supplements, Ready-to-Use Supplementary Foods, and Ready-to-Use Therapeutic Foods

Because mixed-fed infants consume the same foods as the rest of the family in many settings, fortified CFS have been developed to increase key nutrient intake for this age group. One example of such CFS are LNS (in medium and large quantities), which supply energy, protein, essential fatty acids, and micronutrients to meet the needs of individuals (Gibson 2014); LNS have been associated with a 16 percent reduced risk of anemia (Tam et al. 2020). Various studies, reviewed by Dewey and Adu-Afarwuah (2008), have observed positive effects of fortified LNS on iron and vitamin A status in infants.

RUSF are a type of LNS aimed at providing sufficient macro- and micronutrients to prevent moderate acute malnutrition in populations vulnerable to it, while RUTF are concentrated formulations to stimulate recovery for individuals who are severely wasted. The latter are used to treat uncomplicated cases of severe acute malnutrition (SAM) in outpatient settings. When supplementing the local diet, RUSF helps prevent SAM and stimulate recovery from moderate wasting (Webb and Kang 2010).

Small-quantity LNS (SQ-LNS) may be considered CFS for small children as they provide around 75 kilocalories per serving. However, for other age groups because of the low energy and protein supply, these products belong to the category of micronutrient supplements. Therefore, they are not included in this brief.

Biofortification

WHO defines biofortification as "the process by which the nutritional quality of food crops is improved through agronomic practices, conventional plant breeding, or modern biotechnology" (WHO 2019). Examples include the enhancement of zinc in wheat and rice (Cakmak and Kutman 2018), provitamin A in orange-fleshed sweet potato and orange maize (Nkhata et al. 2018). Harvested biofortified crops typically have higher nutrient levels than non-biofortified crops. Scaling up biofortification requires time for introducing biofortified traits into public plant breeding programs, increasing crop production, and building consumer demand. However, given the urgency due to climate change and its impact on the micronutrient content of crops, broader consideration of introduction of biofortified crops into policies and programs is needed.

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