Linking Rice Fortification Opportunities with Nutrition Objectives

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Key Messages

- Linking rice fortification with nutrition objectives requires the identification of groups who are most at risk of micronutrient deficiencies, the groups who can most benefit from rice fortification, and the most appropriate delivery option to reach these vulnerable groups.
- In order to determine the potential impact of rice fortification, the population's micronutrient status should be assessed through a combination of available data on their biochemical micronutrient deficiency status, nutrient intake, and other proxy indicators. There is no need to conduct additional micronutrient surveys where this information is available.
- Mandatory fortification has the greatest potential to make a public health impact when it reaches the whole population. When this is not feasible, distribution of fortified rice through social safety net programs is an alternative.
- Social safety nets typically target the same population groups that can benefit most from rice fortification (e.g., schoolchildren and lower socio-economic groups). Voluntary fortification is likely to benefit higher income groups only.
- Rice fortification cannot completely fill the micronutrient gap for groups with high micronutrient needs, such as pregnant and lactating women and young children. Additional targeted interventions remain necessary, such as iron/folate supplementation for pregnant women or micronutrient powders for young children.

Introduction

To determine the potential impact and the most appropriate delivery channel for fortified rice, it is essential to understand the population's micronutrient status, existing programs to improve micronutrient status, and the extent to which rice fortification can contribute to the micronutrient intake of the population. This article describes the process of identifying the type and level of micronutrient deficiencies in the population and the groups that are most affected. It also explains how the different delivery options may help to improve micronutrient status among identified vulnerable groups.

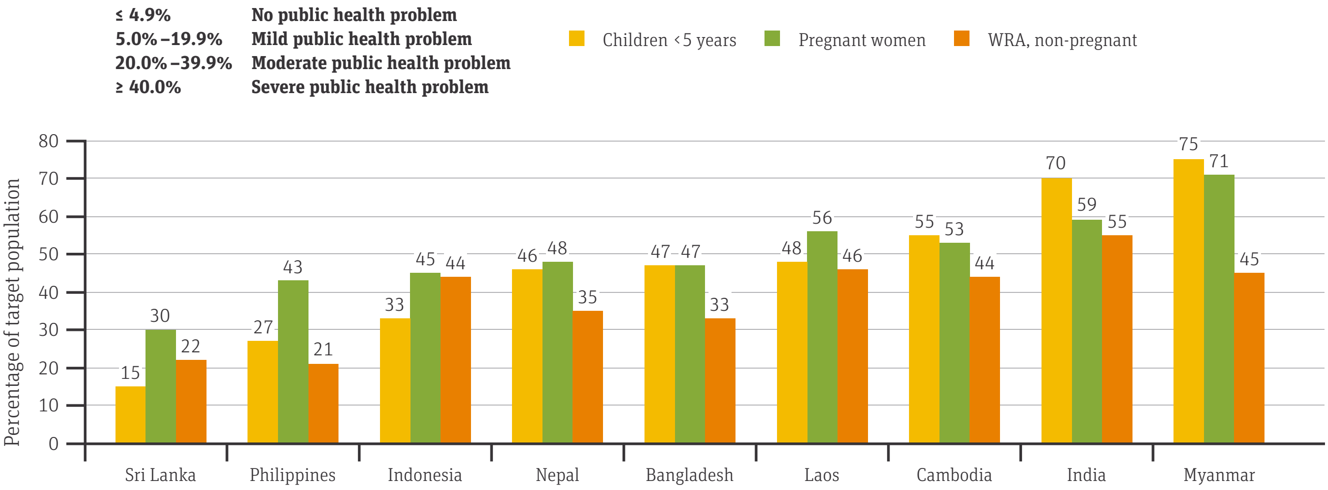
Importance of understanding micronutrient status

An analysis of the micronutrient deficiency situation is the first step in estimating the potential of fortified rice to improve the micronutrient status of the population.

As with all food fortification, rice fortification aims to increase a population's intake of specific micronutrients in order to reduce the proportion of that population which is at risk of micronutrient deficiencies. At the same time, fortification levels need to be set so that those who consume larger amounts of the food vehicle are unlikely to exceed the so-called tolerable upper intake level (UL). In other words, the vitamins and/or minerals added to rice should make a significant contribution to the micronutrient intake of the general population while not providing too much to individuals who consume relatively large amounts of rice. For additional information on safe micronutrient fortification of rice, please refer to the contributions of de Pee et al (p. 143), Pachón et al (p. 188) and Bruins in *Sight and Life* 1/2015, pp. 45–50.

> "A combination of available data and proxy indicators is sufficient for estimating the burden of micronutrient deficiencies"

FIGURE 1: Prevalence of anemia in three vulerable groups, for nine Asian countries.[2]



To gain a comprehensive understanding of a population's micronutrient status, it is recommended to examine data from multiple sources and methods, and where possible disaggregate by population group using factors such as socioeconomic status and geographic location, in addition to age and gender. This segmentation helps identify the target groups who can most benefit from rice fortification. The three main sources of information for obtaining a picture of the micronutrient status of a population are:

1) Micronutrient deficiency surveys, using biochemical data
2) Dietary intake of micronutrients, usually with 24-hour recall surveys
3) Proxy indicators, such as prevalence of anemia, stunting, neural tube defects, dietary diversity, infant and young child feeding practices, food security, and sanitation

It is important to emphasize that having complete micronutrient and nutrient intake data is NOT a prerequisite for fortification initiatives. A combination of available data and proxy indicators is sufficient for estimating the burden of micronutrient deficiencies.

> "Multiple micronutrient deficiencies tend to coexist in low- and middle-income countries"

Multiple micronutrient deficiencies tend to coexist in low- and middle-income countries. The most common ones are iron, iodine, and vitamin A. These can be estimated using biochemical data. Zinc deficiency also makes a substantial contribution to the global burden of disease. Black et al, in the landmark 2013 Lancet Maternal and Child Nutrition series, used an analysis of national diets to estimate that 17% of the world's population is at risk of zinc deficiency.[1] This method was used as there is little biochemical data on zinc deficiency. These detectable deficiencies may also coexist with other deficiencies that are harder to detect, such as vitamin B_{12}, folic acid or vitamin D. For additional information on the global burden of micronutrient deficiencies, please refer to **Figure 1** in the contribution by Milani et al (p. 137).

Micronutrient deficiency surveys can estimate a population's micronutrient status using biomarkers such as plasma retinol or retinol binding protein (RBP) for vitamin A, or ferritin to estimate iron. However, validated biomarkers do not exist for all micronutrients, and the interpretation of the results can be complex. In addition, logistics, sample collection and storage of samples may be complex. Although micronutrient deficiencies primarily affect the poorest and rural populations, other socioeconomic strata and urban populations may also be affected. For additional information, please refer to **Figure 1** in the contribution by Pachón et al (p. 188).

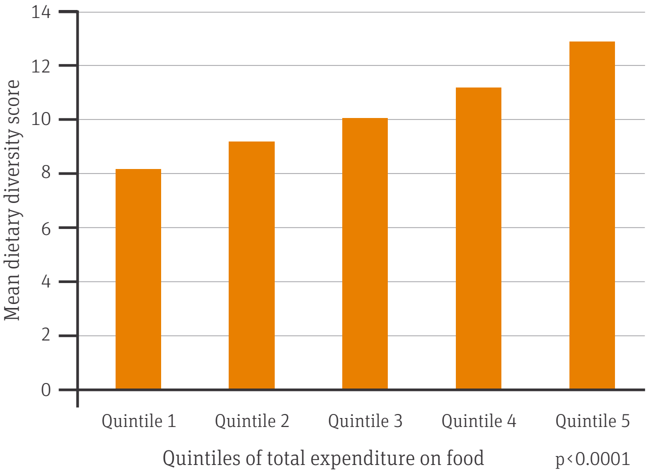
Dietary intake data

Data on foods commonly consumed by the population can supplement biochemical and clinical evidence of micronutrient deficiencies. Such data can help to identify which micronutrients are most likely to be insufficient, which population groups have insufficient diets and which areas of the country are most affected, using food composition tables indicating the micronutrient content of the foods.

Use of proxy indicators

When nutrient intake data is not available, as is often the case in low-income countries, proxy indicators can be used to esti-

FIGURE 2: Mean dietary diversity score by quintiles of total expenditure on food



Adapted from[7]

mate the population's risk of micronutrient deficiencies. Anemia, stunting, dietary diversity and neural tube defects are most often used as proxy indicators. Additional indicators include infant and young children feeding, sanitation, and other health and food security indicators.

Anemia, commonly used as a proxy indicator for iron deficiency, has multiple causes, beyond inadequate iron or other micronutrient intake (e.g., vitamin A, folic acid, vitamin B_{12}). Anemia is most prevalent in children under five, pregnant women, and women of reproductive age. Although there is significant variation by country, it is estimated that globally only half of the anemia is caused by iron deficiency.[2] Non-nutritional causes of anemia include hookworm infestation, malaria, other infections, and red blood cell disorders such as thalassemia. **Figure 1** shows the high prevalence of anemia across nine Asian countries.

Stunting for children under five years of age can also be used as a proxy indicator for micronutrient deficiencies. Countries where stunting is of significant public health concern also experience significant micronutrient deficiencies, as the two public health problems share many of the same causes,[3] such as inadequate nutrient intake and illness. Significant disparities exist in stunting prevalence, with children in the lowest income percentile up to three times more likely to be stunted compared to children in the highest income percentile. Rural children are up to twice as likely to be stunted compared to urban children.[4] The disparities in stunting prevalence often mirror disparities in micronutrient status and household income levels. Nevertheless, in many Asian countries there are also substantial stunting rates in high-income and urban populations.

Dietary diversity is commonly used as a proxy indicator for risk of micronutrient deficiencies, as a lack of dietary diversity often results in micronutrient deficiencies. Diets lacking in diversity may have a high intake of plant-source foods and a low intake of animal-source foods, which are associated with deficiencies of key micronutrients. Cereals, roots and tubers have very low micronutrient content and/or low bioavailability (especially after milling). Monotonous diets based on these staples typically provide only a small proportion of the daily requirements for most vitamins and minerals. Fat intake, which aids absorption of fat-soluble vitamins, is also often very low with diets of poor diversity.

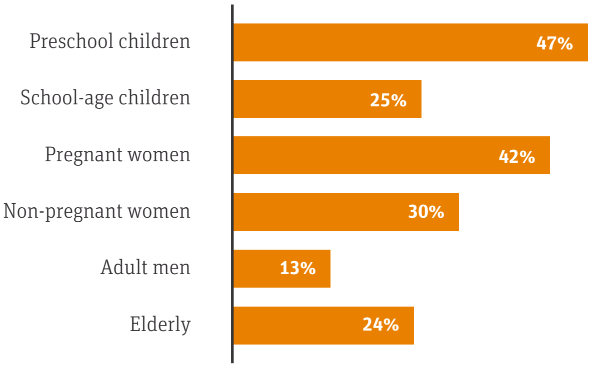
Animal-source foods are rich sources of protein (essential amino acids), energy, and micronutrients, including iron, preformed vitamin A, vitamin B_{12}, riboflavin, calcium, phosphorus and zinc.[5] Vulnerable groups in populations with a low intake of animal-source foods are more likely to have deficiencies in some or all of these nutrients.[5] Animal-source foods also fill multiple micronutrient gaps with smaller volumes of intake than plant-source foods. For example, to meet the daily requirements for energy, iron, or zinc, a child would need to consume 1.7–2.0 kg of maize and beans in one day. In addition, animal-source foods do not have the anti-nutritional factors that are present in plant-source foods (pulses, grains, and legumes). Anti-nutrients, or inhibitors, are natural compounds that impair the digestibility and absorption of essential nutrients. One common plant-based inhibitor is phytate, which inhibits the absorption of minerals, especially iron and zinc.[5] Plant-based foods are often a good source of vitamin B_6, niacin and thiamin. However polishing rice markedly reduces its micronutrient content.[6]

Wealthier households tend to have more diverse diets. As shown in **Figure 2**, a study in Bangladesh found a strong correlation between household dietary diversity and socioeconomic status and expenditure on food.

Neural tube defects (NTDs) can be used as a proxy indicator for folic acid deficiency.[8] NTDs, including spina bifida, occur when part of the neural tube, which forms the spine, spinal cord, skull and brain, fails to close between 21 and 28 days after conception – before women typically realize they are pregnant. Many children affected by neural tube defects have multiple lifelong disabilities. Women with low folate intake before and during early pregnancy are at increased risk of having babies with NTDs. It is recommended that all women of reproductive age should receive folic acid daily, which can be added to their diet through fortification or supplementation.

Other proxy indicators that can be used as indicators of risk of micronutrient deficiencies are high infection prevalence, low health service access/utilization, poor sanitation, hygiene and water quality, high food insecurity, proportion of household food expenditure on e.g., non-grain or animal-source foods, in-

FIGURE 3: Prevalence of anemia in different age groups.[2]



WHO 2008: Worldwide prevalence of anemia

adequate breastfeeding and infant and young child feeding and caring practices, etc.

Assessing the burden of micronutrient deficiencies

Although rice fortification can benefit a wide range of population groups, it is important to assess which population groups have the highest risk of micronutrient deficiency or inadequate intakes, and why. **Figure 3** shows the estimated prevalence of anemia across different population groups. The highest prevalence is estimated for preschool children with almost half of the children estimated to be anemic. In comparison, only 13% of adult men are estimated to be anemic.

> "It is important to assess which population groups have the highest risk of micronutrient deficiency, and why"

Several vulnerable groups are most likely to be affected by micronutrient deficiencies:

- **Girls and women of reproductive age** are biologically more vulnerable, especially to iron deficiency, as they experience iron loss due to menstruation.
- **Pregnant and lactating women** have greater micronutrient requirements to support growth and breastfeeding.
- **Infants and young children** have greater micronutrient requirements due to rapid growth. Their relatively small stomach size also limits their intake of foods. Therefore, their foods should be more nutrient dense than food that is consumed by older age groups.
- **Adolescents** have increased micronutrient requirements due to growth spurts.
- **Lower socioeconomic groups** tend to have a higher prevalence of deficiencies compared to higher socioeconomic groups. Typically, the diets of lower socioeconomic groups lack diversity and are primarily based on cereals, roots and tubers, with limited animal-source foods, fats and fruits and vegetables. Although the diets of poorer populations tend to be more micronutrient-deficient, the transition to energy-dense but micronutrient-poor diets with a high proportion of processed foods also puts higher-income groups at risk of micronutrient deficiencies.
- **Populations affected by emergency**, due to poor dietary diversity (mitigated to some extent when they receive fortified foods).
- **Groups marginalized** as a result of geography, ethnicity or religion.

Potential to benefit from food fortification varies across life cycle

As a population-based intervention, rice fortification must benefit those at risk of deficiencies, while remaining safe for the members of the general population that consume the most rice. To calculate the potential benefit that rice fortification can provide, the following must be assessed:

- The existing need for micronutrients, defined by the likely dietary gaps.
- The quantity of fortifiable food consumed, defined as the total amount of food consumed and the types and sources of foods that can be fortified.
- The level of fortification, where the aim is to provide enough micronutrient to reach the estimated average requirement (EAR) of adult men or women (which is approximately 70% of the recommended nutrient intake) from the fortified food, using the typical amount of the food that is consumed by adult men and women to determine the content per 100 g. For more information on calculating levels of micronutrients, please refer to the contribution by de Pee et al (p. 143).

Rice fortification is one component of an integrated approach to address micronutrient deficiencies, including micronutrient supplementation (for specific target groups), promotion of dietary diversification, social protection schemes, and disease control. The potential of rice fortification to address micronutrient deficiencies varies across the life cycle. As shown in **Figure 4**, the potential for benefit from rice fortification depends on the needs of the target group, the amount of fortified rice

FIGURE 4: Potential to benefit from food fortification across the life cycle

	Pregnancy	Lactating mother	6–23 mo	2–5 years	5–18 years	WRA (15–49 years)	Adult men	Elderly
Micro-nutrient need	very high	very high	very high	high	moderate to high	moderate to high	low to moderate	moderate to high
Amount of food eaten	moderate	moderate	low	low, increasing with age	increases with age	moderate	high	moderate
Potential to benefit	high	high	low	low, increasing with age	increases with age	high	high	high
Potential to fully meet need	**low**	**low**	**no**	**low, increasing with age**	increases with age	high	high	high

the group typically consumes, the group's potential to benefit from fortified rice (dietary gap), and the potential of the fortified rice to meet the target group's micronutrient needs (filling the gap).

As shown in **Figure 4**, pregnant and lactating women have high micronutrient needs. They also have a high potential to benefit from rice fortification, because they consume a substantial amount of rice. However, despite making a good contribution, fortified rice will not be able to provide enough micronutrients to fully meet their needs. Children aged 6–23 months also have very high micronutrient needs. However, given the small quantity of rice they consume, fortified rice has a low potential to meet their micronutrient needs.

FIGURE 5: Potential public health benefit of different delivery options for fortified rice among vulnerable socioeconomic groups

Delivery option	Low income	High income	Rural	Urban
Voluntary	**low**	high	**low**	high
Mandatory	high	high	high	high
Social safety nets	high	**low**	high	high

"Rice fortification should be one component of an integrated approach to address micronutrient deficiencies"

Public health impact of rice fortification depends on choice of delivery option

The potential public health impact of rice fortification for specific socioeconomic population groups is dependent upon the choice of delivery options (**Figure 5**).

Mandatory fortification is generally recognized as the most effective and sustainable option. It provides more equitable access, has the potential to reach the majority of the population, and significantly helps lower the national prevalence of micronutrient deficiencies. The most vulnerable socioeconomic groups will benefit.

Voluntary fortification has significantly lower potential to reach the most vulnerable groups, such as lower socioeconomic groups and rural populations. In this market-driven approach, these groups may not be able to afford or access branded fortified rice due to higher pricing. However, voluntary fortification can help meet the nutrient requirements of some segments of the population, typically high-income groups. Experience so far has indicated that coverage remains rather low, even with high-income groups. As such, the public health impact of voluntary fortification is limited.

The distribution of fortified rice through social safety nets has great potential to reach those most at risk for micro-

A mother carrying her baby, Colombia 2013

nutrient deficiencies. However, its contribution to reducing micronutrient deficiencies among the wider population depends on the proportion of the population that is reached by the social safety net.

For more information on delivery options, please refer to the contribution by Codling et al (p. 170).

Conclusion

Rice fortification has the potential to contribute to the reduction of micronutrient deficiencies and positively impact public health. While all population groups may be micronutrient-deficient, the magnitude varies between groups. Additional interventions specifically targeted towards those with the highest micronutrient needs, such as pregnant and lactating women and preschool children, remain necessary.

Linking rice fortification with nutrition objectives requires the identification of groups which are most at risk of micronutrient deficiencies, the groups that will benefit the most from rice fortification, and the most appropriate delivery option to reach identified target groups. Mandatory fortification offers the greatest potential for achieving a public health impact. The fortification of rice distributed through social safety net programs provides an opportunity to reach vulnerable groups when mandatory fortification is not feasible.

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