Strategic Paper: Fortification of rice and wheat flour with vitamins and minerals in the Western Pacific region

Prepared for the WHO WPRO Consultation on the Regional Action Plan to Reduce the Double Burden of Malnutrition in the Western Pacific Region, by the Flour Fortification Initiative, with inputs from the World Food Programme, World Health Organization and Global Alliance for Improved Nutrition

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General introduction to staple food fortification

The Comprehensive Implementation Plan on Maternal, Infant and Young Child Nutrition,[1] endorsed by the Sixty Fifth World Health Assembly in 2012, is intended to accelerate improvements in maternal, infant and young child nutrition to contribute to achievement of the Millennium Development Goals. The Plan recognizes that many effective nutrition interventions are not implemented on a sufficiently large scale. The Plan thus urges the inclusion of "all required effective health interventions with an impact on nutrition" in national nutrition plans and the stimulation of development policies and programmes outside the health sector that recognize and include nutrition. Effective direct nutrition interventions and health interventions that have an impact on nutrition and that can be delivered by the health system are summarized in the WHO publication *Essential Nutrition Actions: improving maternal, newborn, infant and young child health and nutrition*.[2] One of the essential nutrition interventions is **wheat and maize flour fortification in public health**, in settings where these are staple foods. This paper also considers **fortification of rice** because rice is the major staple food in the Western Pacific region, and WHO is developing recommendations for fortification of this staple food.[3] A complementary paper on the current status of rice fortification and factors that influence the feasibility of implementation has been prepared by the World Food Programme (WFP) and PATH – *Strategic and Technical Paper on Rice Fortification.*

Food fortification refers to the addition of micronutrients to foods. Food fortification has long been recognized as an effective and highly cost efficient intervention for reducing micronutrient malnutrition. A specific advantage of food fortification is that it can increase micronutrient intakes to large segments of the population at very low cost without requiring radical changes in food consumption patterns.[4] The World Bank and the Copenhagen Consensus have identified bundled micronutrient interventions to fight hunger and improve education worthy of investment. This includes universal fortification of relevant staple foods and condiments as highly cost effective. For every United States (US) dollar spent on fortification of staple foods or condiments, countries have experienced cost savings of US$7.8 to 81 depending on the details of the fortification programme.[5] The savings come through a combination of reductions of

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[1] http://www.who.int/nutrition/topics/WHA65.6_annex2_en.pdf

[2] Essential Nutrition Actions: improving maternal, newborn, infant and young child health and nutrition. WHO 2013 http://www.who.int/nutrition/publications/infantfeeding/essential_nutrition_actions/en/

[3] Ashong et al. Fortification of rice with vitamins and minerals for addressing micronutrient malnutrition. Cochrane Database of Systematic Reviews 2012, Issue 6. Art. No.: CD009902. DOI: 10.1002/14651858.CD009902.

[4] WHO and FAO. Guidelines on food fortification with micronutrients. WHO and FAO. 2006

[5] Hoddonit et al. Copenhagen Consensus 2012 Challenge Paper: Hunger and Malnutrition. 2012 Global Copenhagen Consensus. [Fortification in general: 7.8 (Horton et al. Hunger and Malnutrition. Copenhagen Consensus 2008 Challenge Paper, Copenhagen Consensus Center, Copenhagen. 2008); Wheat flour fortification: 9.1 (Horton et al. Double-fortified salt reduces anemia, benefit: cost ratio is modestly favorable. *Food Policy,* 36(5): 581-587. 2011); Salt iodization: 81 (Rajkumar et al. Combating Malnutrition in Ethiopia: An Evidence-Based Approach for Sustained Results World Bank: Washington DC. 2012)]

morbidity or mortality, increased work productivity or educational attainment, or averted healthcare expenditures.

Food fortification has limitations however; it benefits only those who consume the fortified food. It does not benefit those who do not habitually eat the chosen food vehicle; do not have funds to purchase the fortified foods or who live in areas where the food is not available. Another limitation is that in order to ensure that food fortification is safe for the entire population, amounts of nutrients added must be limited. Thus it can seldom alleviate all micronutrient deficiency in a population, in particular those with high requirements, such as young children or reproductive age women. Therefore, food fortification should usually be implemented in combination with additional interventions to reduce micronutrient malnutrition such as daily or intermittent micronutrient supplementation, point-of-use/home fortification of foods, dietary diversification, and health interventions to reduce nutrient losses, such as deworming and infection control.[6] If low amounts of the food vehicle are consumed, it may not be possible to add sufficiently high levels of nutrients without causing negative organoleptic changes in the final product (taste or colour changes). In such conditions, it may be necessary to fortify more than one food with the same nutrient.[7]

Despite these limitations, fortification of staple foods and condiments has a long history for the successful control of deficiencies of vitamin A and D, several B vitamins, iodine, and iron. Fortification of food grade salt with iodine (i.e. salt iodization) was introduced in the early 1920s both in Switzerland and the United States of America and has since expanded to the extent that 76% of households globally currently consume iodized salt.[8] It is estimated that salt iodization protects nearly 91 million children a year from learning impairment related to iodine deficiency disorders and losses in learning capability.[9] In the late 1910s Denmark started to fortify margarine with vitamin A. The United Kingdom started to fortify milk with vitamin D in 1923, and the United States started in 1939.[10] From the early 1940s onwards, fortifying cereal products with thiamine, riboflavin, and niacin became common practice. In many countries, foods for young children are fortified with iron, a practice that has substantially reduced the risk of iron-deficiency anaemia in this age group.[11] For example, Chile started iron fortification of milk powder more than 20 years ago.[12] In more recent years, fortifying wheat and maize flour has become widespread – globally 78 countries have legislation to mandate fortification of wheat and/or maize flour with at least iron or folic acid.[13] National implementation of rice fortification is more limited for reasons discussed below and in the accompanying WFP/PATH paper; currently five countries (Papua New Guinea, Nicaragua, Costa Rica, Panama and the Philippines) and six US states have legislation for mandatory rice fortification.[14]

[6] WHO and FAO. Guidelines on food fortification with micronutrients. WHO and FAO. 2006

[7] WHO, FAO, UNICEF, GAIN, MI, & FFI. Recommendations on wheat and maize flour fortification. Meeting report: interim consensus statement. Geneva, World Health Organization, 2009. http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fortification/en/ Accessed 19 September 2013

[8] UNICEF State of the World's Children 2013

[9] UNICEF - http://www.unicef.org/nutrition/index_iodine.html. Accessed 19 September 2013

[10] Fortification Basics: Milk http://www.dsm.com/products/nip/en_US/publications-page/publications-fortificationbasics.html# Accessed 19 September 2013

[11] WHO and FAO. Guidelines on food fortification with micronutrients. 2006

[12] Fortification Basics: Milk http://www.dsm.com/products/nip/en_US/publications-page/publications-fortificationbasics.html# Accessed 19 September 2013

[13] Flour Fortification Initiative - http://www.ffinetwork.org/global_progress/index.php. Accessed 4 November 2013

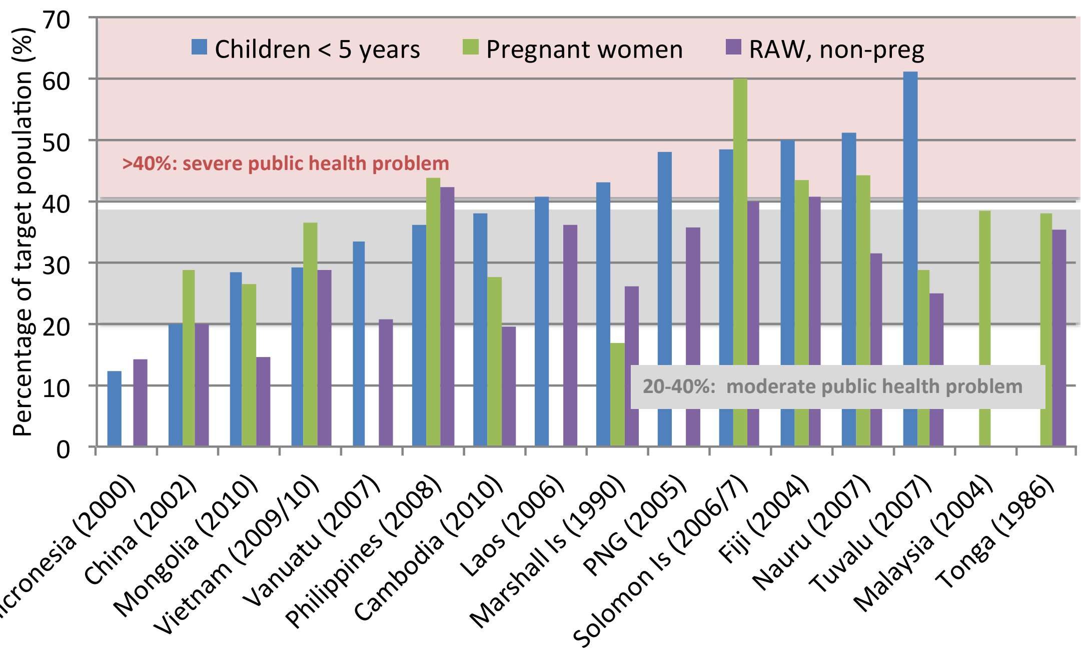
[14] Flour Fortification Initiative - http://www.ffinetwork.org/global_progress/index.php Accessed 4 November 2013

Key nutrition and health problems that staple food fortification can help address and evidence of impact

Wheat flour, maize flour, and rice can be fortified with a variety of micronutrients. Iron can be added to reduce iron deficiency and anaemia, and folic acid to prevent a proportion of neural tube defects, one of the most common congenital anomalies. The B vitamins can also be added, as can zinc, vitamin A and vitamin D. As rice, wheat, and maize are the staple foods (in terms of energy intake) of 60% of the world's population,[15] fortification of these foods can help improve the micronutrient intake of the majority of the world's population.

The prevalence of anaemia in Member States of the WPR is shown in Figure 1. As the figure shows, anaemia in young children and/or women (pregnant or non-pregnant of reproductive age) is of moderate public health significance (i.e., prevalence of anemia between 20 and 40%) in all countries with data, with the exception of Micronesia where the low prevalence indicates it is a problem of mild public health significance.[16] In several countries it is a problem in both population groups. Anaemia in young children is a severe public health problem in several of the Pacific Islands, including Fiji and Papua New Guinea.

Figure 1: Anaemia prevalence in the Western Pacific



Ref: National surveys, such as DHS or national health or nutrition surveys in the year shown.
RAW: reproductive age women

It is important to recognize that the above figure refers to anaemia, which is often caused by iron deficiency but can also be caused by genetic traits, folate or vitamin B_{12} deficiency, malaria, schistosomiasis, hookworm infection, HIV infection and some non-communicable diseases. It is also possible for iron deficiency to exist without anaemia. Only the nutritional causes of

[15] http://www.fao.org/docrep/u8480e/u8480e07.htm
[16] WHO. Iron Deficiency Anaemia. Assessment, Prevention, and Control: A guide for programme managers. (Table 3. Proposed classification of public health significance of anaemia in populations on the basis of prevalence estimated from blood levels of haemoglobin or haematocrit.) Geneva. World Health Organization. 2001. http://whqlibdoc.who.int/hq/2001/WHO_NHD_01.3.pdf Accessed 4 November 2013

anaemia, such as iron, folate or B_{12} deficiency, could potentially be reduced by food fortification. In general, the assumption is that at least half of all anaemia is due to iron deficiency.[17] Stevens et al. calculated that "the proportion of anaemia amenable to iron" was about 50% in non-pregnant and pregnant women and 42% in children, with variations based on the existence of other cause of anaemia.[18]

Not many countries have data on iron deficiency (as opposed to anaemia). Mongolia's 4th National Nutrition Survey 2011[19] measured both anaemia (haemoglobin) and iron deficiency (serum ferritin) in 433 children. The results indicate that although 28.8% of children 2-59 months old had anaemia and 21.4% had iron deficiency; only 5% had iron deficiency anaemia. Similar analysis from the Laos National Maternal and Child Nutrition Survey (MICS 3/NNS) 2006 found that 43% of non-pregnant women and 35% of young children with anaemia had iron deficiency.[20] The 2004 National Nutrition Survey of Fiji found 23% of women 15-44 years old to be iron deficient, with much higher prevalence amongst Indian women (43%) compared to Fijian women (11.5%). As a result, iron deficiency accounts for about a quarter of anaemia in Fijian women and more than half of the anaemia in Indian women in Fiji. In Laos, Mongolia and amongst Fijian women, therefore, iron deficiency was the cause of less than half of the anaemia, contrary to the traditional assumption mentioned above. Only in Indian women in Fiji was iron deficiency the cause of half or more of the anaemia. It is assumed that the remaining anaemia is due to other causes such as vitamin B_{12} or folic acid deficiency or haemoglobinopathies, or thalassemia.

Although multiple efficacy studies have recorded improvements in either anaemia or iron status as a result of food fortification,[21, 22] relatively little evidence exists from evaluations of large-scale implementation. A review by the Flour Fortification Initiative of existing programmes which compared serum ferritin and haemoglobin levels before and after large-scale iron fortification started, however, found that serum ferritin increased in 9 out of 11 studies (increase ranged from 3.8mcg/L in Mongolian children to 25mcg/L in Fijian women) and haemoglobin levels increased in 11 out of 23 studies (increase ranged from 21g/L in Tajiki children to 1g/L in Brazilian pregnant women). The changes in haemoglobin levels are non-conclusive most likely because haemoglobin levels and anaemia are affected by many factors, which may therefore not be readily affected by increased nutrient intake through food fortification.[23]

The fortification of wheat flour has been very effective at reducing the prevalence of neural tube defects (NTDs) in multiple countries around the world. A meta-analysis of eight studies, which reported NTD birth prevalence before and after mandatory fortification with folic acid, found a

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[17] WHO/UNICEF/UNU. Iron deficiency anaemia assessment, prevention and control: a guide for programme managers. Geneva, World Health Organization. 2001

[18] Stevens et al. Global, regional and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: a systematic analysis of population-representative data. Lancet Global Health 2013

[19] Public Health Institute, Nutrition Research Centre. Nutrition Status of the Mongolian Population. Fourth National Nutrition Survey Report. Ulaanbaatar, Mongolia 2011

[20] Knowles et al. Impact of inflammation on biomarkers of iron status in a cross-sectional survey of Lao women and children. (under review for publication).

[21] Hurrell 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 and Nutrition Bulletin, vol 31, no 1 (supplement). 2010

[22] Gera et al. Effect of iron-fortified foods on hematologic and biological outcomes: systematic review of randomized controlled trials. AJCN, 2010

[23] Pachón H. and Fanning-Dowdell G. Review of the public health evidence of flour fortification impacting serum folate, neural tube defects, serum ferritin and haemoglobin. FFI 2013. (unpublished) http://www.ffinetwork.org/about/calendar/2013/documents/HealthImpact.pdf

mean reduction in NTDs of 46% (95% CI:37-54%).[24] A literature review of 27 effectiveness studies showed that fortification of flour with folic acid had significantly reduced the number of children with NTD in all countries that have mandated it. Pre-fortification prevalence ranged from 3.78-31.6 NTDs per 10,000 births, and the relative percent reduction after fortification ranged from 15.5% to 58%. The greatest reductions were where pre-fortification NTD prevalence was highest.[25] One study published after this literature review found no improvement in NTDs after folic acid fortification. The study was undertaken in Peru where the flour was fortified with 1.2mg/kg of folic acid. The authors suggest that to have an impact on NTDs, the folic acid level may need to be increased given the amount of wheat flour that the population consumes.[26]

Few countries in the region currently have surveillance systems measuring the prevalence of neural tube defects. Global estimates of NTD rates were provided by the March of Dimes in 2006. The NTD rates reported by the March of Dimes are based on existing country surveillance systems. These data were then used to calculate estimates of NTD birth prevalence for neighbouring or similar countries that lacked data.[27] The data represent the estimated situation in 2001.

As the figure below shows, NTD rates in the region are generally between about 13 and 20 per 10,000 live births with a few exceptions. Korea and Tuvalu appear to have particularly high rates while Australia has a relatively low rate. Countries that fortify flour with folic acid often report a neural tube defect rate of less than 10 per 10,000 live births.

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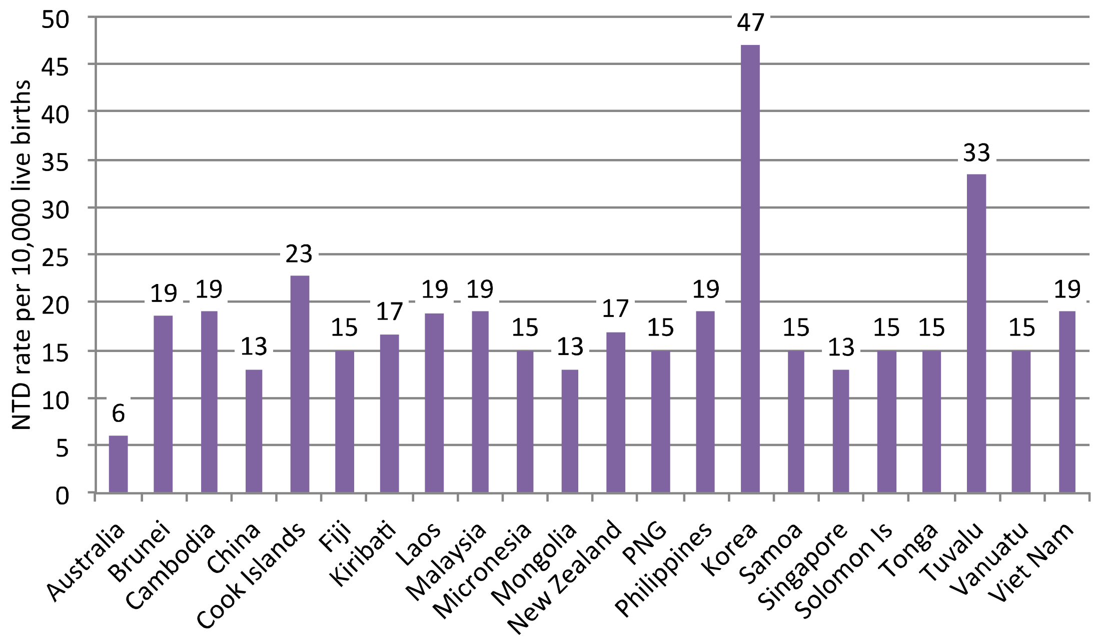
[24] Blencowe et al. Folic acid to reduce neonatal mortality from neural tube disorders. International Journal of Epidemiology 2010, 39, i110-i121
[25] Castillio-Lancellotti et al. Impact of folic acid fortification of flour on neural tube defects: a systematic review. Public Health Nutrition. 2012. 16. 901-11
[26] Ricks et al. Peru's national folic acid fortification program and its effect on neural tube defects in Lima. Rev. Panam Salud Publica 32(6), 2012
[27] Christianson et al. March of Dimes Global Report on Birth Defects: the hidden toll of dying and disabled children. March of Dimes Birth Defects Foundation, White Plains, New York, 2006.

Figure 2: NTD rate per 10,000 live births in the Western Pacific



Ref: March of Dimes Global Report on Birth Defects, March of Dimes Birth Defects Foundation, New York 2006. NTD rate calculated from estimated number of affected births, based on 2001 annual births data

In addition to reducing iron deficiency, anaemia and neural tube defects, staple food fortification, depending on what nutrients are added, could be expected to also increase other micronutrient intakes, including B vitamin, zinc and vitamin D.

Factors determining the feasibility of staple food fortification

The fortification of wheat or maize flour requires the addition of powdered micronutrients (i.e., fortificant premixes) during the milling process. Fortificant premixes are added by 'feeders' late in the milling process, often in addition to other ingredients such as flour improvers. It is overall a very simple process but requires accurate addition of the fortificant premix to the flour and adequate mixing. It also requires purchase of high quality fortificant premixes to ensure the potency and safety of fortification and to avoid negative colour and taste changes to finished products such as breads or noodles. Flour fortification is thus best carried out in industrial roller mills; a 'cut-off' of 20MT/day milling capacity has been used to define large milling facilities on wheat and maize flour fortification,[28] although in reality most modern mills operating in the world today are considerably larger than this. Rice fortification is more complex as powdered or liquid micronutrients (i.e., fortificant premixes) need to be added to rice kernels/grains. The *Strategic & Technical Paper on Rice Fortification* by WFP and PATH discusses the various rice fortification technologies, including their advantages and disadvantages with regards to micronutrient retention, cost etc. The preferred technologies for Asia involve the creation of fortified kernels that are blended with non-fortified rice. These

[28] WHO, FAO, UNICEF, GAIN, MI, & FFI. Recommendations on wheat and maize flour fortification. Meeting report: interim consensus statement. Geneva, World Health Organization, 2009. http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fortification/en/ Accessed 19 September 2013

technologies therefore require a two-step process of production of the fortified kernels and blending with the non-fortified rice; these two steps need not necessarily happen at the same location. An important consideration for these technologies is how similar the fortified kernels are to the non-fortified rice and the level of acceptance of fortified rice, in order to avoid the fortified kernels being picked out prior to cooking. All these factors are discussed in greater detail in the accompanying paper prepared by WFP and PATH. They are additional complexities to rice fortification that are not found in wheat or maize flour fortification.

A key factor determining the feasibility of staple food fortification is the proportion of the food vehicle processed in facilities with the capacity for fortification. For wheat/maize flour this would be the proportion that is milled in industrial roller mills, while for rice this would be the proportion of rice milled in large-scale mills or that is centrally warehoused by traders or wholesalers, where blending of the fortified kernels with the unfortified rice can occur. Overall, the more processing and handling is centralized, the easier fortification, and regulatory monitoring by authorities, becomes. Small-scale fortification is possible for both wheat and maize flour, and rice, but there are added complications with supply of premix, quality assurance, and regulatory monitoring.

Food fortification is undertaken by the producers of processed food. However food producers can only effectively fortify their products if a supportive environment exists. In theory, food producers could voluntarily fortify their products and promote them to health-conscious consumers to increase market share (and hence profits). In reality, however voluntary fortification seldom achieves high coverage of the fortified product[29] and mandatory fortification, i.e. legislation requiring all producers to fortify, is necessary to achieve a public health benefit from food fortification.[30] The WHO recommendations for wheat and maize flour fortification therefore state "Wheat and maize flour fortification programmes could be expected to be most effective in achieving a public health impact if mandated at the national level…"[31] One advantage of establishing mandatory legislation for food fortification is that it means all industry members incur the same relative costs, including importers. Also, the government can establish fortification standards based on international norms and guidance so that fortification can be expected to be both safe and effective in improving nutrition, and government and industry can establish systems for internal and external regulatory monitoring, based on the existing legislation, to ensure that the fortification is undertaken well and safely.[32]

Mandatory legislation also helps to address the issue of who covers the cost of fortification. In most mandatory fortification programmes, producers pass on the cost of fortification to consumers. The cost of fortification becomes part of the cost of food processing but as all producers are in competition, any price rises due to fortification are kept to a minimum to avoid losing market share. In the case of wheat/maize flour fortification, the cost of fortification (about US$ 1.50-4.00/MT depending on the nutrients included[33]) is so low that it may be possible to initiate fortification without consumers noticing a cost increase. The total cost of rice fortification is significantly higher, varying from US$ 9 – 35 US$/MT depending on the

[29] Horton et al. Micronutrient fortification (iron and salt iodization). Copenhagen Consensus Best Practices Paper 2008. http://www.copenhagenconsensus.com/sites/default/files/BPP_Fortification.pdf Accessed 20 September 2013

[30] Brown et al. The impact of mandatory fortification of flour with folic acid on the blood folate levels of an Australian population. Med J Australia. 2011

[31] WHO, FAO, UNICEF, GAIN, MI, & FFI. Recommendations on wheat and maize flour fortification. Meeting report: interim consensus statement. Geneva, World Health Organization, 2009. http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fortification/en/ Accessed 19 September 2013

[32] van den Wijngaart et al. Regulatory monitoring systems of fortified salt and wheat flour in selected ASEAN countries. Food and Nutrition Bulletin. 2013, 34 (2), S102-111

[33] http://www.ffinetwork.org/about/faq/faq_wheat_industry.html Accessed 20 September 2013

technology used.[34] However, it is expected that the costs involved in rice fortification will decrease substantially when reaching economy of scale and when competitive markets arise. To overcome the higher initial investments involved in rice fortification, some sort of government subsidy or other financing programme may be needed. It may also be possible to fortify rice that is distributed free or at a subsidized rate to certain segments of the population, usually the poor, as part of a social security intervention. Such public distribution rice might be centrally processed before being distributed, offering an opportunity for fortification. If it is publicly funded or subsidized, the government could cover the cost of fortification within the cost of the programme. Such a programme would likely target populations at particular risk of micronutrient deficiencies.

A second consideration is the amount of the food vehicle that is consumed. The food vehicle needs to be consumed, in sufficient quantities, by a significant proportion of the population, preferably the segments of the population with the greatest nutritional needs. Although it has been noted that food fortification will seldom be able to provide all the micronutrient requirements of the population, improving the micronutrient status of reproductive age women is usually a primary objective of staple food fortification programmes. Fortification with folic acid has been a particularly important strategy for prevention of birth defects because it has successfully increased folate intakes of reproductive age women who have subsequently become pregnant. Supplementation programmes in comparison have not been able to achieve greater than 50% coverage of women in the period around conception[35] partially because at least 50% of pregnancies are unintended globally.[36] Children younger than five are frequently another important target group for improvement of micronutrient status. Rice consumption in this age group in the WPR is likely quite high, but wheat/maize flour consumption may be relatively low. Rural populations may also be less likely to consume wheat/maize flour, which is generally consumed as processed products such as instant noodles, breads, and biscuits. In considering whether or not to implement a wheat/maize flour fortification programme, it is therefore important to obtain information on the total amounts of wheat/maize flour eaten by different population groups to the extent possible. Rice, on the other hand, is usually eaten by all social groups, although often in higher quantities by rural and poor communities. As noted above, food fortification should usually be complemented by other interventions to increase micronutrient intake, and in some circumstances it might be necessary to fortify more than one food vehicle.

Feasibility of staple food fortification in WPR Member States

Feasibility of wheat flour fortification

Wheat flour is consumed in all countries in the WHO Western Pacific region and so could potentially be fortified. However in some countries availability (apparent consumption) levels appear to be too low to make wheat flour fortification an effective intervention, in particular if other food vehicles are not simultaneously fortified. NTD reductions have been recorded as a result of wheat or wheat and maize flour fortification in nine countries[37] with wheat availability

[34] WFP/PATH. Strategic & Technical Paper on Rice Fortification. Paper prepared for WHO Consultation in Manila, November 2013

[35] Ray et al. Evidence for suboptimal use of periconceptual folic acid supplements globally. BJOG, 2004, 111, 399-408

[36] Thurman et al. Multipurpose prevention technologies; biomedical tools to prevent HIV-1, HSV-2, and unintended pregnancies. Infectious Diseases in Obstetrics & Gynecology 2011: 1-10

[37] Castillio-Lancellotti et al. Impact of folic acid fortification of flour on neural tube defects: a systematic review. Public Health Nutrition. 2012

varying from 110g/capita/day (Costa Rica)[38] to 430g/capita/day (Iran). The most evidence of reduction in NTDs from wheat flour fortification comes from the US where average national wheat flour availability is 222g/capita/day.[39] In terms of improving iron intakes, the WHO recommendations indicate that where flour intakes are less than 75g/day, it is not possible to add sufficient iron to cover needs of women of childbearing age, thus fortification of additional food vehicles and other interventions should be considered.[40]

Figure 3 shows wheat (grain, flour and flour products) availability in Western Pacific countries. It suggests that in Cambodia, Laos, Viet Nam, and the Solomon Islands if wheat flour fortification was to be implemented, it should be complemented with fortification of additional vehicles and/or interventions to improve micronutrient intake. One country with relatively low consumption of wheat flour is the Philippines, which already has mandatory fortification of wheat flour. As recommended however wheat flour is not the only food being fortified; the Philippines is also fortifying rice with iron,[41] in addition to implementing iron supplementation of pregnant women. In remaining countries in the region, in particular, New Caledonia, Fiji and Mongolia, wheat availability levels are similar to those in countries with recorded improvements in NTD reduction after folic acid fortification was implemented.

The figure also provides an indication of trends in wheat availability (apparent consumption), which appears to be increasing in countries such as Viet Nam, Vanuatu, Japan, Malaysia, and French Polynesia. Greater consumption of convenience and processed foods such as instant noodles and bread is contributing to the increase of wheat-based foods. The World Instant Noodle Association has recorded a dramatic increase in instant noodle consumption in the world,[42] the majority of which are made from wheat flour. The countries with the highest per capita consumption of instant noodles are in the Western Pacific region, with the Republic of Korea having the highest consumption in the world (6.1 packs or cups/person/month), followed by 4.79 packs or cups/person/month in Viet Nam and 3.87 and 3.57 in Malaysia and Japan, respectively. On a country basis, China and Hong Kong together consumer 44,030 million packs or cups per year. In the Solomon Islands, the Philippines, Brunei, South Korea, and China, wheat consumption appears to be declining, potentially as cereal food consumption is replaced by greater consumption of meat and vegetables due to economic development.

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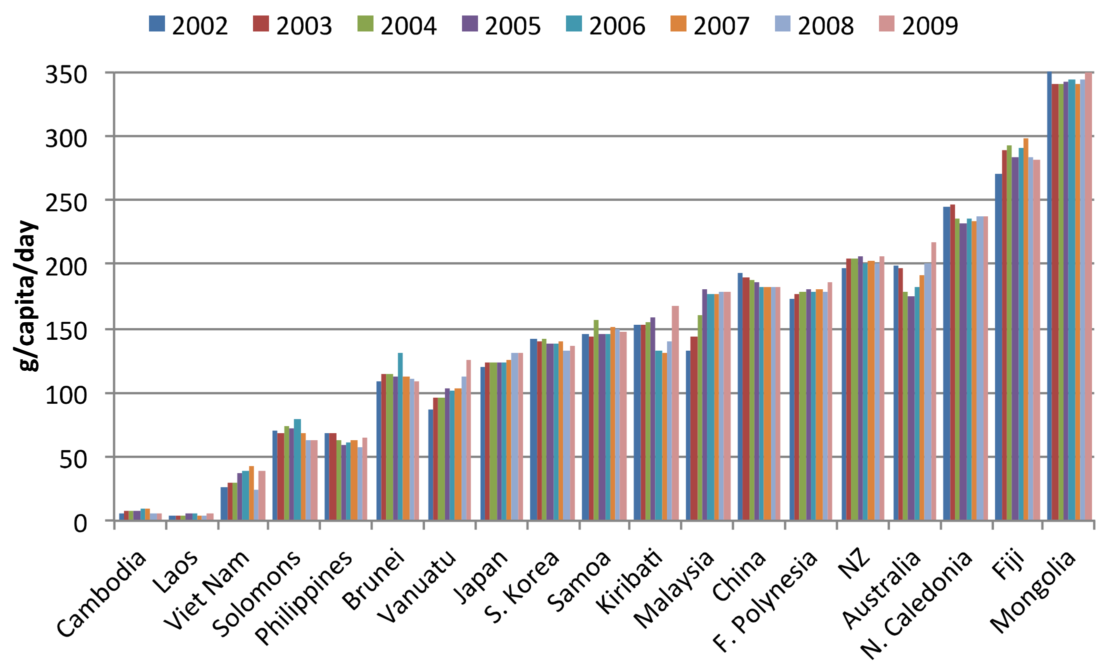
[38] In Costa Rice, both wheat and maize flour are fortified. The combined average amount of wheat and maize flour available for consumption is 137g/capita/day. Maize flour is also fortified in Brazil and South Africa.
[39] Wheat and maize availability data is from FAO.
http://faostat.fao.org/site/609/DesktopDefault.aspx?PageID=609#ancor
[40] WHO, FAO, UNICEF, GAIN, MI, & FFI. Recommendations on wheat and maize flour fortification. Meeting report: interim consensus statement. Geneva, World Health Organization, 2009.
http://www.who.int/nutrition/publications/micronutrients/wheat_maize_fortification/en/ Accessed 20 September 2013
[41] Congress of the Philippines. Republic Act No. 8976. An Act establishing the Philippine food fortification program and for other purposes. 24 July 2000. http://www.fnri.dost.gov.ph/index.php?option=content&task=view&id=690 Accessed 20 September 2013
[42] http://instantnoodles.org/noodles/expanding-market.html Accessed 20 September 2013

Figure 3: Trends in wheat supply in the Western Pacific



Ref: FAO - faostat.fao.org/site/609/DesktopDefault.aspx?PageID=609. Wheat includes "default composition of wheat, flour of wheat, macaroni, bread, bulgur, pastry, starch of wheat, breakfast cereals, and wafers"

A further consideration in the potential for wheat flour fortification is the proportion of wheat flour industrially milled. Wheat flour fortification is less feasible in countries with many small mills for quality assurance, fortification capacity, and regulatory monitoring reasons. Table 1 below suggests that in all countries in the Western Pacific 90% or more of wheat flour is milled in industrial-scale mills and in all countries, with the possible exception of China, the number of mills is relatively small. Even in China, considering the size of the country, the estimated number of mills is not large. Several countries in the region import all of their wheat or flour requirements. Countries, such as the Philippines and Viet Nam, which import all/majority of their requirements as wheat, tend to have a relatively small number of domestic mills. Countries that import flour (rather than wheat) have no mills and fortification could be achieved simply by requiring the import of fortified rather than non-fortified flour. The table below assumes that all imported flour is milled in industrial mills (in the country of origin). In terms of industry structure therefore, wheat flour fortification is a very plausible strategy in all Western Pacific countries.

Table 1: Number of industrial scale flour mills and proportion of flour milled in them by country[43]

Country	Proportion of wheat domestically grown[44]	Estimated total number of flourmills >20 MT/day	Estimated proportion of total flour milled in industrial mills

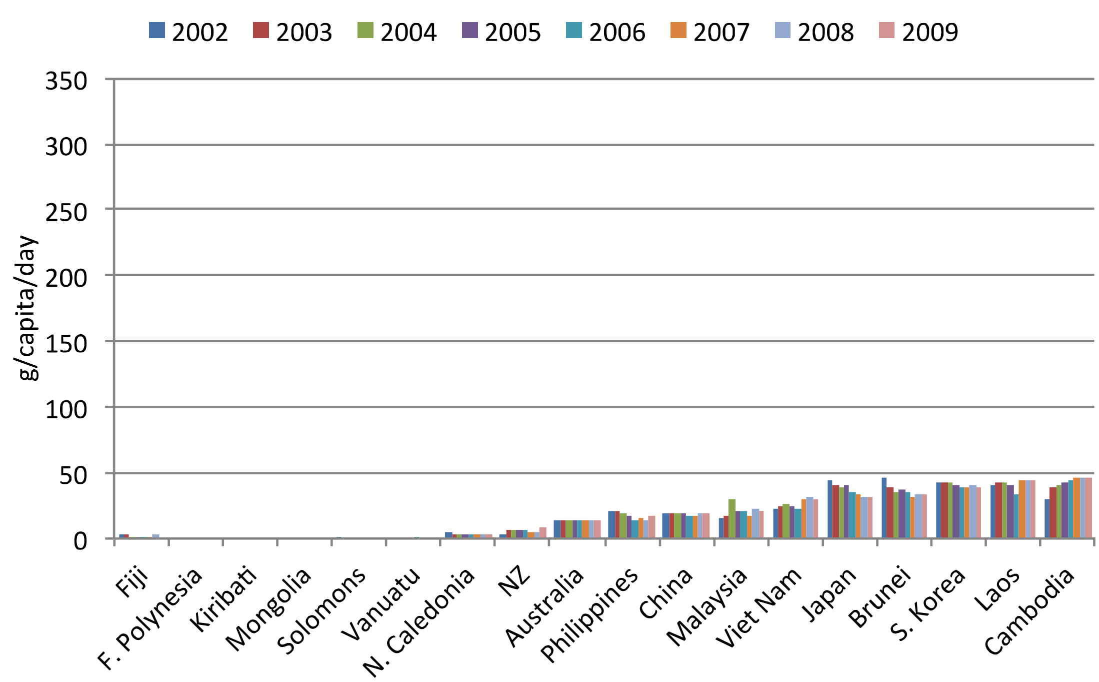
[43] FFI database. Information is sourced from national stakeholders, usually from the milling industry.
[44] Calculated by FFI from FAO data on wheat production and imports, 2009 (latest data available)

Australia	100%	28	100%
Brunei	0%	0	100%
Cambodia	0%	2	100%
China	100%	2479	99%
Fiji	0%	2	100%
Japan	0%	98	100%
Laos	0%	0	100%
Malaysia	0%	13	100%
Mongolia	60%	20	90%
New Zealand	56%	4	100%
Papua New Guinea	0%	2	100%
Philippines	0%	12	100%
Korea	0%	9	100%
Singapore	0%	1	100%
Viet Nam	0%	8	90%
Pacific Islands	0%	0	100%

Feasibility of maize flour fortification

The availability of maize is shown in the figure below for countries in the Western Pacific. The figure indicates that maize is not consumed in significant quantities (<50g/capita/day) in any country in the region and is hence not a relevant vehicle for fortification.

Figure 4: Trends in maize supply in the Western Pacific

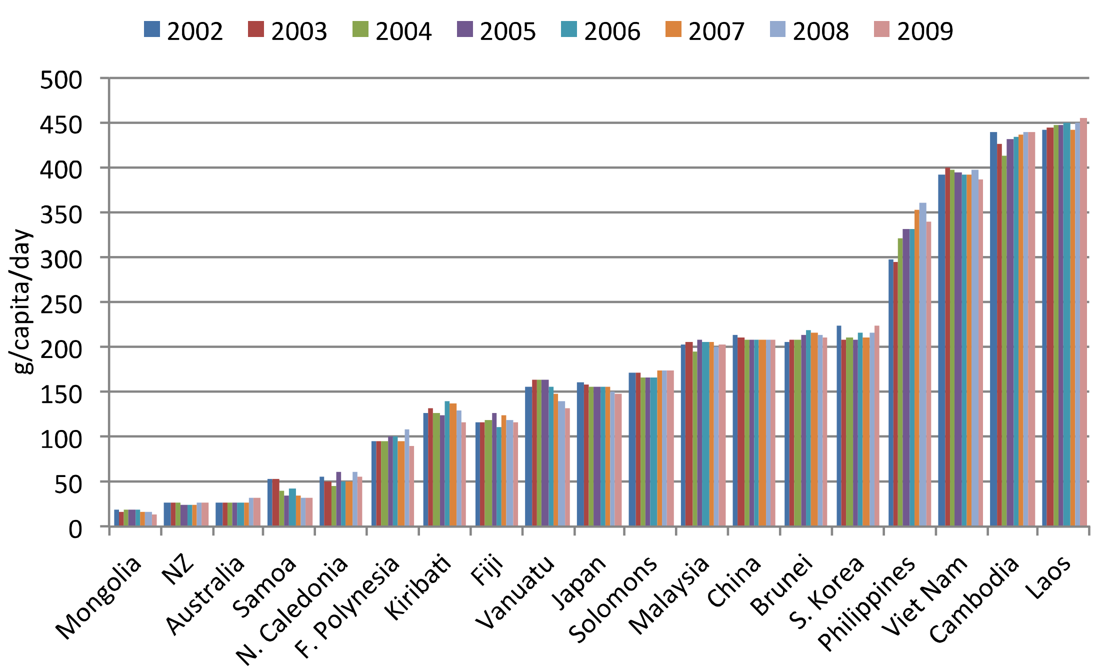


Ref: FAO - faostat.fao.org/site/609/DesktopDefault.aspx?PageID=609. Maize includes "default composition of maize, maize flour, and other maize products included in food consumption."

Feasibility of rice fortification

Research studies to date have used rations of 70-100g/person/day of uncooked fortified rice to assess the impact of rice fortification on nutritional status. Quantities less than 100 g/person/day are considered too low for fortification because it would require the fortified kernel to have a high concentration of vitamins and minerals thus compromising its taste and appearance. All countries in the Western Pacific region have rice availability above this level, with the exception of Mongolia, New Zealand, Australia, Samoa, New Caledonia, and French Polynesia, making rice fortification a feasible intervention in terms of adequacy of rice consumption. Rice consumption exceeds 200g/capita/day in Malaysia, China, Brunei, S. Korea, the Philippines, Viet Nam, and Cambodia. Rice consumption in Laos is particularly high. The high consumption of rice in the region can be expected to contribute to high levels of impact, in particular for the poorest and rural populations who tend to have highest cereal consumption. On the other hand, in countries with lower consumption, the cost effectiveness of rice fortification will be less because of the high start-up costs.

Figure 5: Trends in rice supply in the Western Pacific



Ref: FAO - faostat.fao.org/site/609/DesktopDefault.aspx?PageID=609. Rice includes "default composition of paddy rice, husked rice, milled rice, broken rice, and other rice products available for human consumption."

Unlike the wheat flour industry, information on the number of rice mills in each Member State is less available. In most Member States, the majority of rice is domestically grown and hence domestically milled. Table 2 below suggests that in most WPR countries the majority of rice is milled in large-scale mills. The only exceptions are Viet Nam, Cambodia, and Laos where it is estimated that only a very small proportion of total rice is milled in large-scale mills. If this estimate is true, the options for rice fortification in these countries are: (i) fortification by traders or wholesalers if they centralize a significant proportion of rice, (ii) fortification of rice distributed through a public distribution system, (iii) fortification by small-scale millers or (iv) fortification in the future if the milling industry consolidates. In countries where rice is imported, it is assumed that it is industrially milled in the country of origin and can be fortified.

Table 2: Number of industrial scale rice mills and proportion of rice milled in them by country[45]

Country	Proportion of rice domestically grown[46]	Estimated total number of rice mills >20 MT/day	Estimated proportion of total rice milled in industrial mills
Australia	67%	unknown	100%
Brunei	95%	1	100%
Cambodia	100%	15	very low
China	100%	7,287	99%
Fiji	30%	3	90%
Japan	100%	unknown	unknown
Laos	99%	unknown	very low
Malaysia	70%	224	100%
Mongolia	0%	0	100%
New Zealand	0%	0	100%
Papua New Guinea	10%	1	90%
Philippines	87%	3000	61.5%
Korea	99%	unknown	100%
Singapore	0%	0	100%
Viet Nam	100%	200	20%
Pacific Islands	0%	0	100%

Taking into account levels of wheat flour and rice (assumed) consumption and the above rough estimates of the industry structure, countries in the Western Pacific region have been categorized as to the feasibility of wheat flour and rice fortification. For all countries it has been assumed that there is a health need for fortification because even if iron deficiency/anaemia are not of public health significance, staple food fortification is a cost-effective intervention for addressing other micronutrient deficiencies and reducing neural tube defects, including in developed countries. The table below indicates the feasibility of wheat flour and rice fortification in the following categories:

- **Feasible: adequate consumption and >70% industrially milled.** In these countries wheat flour availability (apparent consumption) is >75g/capita/day and rice availability (apparent consumption) is >100g/capita/day. In addition, it has been estimated that more than 70% of the total wheat flour or rice is milled in industrial-scale mills that would have the capacity to apply quality fortification. For wheat flour milling, the quality of these estimates is quite strong and well referenced[47] but for the rice milling industry, the data should be verified at country level. Countries in this category should consider implementing mandatory wheat flour or rice fortification as indicated.
- **Feasible but inadequate consumption – additional foods should be fortified.** In these countries, fortification of either wheat flour or rice are considered feasible based on industry structure (more than 70% of the food vehicle is industrially milled) but consumption levels are considered too low for achieving a public health impact. As noted above, when consumption of the food vehicle is low, it is not possible to add

[45] FFI database. Information is sourced from national stakeholders, usually from the milling industry.
[46] Calculated by FFI from FAO data on wheat production and imports, 2009 (latest data available)
[47] Flour Fortification Initiative country profiles

sufficient levels of micronutrients without causing negative taste and/or colour changes to the finished product. If these foods are to be fortified therefore, additional foods should be fortified or additional interventions to increase micronutrient intake or reduce micronutrient losses should be implemented to complement the fortification intervention. Countries in this category should consider implementing mandatory wheat flour or rice fortification as indicated and seek to identify additional relevant interventions if not yet implemented.

- **Mass fortification not easy because <70% industrially milled although high consumption.** In these countries, mass fortification of wheat flour or rice are considered not easy to implement because less than 70% of the food vehicle is estimated to be milled in industrial-scale mills with the capacity to fortify. No countries are in this category for wheat flour because only four countries grow wheat in the Western Pacific region and almost all wheat is milled in large-scale mills. Only four countries are in this category for rice fortification.[48] Even in these countries, rice fortification may still be possible if rice is centrally accumulated by traders or wholesalers, if there is a public distribution system which includes a centralized processing step or if small scale milling/blending is feasible. Such countries should explore such options and continually monitor opportunities for large-scale fortification as the general trend is for larger and larger mills.
- **Mandatory fortification already legislated.** These countries have already passed legislation mandating fortification of wheat flour or rice. Such countries should ensure optimal implementation of existing legislation including most effective standards for fortification, adequate internal and external quality assurance procedures and regulatory monitoring, and monitoring of the coverage and health impact of mandatory fortification.

Table 3: Feasibility of wheat flour and rice fortification in Western Pacific countries

	Wheat Flour	Rice
Feasible: adequate consumption and >70% industrially milled	Brunei, China, Hong Kong, Japan, Macau, Malaysia, Mongolia, New Zealand, PNG, Korea, Singapore, Pacific Islands	Brunei, China, Hong Kong, Japan, Macau, Malaysia, Korea, Singapore, Pacific Islands
Feasible but inadequate consumption – additional foods should be fortified	Cambodia, Laos, Viet Nam	Australia, Mongolia, New Zealand
Mass fortification not easy because <70% industrially milled although high consumption		Cambodia, Laos, Viet Nam
Mandatory fortification already legislated	Australia (folic acid only), Fiji, Philippines, Solomon Islands	Papua New Guinea (iron & B vitamins only), Philippines (not fully implemented)

[48] The Philippines has less than 70% of rice milled in industrial mills but it already has mandatory legislation for rice fortification and so is listed in the final category in the table.

Proposed strategy for promoting staple food fortification in WPR Member States to improve micronutrient status

The WHO Comprehensive Implementation Plan on Maternal, Infant, and Young Child Nutrition calls for the scaling up of effective nutrition interventions, one of which is the fortification of staple foods. As this paper has shown the fortification of wheat flour appears highly feasible in the Western Pacific region and its efficacy, effectiveness and cost-effectiveness are well established. The main limitation of wheat flour fortification in some countries of the region is that consumption levels of wheat flour are relatively low. Yet in consideration of the ease of implementation and high-cost-effectiveness, wheat flour fortification can contribute to increasing micronutrient intakes for the segments of the population who consume wheat flour, and should be considered as one intervention in a holistic package of micronutrient interventions. Rice fortification also appears to be a feasible intervention for several countries in the region and, due to the high levels of consumption in most countries, offers a huge opportunity to address micronutrient malnutrition as the technology for rice fortification exists and efficacy and acceptability have been proven. Although it is not as simple or as cheap to fortify rice as it is to fortify wheat or maize flour, the potential benefit justifies national and international partner efforts to scale up this highly promising intervention, in particular in countries where there are resources to support start up costs and where industry structure or public distribution programmes provide opportunities.

Lessons learnt in wheat and maize flour fortification can guide future staple food fortification

Wheat flour fortification is becoming the industry norm and 'lessons learnt' in wheat and maize flour fortification can guide future efforts for staple food fortification in general. Wheat and/or maize flour fortification is now mandatory throughout the Americas, in much of the Middle East and Central Europe and a growing number of countries in Africa. The Flour Fortification Initiative (FFI) is an international partnership of individuals and organizations working together to advocate for and support fortification of industrially milled cereal grains. Over the years, FFI has come to recognize a number of lessons learnt or best practices in wheat and maize fortification that contribute to ensuring a successful and effective programme. The main interest of WHO, FFI, UNICEF, WFP, GAIN, MI, other international partners and national governments in wheat and maize fortification is a strategy towards improved public health and nutrition, such as reductions in NTDs or the prevalence of anaemia and iron deficiency. Thus the following lessons learnt are based on programmes with improved public health and nutrition as the ultimate objective. These lessons learnt from wheat and maize flour fortification can guide the future establishment of successful staple food fortification programmes.

- Fortification programmes are most successful when driven by national stakeholders, in particular national governments, millers, and civil society advocates concerned about NTDs or micronutrient deficiencies. Ideally all these stakeholders collaborate to create an enabling environment for fortification, with each stakeholder contributing its individual expertise and sphere of influence. Preparation for fortification programmes often involves collection of information on consumption of the food vehicle, nutrient deficiency levels or NTD prevalence, information on the milling industry etc. Such information can be easily compiled when all the stakeholders work together to collect and analyze it. Together it is also easier to address questions and concerns that arise from within and beyond the group.[49]
- A key role of national governments is to create legislation requiring national fortification. Millers often request this as it creates an "even playing field" in which they know that their competitors will incur the same costs and they will not be disadvantaged. Mandatory fortification has proved to be more effective than voluntary

[49] http://www.ffinetwork.org/plan/index.html

fortification in both salt iodization and wheat flour fortification in increasing fortification levels.[50]

- Clear and specific standards for fortification should be developed based on existing global or Codex standards or, where these are not available, using the EAR cut-point method.[51] For wheat and maize flour fortification, recommendations for fortification standards have already been developed based on the best available global evidence, and should guide Member States. For rice fortification, WHO recommendations are under development.[52]
- Wheat and maize fortification programmes need to be adequately monitored and quality assured. Millers need to implement proper internal quality assurance systems in their mills and national governments need to establish and maintain regular external quality assurance visits to mills to support quality fortification. National governments should also ensure the quality of fortification premix.[53]

Taking the above lessons learnt into account, initial steps for establishing mandatory wheat flour and/or rice fortification programmes are given below although the process in every country is different. They should be implemented by national stakeholders and supported by international partners.

1. Ministry of Health and/or other health advocacy group (concerned about micronutrient deficiencies or NTDs) initiate advocacy for wheat flour/rice fortification as one intervention in the strategy to improve public health
2. Ministry of Health and/or other health advocacy group collaborate with other stakeholders – wheat flour/rice millers, other relevant ministries, health advocates, consumer groups etc. to establish a national fortification alliance
3. Collect information to justify wheat flour/rice fortification and assess its feasibility and implications. Information should include extent of health problem (micronutrient deficiency and/or NTDs), consumption patterns of food vehicle, structure of industry processing the food vehicle, potential costs, trade implications etc.
4. National fortification alliance collaborates to (i) advocate for wheat flour/rice fortification and increase support, (ii) build technical case and collect relevant information, (iii) address concerns or questions, bring critics on board, (iv) develop a plan for passing necessary legislation
5. Relevant personnel in government draft and submit legislation on mandatory fortification for approval by relevant body, including development of national fortification standard taking into consideration global standards/guidelines and national situation.
6. National milling industry prepares for future fortification – source necessary equipment and premix, train staff, establish necessary systems etc. including for adequate internal regulatory monitoring
7. Relevant government departments prepare for future fortification - develop relevant implementing regulations for national legislation, train staff, establish protocols, systems etc. including for adequate external regulatory monitoring of both premix and fortified food (imports and domestic production)
8. For rice fortification, establish fortificant kernel production facility (or import of kernels initially)

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[50] http://www.ffinetwork.org/plan/legislation.html
[51] WHO and FAO. Guidelines on food fortification with micronutrients. 2006
[52] http://www.who.int/elena/titles/rice_fortification/en/index.html Accessed 20 September 2013
[53] van den Wijngaart et al. Regulatory monitoring systems of fortified salt and wheat flour in selected ASEAN countries. Food and Nutrition Bulletin. 2013, 34 (2), S102-111

9. Ministry of Health, academic institution or international partner consider the feasibility of and potential value of putting in place a system to evaluate the impact of fortification programme (before and after comparison or control and intervention comparison)
10. Implement wheat flour/rice fortification. National fortification alliance continues to collaborate to share information on how well the programme is being implemented, address problems, strengthen implementation etc. This should include review of impact data if available, and review of national standards vis-à-vis global experiences and guidelines as necessary.