Rice Fortification: Evidence, Status, and Lessons Learned in Grain Fortification

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Key Messages

- Like wheat and maize flour fortification, fortifying rice is a public health opportunity to prevent micronutrient deficiencies and serious birth defects of the brain and spine. Scientific literature shows that rice fortification can improve iron status in targeted populations – other nutrients are not as well studied.[1]
- At a national scale, rice fortification is mandatory in six countries, and several subnational efforts indicate that interest in, and the practice of, rice fortification is growing. In comparison, 85 countries globally have mandatory wheat flour fortification legislation.[2]
- Fortification of wheat flour with essential vitamins and minerals has been practiced for over half a century; lessons learned in the implementation of wheat flour fortification programs globally can be applied to rice fortification in Latin America and the Caribbean.

Rice fortification technologies

Coated: Rice kernels are coated with a fortificant mix plus ingredients such as waxes and gums. The micronutrients are sprayed onto the surface of the rice grains. The coated rice kernels are blended with non-fortified rice in a ratio between 1:50 and 1:200.

Extruded: Rice-shaped reconstituted kernels are produced by passing rice flour dough, containing a fortificant mix, through an extruder. The extruded kernels are then blended into non-fortified rice in a ratio between 1:50 and 1:200.

Public health evidence for rice fortification: A review of efficacy and effectiveness studies

The Food Fortification Initiative (FFI) conducted a review of rice fortification literature indexed in PubMed and found 16 efficacy trials and five effectiveness studies;[3] this study and an update are available on the FFI website. Studies used either coated or extruded kernels. Eligible English- and Spanish-language studies provided health indicator comparisons of groups eating fortified rice and those eating non-fortified rice.[4]

Efficacy studies

The results of the review are summarized in **Table 1** and **Table 2**. Sixty-four percent (7/11) of studies measuring ferritin concentrations found a significant increase after the intervention group consumed rice fortified with iron. By contrast, only 30% (5/15) of studies measuring hemoglobin found a significant increase in hemoglobin levels. Anemia has multiple etiologies, only one of which is related to iron deficiency.[5] In populations with confounding factors such as parasitic infections (e.g., intestinal worms and malaria), high proportions of inherited blood disorders, and other multiple micronutrient deficiencies, iron indicators are a more direct measure of the impact of rice fortified with iron.[6]

Table 2 presents the results for efficacy studies that evaluated other nutrients added to rice. After iron, vitamin A is the next best-studied nutrient in rice fortification, with five studies

Types of research[a]

Efficacy: The outcomes of a specific intervention *under ideal conditions* ... Ideally, *a randomized controlled trial.*

Effectiveness: The outcomes of a specific intervention, *when deployed in the field in the usual circumstances.*

[a]Porta M. A dictionary of epidemiology. Oxford: Oxford University Press, 2008.

evaluating plasma retinol concentrations. However, the results for vitamin A are equivocal, possibly because vitamin A is a homeostatically controlled nutrient in the body,[7] and identifying significant changes is most likely when the targeted individuals have low vitamin A reserves. Two or fewer studies assessed the rest of the nutrients.

Effectiveness studies

Five studies, in Costa Rica, India, Thailand, and the Philippines, assessed rice fortification in the context of a large effectiveness trial (**Table 3**). The trials studied different populations and different outcomes, and three of the five included more than one nutrient in the rice. Four of the five studies reported improved outcomes (decrease in neural tube defects (n=1/1), increase in hemoglobin (n=2/4), decrease in anemia (n=2/3), decrease in beriberi incidence (n=1/1), decrease in infant beriberi deaths (n=1/1), although statistics were not always reported. The body of effectiveness data is relatively small and not easy to compare, but it indicates beneficial outcomes for rice fortification.

Key takeaways

In multiple studies, iron indicators improved in participants consuming fortified rice. Studies of the health impact of rice fortification largely focus on the impact on iron indicators, anemia prevalence, or hemoglobin concentrations. A limited number of effectiveness or efficacy studies assess other nutrients. Using indicators specific to the nutrients added through fortification is key when evaluating the health impact of rice fortification.

> "In multiple studies, iron indicators improved in participants consuming fortified rice"

Current status of global rice fortification programs and projects

Fortification activities, programs, or projects can be classified as mandatory, voluntary, or delivered via social safety nets.[8] One, two, or all three types of rice fortification can occur in a single country. For example, a country can have mandatory legislation for rice fortification for iron, folic acid, and zinc, and it could also have standards that allow rice producers to voluntarily include additional nutrients. Social safety nets are typically welfare programs targeted towards vulnerable populations. Examples include school feeding programs, food distribution programs, workplace benefit programs, or emergency aid rations.

Mandatory fortification

FFI monitors the global status of mandatory legislation for cereal grain fortification. In 2014, realizing that the bulk of rice

TABLE 1: Summary of rice fortification efficacy studies assessing iron indicators[a,b]

Outcome assessed (unit)	Number of studies that found significant improvement in this outcome	Total number of studies that investigated this outcome
Hemoglobin (g/L)	5	15
Anemia (%)	5	9
Iron status		
Ferritin (µmol/L)	7	11
Iron deficiency (%)	6	7
Transferrin receptor (mg/L)	3	5
Iron-deficiency anemia (%)	0	2
Iron body stores (mg/kg)	2	3
Zinc protoporphyrin (µmol/mol heme)	1	2
Total iron binding capacity (µg/dL)	1	1

[a] n=16 efficacy studies

[b] Food Fortification Initiative (FFI). Rice fortification's impact on nutrition. Atlanta: FFI, 2014. Updated 2016.

TABLE 2: Summary of rice fortification efficacy studies assessing other nutrient indicators [a,b]

Outcome assessed (unit)	Number of studies that found significant improvement in this outcome	Total number of studies that investigated this outcome
Plasma retinol (µmol/L)	2	5
Vitamin A deficiency (%)	1	2
Total body retinol reserves (µmol)	1	1
Serum zinc (µmol/L)	2	2
Zinc deficiency (%)	0	1
Folate (ng/mL)	1	1
Homocysteine (µmol/L)	1	1
Plasma B_{12} (pmol/L)	1	1
Thiamin (nmol/L)	0	1

[a] n=16 efficacy studies

[b] Food Fortification Initiative (FFI). Rice fortification's impact on nutrition. Atlanta: FFI, 2014. Updated 2016.

fortification activities were outside of mandatory legislation, with help from partners, FFI began collecting and disseminating information on the status of voluntary and social safety net programs as well. This information is gathered through quarterly phone calls with partners who work in rice fortification. **Figure 1** depicts current mandatory, voluntary, and social safety net programs in rice fortification.[9] As of September 2016, six countries have mandatory legislation for rice fortification: Costa Rica, Nicaragua, Panama, Papua New Guinea, the Philippines, and the USA.[10] Legislation does not necessarily mean successful implementation; lack of feasibility in the private sector and lack of strong regulatory enforcement can hinder even the most well-intentioned fortification programs. Of those six countries, only Costa Rica, Papua New Guinea (PNG), and the USA fortify over 70% of the country's industrially milled rice.[11] In the Philippines, a rice milling industry dominated by thousands of small rice mills scattered across an island archipelago challenges implementation,[12] whereas in Nicaragua lack of regulatory enforcement is a barrier.[13] It is not clear what barriers exist in Panama. **Table 4** shows the nutrients and standards required in each country.

After passing a mandatory law for rice fortification, regulatory monitoring is needed to ensure that the legislation is implemented by private industry. For the past two years, FFI has been asking regulatory authorities in these countries about rice fortification monitoring activities.[14] The activities listed in **Table 5** are important actions that countries can take to ensure that, when implemented, their fortification programs have oversight, the necessary guidance for their regulatory agencies to enforce, and transparency.

Voluntary rice fortification

Fortified rice is commercially available in four additional countries through companies that voluntarily market fortified rice: Brazil, Colombia, Peru, and Myanmar (**Figure 1**). In these countries, companies typically choose the types of nutrients and levels to add, as no countries currently have voluntary standards for rice fortification. Voluntary standards are useful tools to guide food producers and also ensure that when com-

A mother with her two children, Guatemala 2012

TABLE 3: Rice fortification effectiveness studies[a]

Study and country	Study population (sample size)	Nutrients in fortified rice	Result
Arguello et al 2011[b] Costa Rica	Births in country (n=65,000–75,000 per year)	Folic acid*, vitamin B_{12}, thiamin, zinc, vitamin E, selenium	Statistically significant decrease in NTDs** from pre to post rice and milk fortification*
Angeles-Agdeppa et al 2011[c] Philippines	Mothers (n=392) and their children 6–9 years (n=424)	Iron	Statistically significant improvement in hemoglobin and anemia for children, but not their mothers
Gershoff et al 1977[d] Thailand	Children 1.5–9 years (n=2,250)	Thiamin, riboflavin, retinol, iron, lysine, threonine	No statistics reported. Authors stated no differences in hemoglobin or morbidity between high (67% of time) and low (10% of time) consumers
Paithankar et al 2015[e] India	Children 6–15 years (n=945)	Iron	Statistically significant increase in hemoglobin and reduction in anemia prevalence for fortification district compared with control district
Salcedo et al 1950[f] Philippines	Infants, children >2–15 years old, mothers, pregnant mothers, and other adults (n=11,492)	Thiamin, niacin, iron	No statistics reported. Beriberi incidence and infant beriberi deaths decreased in fortification areas. In the non-fortification areas, these increased.

[a] n=5 effectiveness studies

[b] Arguello M, Solis L. Impacto de la fortificación de alimentos con ácido fólico en los defectos del tubo neural en Costa Rica. Rev Panam Salud Publica 2011;30(1):1–6.

[c] Angeles-Agdeppa I, Saises M, Capanzana M. Pilot-scale commercialization of iron-fortified rice: effects on anemia status. Food Nutr Bull 2011;32:3–12.

[d] Gershoff SN, McGandy RB, Suttapreyasri D. Nutrition studies in Thailand. II. Effects of fortification of rice with lysine, threonine, vitamin A, and iron on preschool children. Am J Clin Nutr 1977;30:1185–95.

[e] Paithankar P, Yunus S, Tiwari D. Mid-day school meals as social safety nets: an evaluation of the impact of iron fortification of Mid-Day Meals on the prevalence of anemia among children in Odisha, India (abstract). Internet: http://paa2015.princeton.edu/sessions/P7#72 (accessed 12 February 2017).

[f] Salcedo J Jr, Bamba MD, Carrasco EO et al. Artificial enrichment of white rice as a solution to endemic beriberi; report of field trials in Bataan, Philippines. J Nutr 1950;42:501-23.

* Wheat flour, maize flour, and milk are also fortified with folic acid

** NTD: neural tube defect

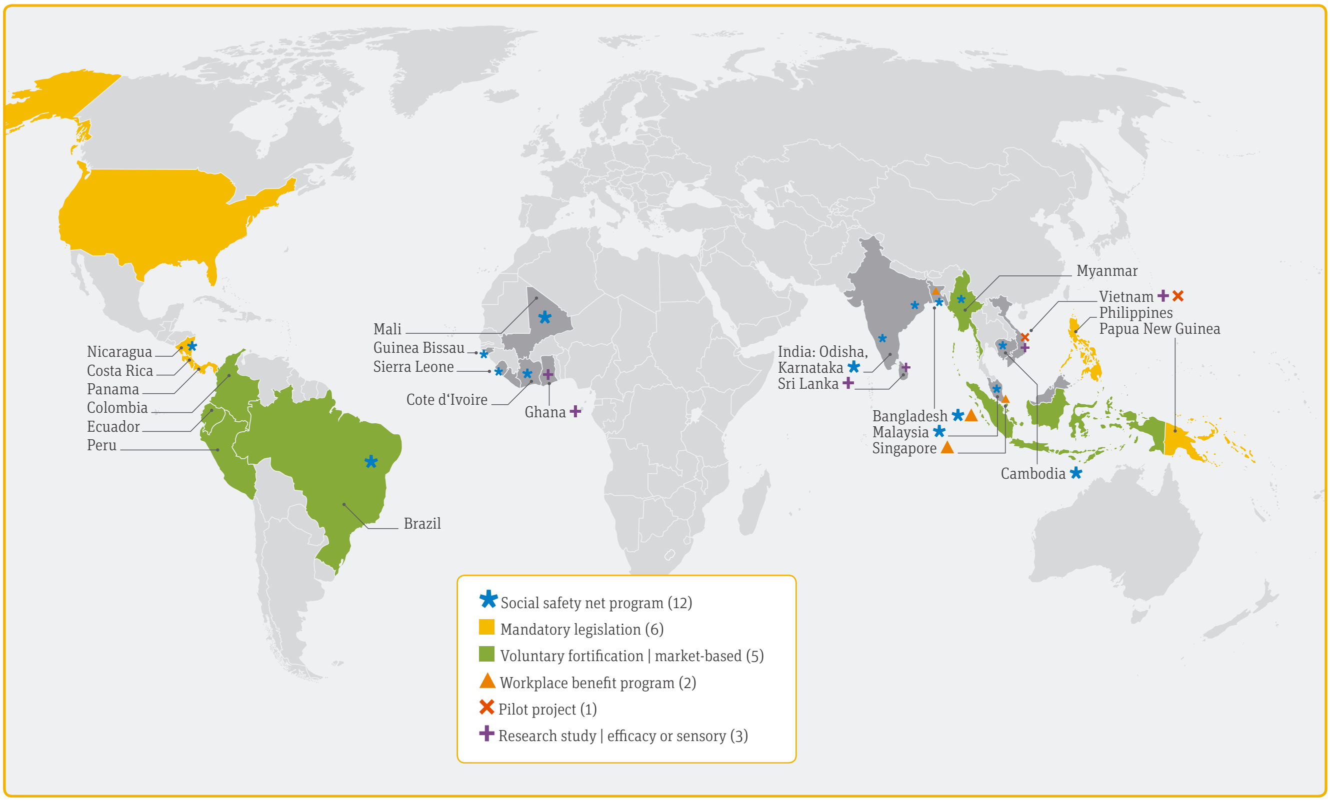
panies fortify, they do so at levels that are safe and intended for a public health benefit.

Since voluntary rice fortification is a choice made by an individual food producer or supplier, it can be difficult to achieve high coverage of fortified rice unless a monopoly exists or producers jointly agree to fortify. In all but one country, Colombia, the availability of fortified rice is estimated at less than 2% of the total rice industrially milled in the country.[15] Colombia's experience with voluntary rice fortification shows that moderate coverage of fortified rice can be achieved.[16] Even if coverage is high, however, the use of an effective technology is also essential to ensure that fortification contributes to public health. An issue in voluntary fortification is that there is more discretion about how to fortify and effective methods might not always be chosen.

Social safety nets

Social safety nets typically target those considered at need; their sustainability is reliant on the funding agency – usually a non-governmental organization, government agency, or in some cases also a private employer. Fortifying the rice already distributed (i.e. not a cash-transfer system) in a school feeding program, emergency ration, or food basket can be a way to improve nutrition at a relatively small additional cost to the overall program. Distributing fortified rice through social safety nets is most efficiently done through a centralized delivery system – for example, through a warehousing center that can distribute fortified rice in a food basket, a centralized kitchen that can bulk-cook fortified rice and distribute it to schools, or a modern rice mill that can produce large quantities of fortified rice to bid for procurement contracts.

FIGURE 1: Global status of rice fortification programs[a]



[a] Does not include research studies involving fortified rice, but includes pilot studies that are intended to demonstrate feasibility of rice fortification (rather than efficacy).

Currently, several countries feature rice fortification in social safety nets – in Bangladesh the government's Vulnerable Group Feeding/Development programs provide fortified rice to low-income populations,[17] and a garment factory staffed primarily with female employees began providing fortified rice in lunches in December 2015.[18] The World Food Programme distributes fortified rice through school feeding programs in Bangladesh, Odisha State in India, and Cambodia (**Figure 1**). In Singapore, construction companies are working with a social enterprise, *45Rice* (a play on the phonetic similarities between the number "45" and "fortified"), to source fortified rice for the caterers that feed their migrant workers.[19]

> "Mandatory fortification can reach high population coverage if implemented and enforced by regulatory agencies that are supported by political commitment and policies"

Key takeaways

Mandatory fortification can reach high population coverage if implemented and enforced by regulatory agencies that are supported by political commitment and policies.[20] Outside of special exceptions (such as monopolies or oligopolies), sustained, high coverage of fortified rice is difficult to achieve in voluntary fortification, but voluntary standards can at least help ensure quality fortification. Social safety net programs offer the opportunity to target populations who are most at need of nutritional interventions, but they require the commitment of the implementation agency for sustained delivery.

Lessons learned from wheat flour fortification

Fortification is most sustainable in a modern milling industry

Perhaps one of the greatest lessons learned from wheat flour fortification is the importance of a modern milling industry.[21,22] Fortification relies on both the private sector to produce high-quality fortified foods under safe and hygienic conditions and the government to ensure a fair business environment by enforcing national regulations among all millers.[23] When milling of wheat, maize, or rice occurs most frequently in the home or in villages, fortification is technically feasible but very

TABLE 4: Fortification levels (mg/kg) of vitamins and minerals in mandatory rice fortification countries[a]

Fortification Levels (mg/kg)

	Vitamins					Minerals			
Country	**Thiamin (B_1)**	**Niacin (B_3)**	**Pyridoxine (B_3)**	**Folic Acid (B_9)**	**B_{12}**	**Iron**	**Type of Iron**	**Selenium**	**Zinc**
Costa Rica	5.3	35	–	1.8	0.01	–	–	0.105	7.5
Nicaragua	5	40	4	1	0.01	24	Ferric pyrophosphate	–	25
Panama	5	40	4	1	0.01	24	Ferric pyrophosphate	–	25
Papua New Guinea	5	60	–	–	–	30	Not specified	–	–
Philippines	–	–	–	–	–	60–90	Ferrous sulfate	–	–
USA	4.4–8.8	35.2–70.4	–	1.54–3.08	–	28.6–57.2	Not specified	–	–
No. countries	5	5	2	4	3	5	3	1	3

[a] Food Fortification Initiative Database, 2016. Unpublished.

difficult to sustain financially, monitor for quality, and produce consistently.[24] Small-scale and home producers usually do not have the available capital to purchase premix or invest in fortification equipment. Regular miller training at the village level to ensure consistency is both resource- and time-consuming for millers and government agencies. And finally, government agencies already stretched to regulate food safety are simply unable to monitor milling when it occurs at thousands or tens of thousands of mills, as is the case with rice milling in countries like Sri Lanka,[25] Philippines,[26] and Vietnam.[27]

Fortification is most easily sustained when it capitalizes on a centralized milling industry. Future efforts in rice fortification should include milling industry analyses[28] as part of a fortification feasibility assessment.

Mandatory fortification is more likely to achieve public health impact than voluntary

Consumers are extremely sensitive to grain prices because wheat flour, maize flour, and rice are everyday staple foods eaten in large amounts. With wheat flour and oil, consumers who are more concerned with pricing than branding are unable to afford more expensive voluntarily fortified products.[29,30] Customers have limited and varying access to voluntarily fortified food, with a correspondingly unstable health impact.[20] Both of these problems have been demonstrated with voluntarily fortified food in Ireland, where products with folic acid have decreased in availability,[31] and researchers have found recent increases in the rate of neural tube defects.

Research in Australia demonstrated that mandatory fortification was more effective than voluntary for improving blood folate levels,[33] and also preventing neural tube defects.[34] Australia allowed food processors to voluntarily add folic acid to wheat flour for several years before mandating fortification of bread flour with folic acid in 2009. A clinic's analysis of blood folate concentrations during the voluntary and mandatory periods showed a marked increase in blood folate concentrations only after mandatory fortification came into place.[33] Similarly, the birth prevalence of neural tube defects remained relatively stagnant in Australia during the voluntary fortification period, with decreases only occurring after mandatory fortification had been implemented.[34]

Following WHO recommendations for fortification appears to be related to program effectiveness

In 2009, the World Health Organization (WHO) released global recommendations for wheat flour and maize flour fortification.[35] Fortification should provide enough of a nutrient to produce a public health benefit, but not so much as to be unsafe. These evidence-informed standards help countries set beneficial and safe standards.[36]

In 2015, FFI and partners conducted a review of reports from 13 countries which had conducted pre- and post-fortification evaluations.[37] Only one third of studies observed a decrease in anemia after fortification. We looked at whether countries followed two iron-related WHO recommendations: they used a recommended iron compound and they used at least the recommended level of iron. In programs that followed both WHO recommendations, two age subgroups showed a decrease in anemia prevalence. In programs that did not follow both WHO recommendations, 10 of 12 age subgroups did not experience a decline in anemia prevalence. These and results from another study[38] suggest that following WHO recommendations for flour fortification can lead to declines in anemia, while not following WHO recommendations can lead to null results. Experience from countries that mandatorily fortify flour with folic acid also points to the importance of following WHO recommendations. We completed a review of eleven countries' reductions in neural tube defects following fortification of wheat flour (alone, or in combination with maize flour) with folic acid.[39] The amount of folic acid added to flour in these

TABLE 5: Rice fortification monitoring activities reported in 2015 among countries with mandatory rice fortification [a,b,c]

Monitoring item	CR	Nica	Pan	PNG	Phil
Is there a national committee that oversees the rice fortification program?	Yes	Yes	Yes	No	Yes
Are rules and operating procedures for external monitoring of rice fortification at mill level by national authorities stipulated in a document?	Yes	Yes	–	No	No
Are rules and operating procedures for commercial monitoring of rice fortification at retail level by national authorities stipulated in a document?	No	No	–	No	No
If import rice, are rules and operating procedures for verification of rice fortification at import level by national authorities stipulated in a document?	Yes	Yes	NA	No	No
In the past five years, has a national report on the status of rice fortification monitoring and compliance been compiled?	Yes	No	–	No	No

[a] CR: Costa Rica; Nica: Nicaragua; Pan: Panama; PNG: Papua New Guinea; Phil: Philippines; NA: not applicable; –: No answer; No data for USA

[b] Food Fortification Initiative Database, 2016. Unpublished.

[c] Food Fortification Initiative (FFI). 2015 year in review. Atlanta: FFI, 2016.

What information should a milling industry analysis include?

An analysis can provide a high-level description of the milling industry: how many mills are in the country, average milling capacity, and geographic clusters. An in-depth look at individual mills in the country can inform as to which mills already have fortification capacity (e.g., equipment, human resources, quality assurance practices) and which may require support to implement.

countries (1.2–2.2 mg/kg) is within the range recommended by WHO (1.0–5.0 mg/kg).

Rice fortification recommendations are forthcoming from WHO.[40] For rice fortification programs with safe and optimal effects on nutrition status, countries should fortify with adequate levels of the recommended iron compounds and other micronutrients.[41]

Conclusions

Scientific literature shows that rice fortification can produce a public health impact, particularly on iron status, as that is the most-studied nutrient. Research for other nutrients is limited yet encouraging. The evidence for other nutrients, particularly folic acid, in wheat flour could be translated to rice. At the same time, rice fortification activities have also largely moved past efficacy and effectiveness studies, onto national programs, voluntarily fortified products in select marketplaces, pilot implementation projects, and social safety net programs targeted at schoolchildren and other vulnerable populations.

The past lessons learned in wheat flour fortification can save valuable resources and improve efficiency in planning for rice fortification programs or evaluating existing programs. These lessons point to ensuring sustainability by pursuing fortification in a modernized milling industry; introducing mandatory fortification with strong regulatory enforcement for greater population coverage and impact; and setting standards in line with WHO recommendations to ensure safe and effective fortification. Rice fortification may be a relatively new public health intervention, but utilizing the past successes of fortifying wheat flour is a win-win for all.

“Rice fortification may be a relatively new public health intervention, but utilizing the past successes of fortifying wheat flour is a win-win for all”

References

1. de Pee S, Fabrizio C, Rosenzweig J. Overview of evidence and recommendations for effective large-scale rice fortification. In: Scaling up rice fortification in Asia. Basel: *Sight and Life,* 2015: 20–25. Republished on page 143 of this publication.
2. Food Fortification Initiative. Global progress. Internet: http://ffinetwork.org/global_progress/index.php (accessed 13 September 2016).
3. Food Fortification Initiative (FFI). Rice fortification's impact on nutrition. Atlanta: FFI, 2014. Updated 2016.
4. Studies comparing organoleptic (i.e. sensory) qualities of fortified rice versus non-fortified rice, assessing rice fortification technologies or measuring impact of parboiled rice, biofortified rice, or other agricultural fortification methods were not included, as they are outside the scope of this objective.
5. Kraemer K, Zimmerman MB, eds. In: Nutritional anemia. Basel: *Sight and Life* Press, 2007.
6. Zimmerman MB. Methods to assess iron and iodine status. Br J Nutr 2008;99(S3):S2–S9.
7. Tanumihardjo SA, Russell RM, Stephensen CB et al. Biomarkers of Nutrition for Development (BOND) – Vitamin A Review. J Nutr 2016;146(Suppl):1816S–48S.
8. Codling K, Fabrizio C, Rosenzweig J. Identifying appropriate delivery options for fortified rice. In: Scaling up rice fortification in Asia. Basel: *Sight and Life*, 2015: 37–42. Republished on page 170 of this publication.
9. The status of voluntary and social safety net projects/programs can be unpredictable given how quickly a voluntarily fortified rice can reach market and new projects stop or start. Thus, the map is a representation of the status of projects as of September 2016, as far as FFI is aware.
10. Food Fortification Initiative. Global progress. Internet: http://ffinetwork.org/global_progress/index.php (accessed 13 September 2016).
11. Food Fortification Initiative (FFI). 2015 year in review. Atlanta: FFI, 2016.
12. Forsman C, Milani P, Schondebare JA et al. Rice fortification: a comparative analysis in mandated settings. Ann NY Acad Sci 2014;1324: 67–81.
13. FFI Personal communications with Born Well Project, an implementing partner in rice fortification in Nicaragua, 2016.
14. No information from the United States.
15. FFI Personal communications with in-country contacts and partners in Brazil, Colombia, Peru, Myanmar. 2015.
16. Tsang BL, Moreno R, Dabestani N et al. Public and private sector dynamics in scaling up rice fortification: the Colombian experience and its lessons. Food Nutr Bull 2016:37(3):317–28.
17. Ebbing H, Rosenzweig J, Karim R. Case study: Bangladesh. In: Scaling Up Rice Fortification in Asia. Basel: *Sight and Life*, 2015: 79–83.
18. World Food Programme. The Netherlands and WFP support Bangladesh to scale up rice fortification. Version current 21 January 2014. Internet: www.wfp.org/news/news-release/netherlands-and-wfp-support-bangladesh-scale-rice-fortification (accessed 12 February 2017).
19. BBC. Tackling 'hidden hunger' in Singapore. Version current 12 April 2016. Internet: www.bbc.com/news/business-36020146 (accessed 12 February 2017).
20. Zimmerman S, Baldwin R, Codling K et al. Mandatory policy: most successful way to maximize fortification's effect on vitamin and mineral deficiency. Indian J Community Health 2014;26 (Supp 02):369–74.
21. Montgomery SJ. Flour fortification: overview and benefits to Europe. Version current 3 October 2012. Internet: www.ffinetwork.org/about/calendar/2012/Documents%202012/GasteinOverview.pdf (accessed 12 February 2017).
22. Kupka R, Fabrizio C, Rosenzweig J. Lessons Learned from Flour and Salt Fortification. In: Scaling up rice fortification in Asia. Basel: *Sight and Life*, 2015: 68–72.
23. World Health Organization, Food and Agriculture Organization. Guidelines on food fortification with micronutrients. Geneva: World Health Organization, 2006.
24. Fiedler JL, Afidra R, Mugambi G et al. Maize flour fortification in Africa: markets, feasibility, coverage, and costs. Ann NY Acad Sci 2014;1312:26–39.
25. Rafeek MIM, Mahrouf ARM, Samaratunga PA. Rice marketing system: implication for rice quality improvement and issue of affordability. Internet: http://agrilearning.goviya.lk/Paddy/Paddy_Research/Paddy_pdf/SE13.pdf (accessed 12 February 2017).
26. Briones RM, dela Pena B. Competition reform in the Philippine rice sector. Version current January 2015. Internet: http://dirp3.pids.gov.ph/webportal/CDN/PUBLICATIONS/pidsdps1504.pdf (accessed 12 February 2017).
27. Ministry of Agriculture and Rural Development. Report on situation of rice production and consumption. Hanoi: Ministry of Agriculture and Rural Development, 2015.
28. Maglalang H. Rice supply chain diagnostic: towards scaling up rice fortification in the Philippines. Atlanta: Food Fortification Initiative, 2014.
29. Dary O, Harvey P. The Philippines food fortification strategy: an analysis. Washington DC: MOST/The USAID micronutrient program, 2002.
30. Gradl C. Building a strategic alliance for the fortification of oil and other staple foods (SAFO). Cambridge: Harvard Kennedy School, 2012.
31. Kelly F, Gibney ER, Boilson A et al. Folic acid levels in some food staples in Ireland are on the decline: implications for passive folic acid intakes? J Public Health (Oxf) 2016;38(2):265–9.
32. McDonnell R, Delany V, O'Mahony MT et al. Neural tube defects in the Republic of Ireland in 2009-11. J Public Health (Oxf) 2015;37(1):57–63.

33. Brown RD, Langshaw MR, Uhr EJ et al. The impact of mandatory fortification of flour with folic acid on the blood folate levels of an Australian population. Med J Aust 2011;194(2):65–7.

34. Hilder S. Neural tube defects in Australia, 2007–2011: before and after implementation of the mandatory folic acid fortification standard. Sydney: The University of New South Wales, 2016.

35. WHO, FAO, UNICEF, et al. Recommendations on wheat and maize flour fortification. Meeting Report: Interim Consensus Statement. Geneva: World Health Organization, 2009.

36. Peña-Rosas JP, De-Regil LM, Rogers LM et al. Translating research into action: WHO evidence-informed guidelines for safe and effective micronutrient interventions. J Nutr 2012;142(1):197S–204S.

37. Pachón H, Spohrer R, Mei Z et al. Evidence of the effectiveness of flour fortification programs on iron status and anemia: a systematic review. Nutr Rev 2015;73:780–95.

38. Hurrell RF. Flour fortification as a strategy to prevent anaemia. Br J Nutr 2015;114(4):501–2.

39. Food Fortification Initiative (FFI). Fortifying flour with folic acid to prevent neural tube defects. Atlanta: FFI, 2012.

40. World Health Organization. Call for authors – fortification of rice with vitamins and minerals: technical considerations. Internet: www.who.int/nutrition/callforauthors_fortification_rice_vitamins_minerals/en/ (accessed 12 February 2017).

41. Hurrell R, Ranum P, de Pee S et al. Revised recommendations for iron fortification of wheat flour and an evaluation of the expected impact of current national wheat flour fortification programs. Food Nutr Bull 2010;31(1 suppl):S7-21