BEST PRACTICE PAPER: NEW ADVICE FROM CC08

MICRONUTRIENT FORTIFICATION (IRON AND SALT IODIZATION)

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COPENHAGEN CONSENSUS CENTER

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WORKING PAPER OCTOBER 2008

Best Practice Paper

Food Fortification with Iron and Iodine

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Acknowledgements: The authors would like to thank Nilanthi de Silva, Dirk Engels and Harold Alderman for helpful comments on a previous draft. Cover image credit: Andrew Hall, Westminster University

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PREFACE

For two years before Copenhagen Consensus 2008, a team of experts wrote papers identifying the best ways to solve the world's biggest problems.

Those papers showed that we have the knowledge to do tremendous amounts of good in each of these areas.

That research was utilized by a panel of top economists, including Nobel laureates, who were commissioned by the Copenhagen Consensus Center to identify the most effective investments.

The prioritized list produced by Copenhagen Consensus 2008 provides governments, donors and philanthropists with a guide to the areas where relatively small amounts of money can prove extremely powerful.

The research that provided the building blocks to this process – and a full description of the outcome – form the book, 'Global Issues, Global Solutions, Volume Two', published by Cambridge University Press in 2009. This is an excellent overview of global problems and the most promising solutions.

Given the level of interest in Copenhagen Consensus 2008, the Copenhagen Consensus Center decided to commission a specific set of papers that deal with the spending options given highest priority by the expert panel.

The goal of these Best Practice Papers is to provide clear and focused empirical recommendations on the costs and benefits of implementing the solutions, and advice on how to do so.

The problems dealt with by Copenhagen Consensus 2008 are vast. The practical approaches identified here prove incredibly powerful reading. The Copenhagen Consensus Center hopes that they shall prove an invaluable resource, and further advance the goal of promoting the most sound investments to help humanity.

Bjorn Lomborg
Copenhagen, 2009

EXECUTIVE SUMMARY

An estimated 2 billion people worldwide have inadequate iodine intake, although international efforts have helped to reduce the most severe manifestations of iodine deficiency disorders (cretinism). Dietary deficiencies are associated with soils which are deficient in iodine, unless there are other sources in the diet such as marine products. Both industrialized and developing countries still exhibit deficiencies.

Iron deficiency affects one in three of the world's population, and severe deficiency (which can cause death of mothers and their newborns) remains a problem. Diets of poor people are often low in animal products (which contain iron that is more readily absorbed), low in fruit (which can enhance iron absorption) and high in some cereals (which contain phytate which hinders absorption). Infection and poor sanitation (hence infection with hookworm) also exacerbate iron deficiency.

Iodization of salt began in Switzerland in 1922 and in Michigan in the US in 1924. The Universal Salt Iodization initiative began a major extension of salt iodization to the developing world in 1990. This increased the proportion of the world's population with access to iodized salt from 20% prior to 1990, to about 70% currently. However, iodine deficiency remains a public health problem in 47 countries.

Fortification with iron is at an earlier stage. Several developed countries have fortified flour with iron since the 1940's, and more recently this has spread to Latin America, the Middle East and North Africa. Currently more than 63 countries are fortifying some or all of their flour with iron and/or folic acid and in some cases other nutrients. An international goal for fortification wheat and maize milled from roller (large scale) mills is being developed for 2015.

Some lessons from salt iodization are as follows:

- Mandatory iodization has much greater success in increasing coverage;
- Legislation alone is not enough, and inspection, monitoring and public education are all necessary;
- Public-private partnerships have been key, both within countries, and internationally; the Network for Sustained Elimination of Iodine Deficiency has played a key role internationally;
- Solving technical issues is important, for example providing technical support for small producers to iodize at source;
- Financial sustainability is an issue which needs to be solved, especially to allow smaller producers to remain viable.
- Maintaining the current 70% coverage and striving to cover the rest of the 30% should be the focus

The issues currently being addressed for iron fortification are similar:

- Mandatory fortification of certain types of flour (identified at the national level) helps improve coverage;
- Inspection, monitoring and public education are all necessary;
- Use of the recommended forms of ion with high bioavailability in the context of the population's diet is important to achieve the impact of reduced iron deficiency
- Public-private partnerships are vital and are currently being strengthened both within countries and internationally;
- Technical issues remain; wheat and maize flour from large mills reach a smaller proportion of the world's population than does salt, so alternatives need to be considered, such as condiments and rice. Home fortification of weaning or complementary foods is another possibility, in order to reach children under 2 years.
- Financial sustainability needs consideration: initial expenditures are required (setting up monitoring systems where they do not exist; purchasing feeders for mills; social marketing campaigns), as well as covering recurrent costs.

Salt iodization and flour fortification with iron are very inexpensive: approximately $0.05/person/year for iodine and $0.12/person/year for iron fortification of wheat and maize flour. Up to 80-90% of the population can be reached at this cost level for iodine, and up to 70% for iron: the cost of reaching the remaining population is higher.

In the long run, consumers can bear the recurrent costs of fortification; however there are costs to initiate programs. International assistance to move towards USI is estimated to have been $350 million to date, with an estimated additional $200m required to reach the goal. To achieve the Flour Fortification Initiative goal by 2015 would require an estimated additional $300 million in international support.

Correcting iodine deficiency yields benefits in terms of increased future cognitive ability with an estimated 30:1 benefit:cost ratio. Correcting iron deficiency yields benefits in increased cognitive ability as well as greater current endurance and work capacity of adults, with an estimated 8:1 benefit:cost ratio. There are additional human benefits in terms of fewer stillbirths (iodine), and lower maternal mortality rates and neonatal deaths (iron). This makes the investments in fortification very worthwhile.

In the Copenhagen Consensus, 2008, a group of world-renowned economists ranked fortification with micronutrients (i.e. vitamins and minerals), among the top three international development priorities. Specifically, fortification with iron and iodine, two minerals needed in small quantities in daily diets, was ranked as a top public health intervention priority for countries using benefit-cost analysis.

Undernutrition remains widespread around the world, despite significant reductions in income poverty in recent years. Recent estimates published in the Lancet (Black et al 2008) suggest that "maternal and child undernutrition is the underlying cause of 3.5 million deaths, 35% of the disease burden in children younger than 5 years, and 11% of total global DALY's" (Disability-Adjusted Life Years).

One of the most widespread nutrient deficiencies is that of iron, which is estimated to affect 1 in 3 of the world's population (Figure 1, from de Benoist et al 2008). Iron deficiency has adverse effects on work productivity of adults, leading to losses in economic output. Improving iron status of deficient adults improves their productivity in heavy manual labor by up to 17%, and in lighter manual labor by up to 5% (see citations in Horton and Ross, 2003). Iron deficiency also interferes with normal brain development and learning among children. Studies confirm that children with adequate iron status better interact with others and have better cognition (see an interesting longitudinal study by Lozoff et al, 2006), as well as perform better in school (Bobonis et al, 2006), and hence the potential for higher lifetime income. Iron deficiency anemia among pregnant women is associated with increased risks in childbirth, causing more than 20% of maternal mortality in Asia and sub-Saharan Africa and more than 20% of the deaths in the first week of life.

Severe iodine deficiency in pregnancy is associated with significant cognitive losses in babies, with the most extreme outcome being cretinism, where the individual is mentally retarded and has almost no chance of a healthy and productive life. Even mild and moderate iodine deficiency among women during pregnancy can result in significant IQ losses and learning ability in their children. Adequate iodine intake is also essential for cognitive development in young children.

Micronutrient fortification of foods and condiments allows for an inexpensive and highly cost-effective strategy to improve and protect micronutrient status of populations. Iodine deficiency has been successfully reduced by the implementation of Universal Salt Iodization programs in most countries. However, more than 1.8 billion people in developed and developing countries are still not covered by iodized salt and therefore not protected from deficiency (Figure 2 from UNICEF 2008). Fortification of wheat and maize flour with iron has been recognized as a sustainable and low cost strategy to reduce the burden of iron deficiency. As well be described further below, essentially all the countries of Americas and a number of countries in the Middle East and Africa have successfully implemented wheat and/or maize flour fortification, and multi-sectoral efforts are underway to have 90% of industrially processed flours fortified by 2015 (source: Flour Fortification Initiative).

Section 1 below briefly discusses the range of challenges that increase the risk of iron and iodine deficiencies in populations; section 2 describes the key components for implementing sustainable national fortification programs as a sustainable solution to reducing the public health burden of vitamin and mineral deficiencies among the large majority of the world's population; section 3 undertakes more detailed economic analysis of fortification; and the fourth and final section discusses the implications of the analysis.

1 THE CHALLENGES

Micronutrient deficiencies are generally associated with poverty and consumption of foods with low micronutrient content, can be exacerbated by poor health conditions, and have especially negative consequences during pregnancy and early childhood.

The diets of poor people in developing countries are primarily composed of starchy staples which are usually low in vitamin and mineral content. Although consumption of animal products and fruit and vegetables help improve micronutrient intake of populations, the high costs of such foods severely limit their regular intake by low income populations who are at highest risk of vitamin and mineral deficiencies. Less diverse diets not only impede total micronutrient intakes, but also contain less bioavailable nutrients (e.g. iron from flesh foods is more readily absorbed than from plant foods, and adequate intake of vitamin C and vitamin A rich fruits and vegetables help improve iron absorption and metabolism).

Where people live and grow their food can also affect their micronutrient status. Some countries, and regions within countries, have soils with lower levels of iodine (iodine levels in soil tend to decrease with distance from a sea coast, and is also quite low in mountain valleys), and therefore individuals who rely on locally-produced food are more at risk of deficiency.

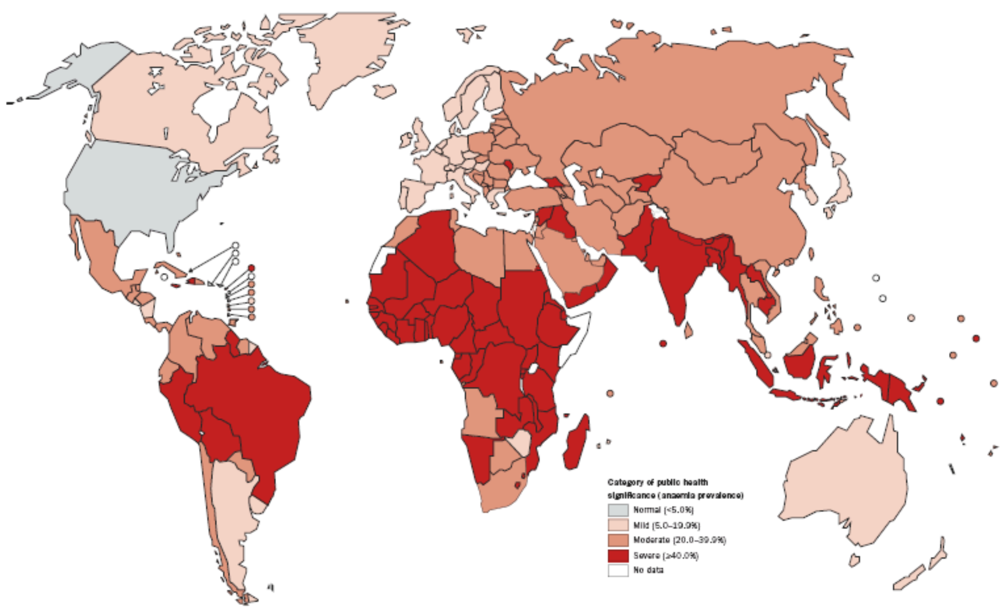

Figure 1. Anaemia as a public health problem by country: Preschool-age children

Source: de Benoist et al 2008

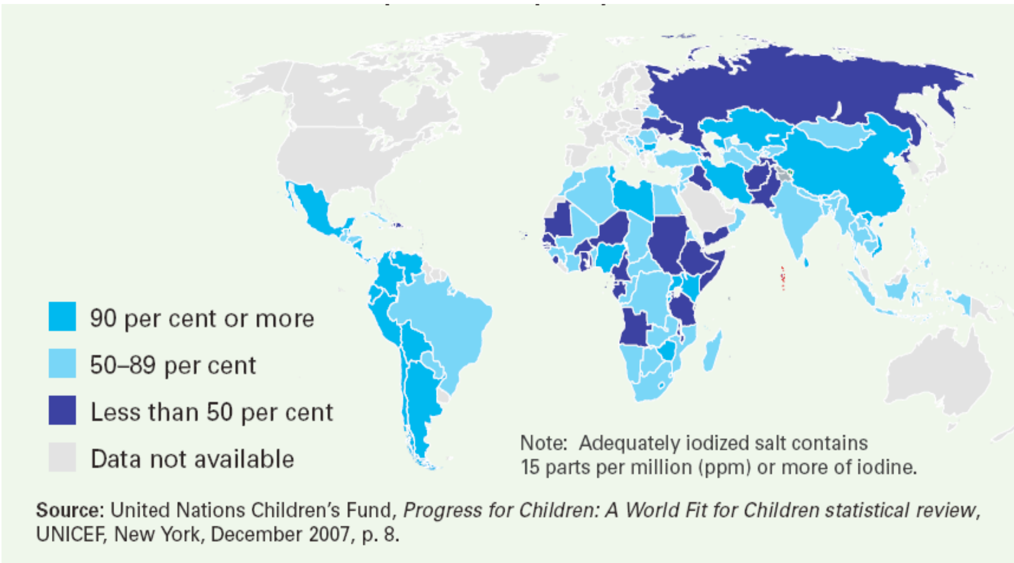

Figure 2. Household consumption of adequately iodized salt worldwide 2000-2006

Source: UNICEF 2008

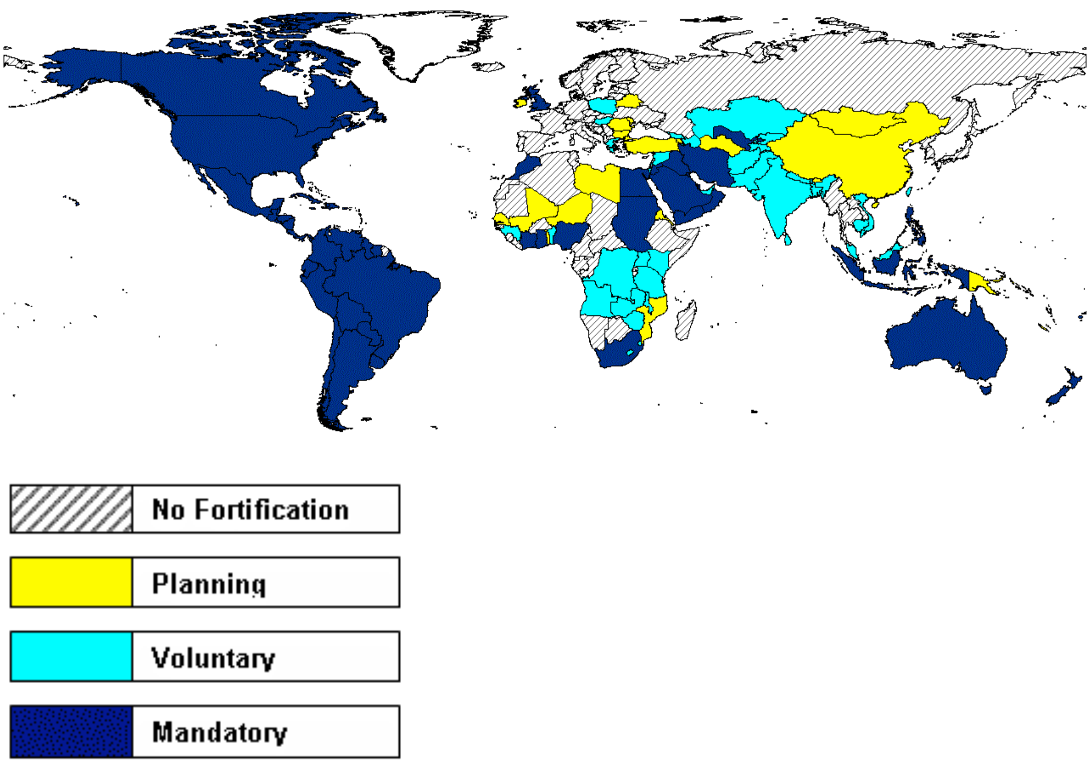

Figure 3. Progress of flour fortification with either iron or folic acid

Source: Flour Fortification Initiative, 2008a

Especially in developing countries, poverty is also associated with higher proportions of populations suffering from parasitic illnesses which further decrease their micronutrient status. For example, people suffering from hookworm infestation suffer from gastrointestinal blood loss which in turn leads to excess loss of body iron. Furthermore, vitamin and mineral status of young children is significantly compromised because chronic parasitic infections damage the lining of their intestines, leading to reduced absorption of nutrient from the foods they consume.

There are also age and lifecycle effects on peoples' micronutrient requirements. Women of reproductive age have a higher need for dietary iron so as to reverse the loss of body stores of the nutrient with monthly menstrual cycles. Pregnant women require more vitamins and minerals to meet the critical needs of the growing fetus and to maintain their own health. After birth, infants and toddlers have very high needs for vitamins and minerals so as to reach their optimum physical and cognitive development. Those needs can only be met when parents and caregivers are enabled to appropriately feed infants and provide them adequate amounts of vitamin and mineral rich complementary foods after 6 months of age.

2 FOOD FORTIFICATION: ONE KEY SUSTAINABLE SOLUTION

Micronutrient fortification (adding small amounts of vitamins and minerals to foods to enhance their nutrient content) is particularly appropriate where inadequate diets and/or infectious and parasitic diseases compromise the micronutrient status of different population groups, and where appropriate food vehicles can be fortified (see below). An appropriate food vehicle is one which is widely consumed an adequate amounts by the target populations, where the micronutrient added does not adversely affect consumer acceptability of the product, where food processing is sufficiently centralized that fortification is feasible and with adequate quality assurance and control procedures and enforcement, etc.

Fortification of salt with iodine has been one of the longest-standing micronutrient interventions which began following scientific proof of the effectiveness of iodine as a goiter prophylactic in the 1920's. Its extension to large proportions of the developing world starting in the 1990's, to its current status where many countries are covered, provides useful lessons for fortification programs for other micronutrients.

On the one hand, huge progress has been made, such that 34 countries have reached the Universal Salt Iodization (USI) goal (whereby 90% of the population consume iodized salt), and at least 28 more have 70-89% of the population covered. On the other hand, there are 47 countries where iodine deficiency is still a public health problem (Zimmerman et al, 2008). The remaining issues with salt iodization are therefore to extend coverage to those countries which do not have national programs (including countries in the former eastern Europe/USSR and in sub-Saharan Africa), and within some countries to increase coverage, particularly to hard-to-reach populations. It is also important to maintain coverage in those countries which have reached the goal, so that they do not to slip back.

Fortification with iron is at an earlier stage. Scientific knowledge of the effectiveness of iron interventions on functional outcomes has been available since the 1830's when doctors began prescribing iron supplements, and iron's role in hemoglobin synthesis has been known since 1932. However it has taken longer to implement widespread interventions. Several developed countries have fortified flour with iron since the 1940's. This spread next to Latin America, and most recently there has been progress in the Middle East and North Africa. The Flour Fortification Initiative estimates that in 2008, more than 63 countries are fortifying all or some of their flour with iron, folic acid and in some cases other nutrients. The original goal was to have 70% of roller mill wheat flour fortified with iron and folic acid by the end of 2008, a timeline which has proved somewhat optimistic, although good progress is being made: currently about 28% of this flour is fortified. A new target is being developed for 2015.

In Section 2.1 we examine past successes and current challenges for extending iodine fortification, and the same in Section 2.2 for iron.

2.1 Iodine

2.1.1. Background and Global progress towards USI

Prior to 1990 the iodization of salt was adopted only in areas with visible signs of iodine deficiency such as cretinism and goiter. Studies in the 1980s established the devastating impact of even sub-clinical (i.e. non-symptomatic) iodine deficiency on the mental development of children. This led to global agreement on the need for USI as a sustainable measure to address Iodine Deficiency Disorders (IDD). In 1990, seventy Heads of State gathered at the World Summit for Children in New York and agreed to the elimination of IDD as one of the health and social development goals to be reached by the year 2000. In 1990 less than one in five households in the world used iodized salt, whereas today 70% of households have access. Since then, a large number of developing countries have taken steps towards USI for human and livestock consumption. Many national governments and salt industries supported by international agencies and expert groups planned and implemented USI programs to achieve elimination of IDD in their populations. The number of countries which iodize salt increased by one-third (to 120) between 2000 and 2006. During that time, nearly US$ 400 million in public sector investments was matched by an estimated US$2 billion in salt industry investment. The tremendous global progress already made through salt iodization means that every year, 90 million newborns' brains are protected against a significant loss of learning ability (Mannar 2007). Salt iodization probably represents the first large-scale experience in national fortification of a commodity to eliminate a public health problem.

The experience of USI has shown that coordinated action by all sectors of society is the key to eliminate micronutrient deficiency in any country. Governments need to pursue policies that protect newborns from preventable brain damage by supporting and sustaining salt iodization, and by monitoring progress; the salt industry and vendors must produce and sell adequately iodized salt at fair prices in cities, towns and villages every day; and civil society has a key role in public education and communication about the importance of adequate iodine intake, helping strengthen and sustain consumer demand for iodized salt.

Once established in a sustainable manner, salt iodization is a long-term and permanent solution to ensuring healthy iodine status of a population in each country. Within one year of adequately iodized salt being available and consumed throughout a country, there will be no further birth of cretins or children with subnormal mental and physical development attributable to iodine deficiency. Most goiters in primary school children and adults will have started to shrink and even disappear altogether. Children will be more active and perform better at school.

As nations implement and expand this highly cost-effective micronutrient intervention, it is important to capture the success factors that contribute to the progress and overcome challenges to ensure the achievement of the goal of IDD elimination and its sustenance thereafter.

Experiences over the past two decades show that implementation of successful USI program are based on the following key elements:

- mobilizing political will to mandate and enforce USI
- formation of multi-sector coalitions and transparent partnerships involving international organizations, private salt producers, national governments and civil society
- a financially sustainable model
- advocacy and communications to help the population to accept and support the effort
- assisting the salt industry to overcome technical issues
- integration of monitoring systems into routine data systems to track population coverage

Supportive political and regulatory environment: According to the latest Global Unified Matrix database, 55 out of 117 developing countries had legislation enacted for USI by 2005 (UNICEF 2005), and since then, additional countries have enacted such legislation. The data show that countries with mandatory legislation have a greater improvement in household coverage of iodized salt in the last decade - from 49 per cent to 72 per cent compared to those which rely on a voluntary salt iodization approach – from 40 per cent to 49 per cent. However, establishing a legislative mandate for universal salt iodization is not enough. Governments must sustain their commitment to IDD elimination, allocating the necessary resources and empowering key ministries to play their respective roles. This includes ensuring adequate salt inspection and enforcement of regulations, adequate education and incorporation of information on iodine deficiency and its consequences in all educational curricula, and adequate overall program oversight. These efforts will help sustain public awareness and demand for iodized salt.

Strong partnerships: The commitment towards USI resulted in a unique combination of enlightened public policies, private sector action and civic awareness. To protect populations from losses in learning ability and from mental retardation that hampers the development of their citizens and their nations, governments are taking concrete steps to implement USI through partnership with the private sector (Gautam, 2007). Today, salt producers worldwide recognize their critical role in providing adequate iodine to their customers, and at least 72 developing countries have adopted national public-private coalitions that provide practical and effective mechanisms to raise and sustain commitments to IDD elimination (UNICEF 2005).

At the global level, efforts to strengthen such partnerships have resulted in the establishment of the Network for Sustained Elimination of Iodine Deficiency, a public-private alliance to coordinate, harmonize and accelerate progress on USI. Many donors have recognized the importance of salt iodization and elimination of IDD. Advocacy efforts led to a major initiative by the Kiwanis International to adopt USI as their major service project. Kiwanis raised over US$ 90 million and helped more than 100 country programs. The Bill and Melinda Gates Foundation, Canadian International Development Agency (CIDA), United States Agency for International Development (USAID), Aus Aid and others continue to contribute to elimination of IDD worldwide. The World Health Organization (WHO) and the International Council for the Control of Iodine Deficiency Disorders (ICCIDD) have provided the scientific consensus and developed norms for identification and correction of the deficiency. Global implementation has been promoted and facilitated though efforts of organizations like UNICEF and the Micronutrient Initiative along with other partners.

Building financial sustainability: As IDD programs mature, many countries transition from a donor-supported to market-supported supply of iodate which is added to salt, including building the salt industry capacity to ensure a regular supply of the fortificant. In many countries, public oversight is now being financed by government revenues and often integrated into the routine operations of relevant agencies.

Strategic advocacy and communication efforts: Communication efforts have reinforced accountabilities of various partners and mobilized support of many actors, including national leaders, salt industry representatives, technical and professional groups and the general public including school children and mothers. China has proved that strong advocacy and re-advocacy, social mobilization and health education programs resulted in sustained elimination of IDD (Wang et al., 1997). China developed a national IDD day to spread messages on the importance of IDD and universal salt iodization programs, and other micronutrient deficiencies. This national event also made it possible to disseminate messages among hard-to-reach social groups on the public's right to iodized salt.

Technical improvements: Over the past decade there have been significant investments in salt refining capacity in several countries. By refining and packaging salt in a good moisture barrier, such as low density polyethylene bags, iodine losses can be significantly reduced, during storage periods of over six to twelve months. In India, refining capacity has increased from less than 5% to nearly 50% over the past 15 years. China has undergone a major modernization of refining, iodization and packaging facilities over the past six years. Most Latin American countries achieved close to USI through modernization of the salt production and refining capacities.

Strengthened population monitoring systems: Countries have moved towards monitoring iodized salt production and quality, and household use – typically as part of other national surveys such as Demographic and Health Survey (DHS) or Multiple Indicator Cluster Survey (MICS). To track impact of the programs, countries have appropriately shifted from tracking goiter to measuring urinary iodine levels to reflect the iodine status of population (De Benoist 2004), and World Health Assembly resolutions have been passed requiring member states to report these statistics every three years. In addition, new measures of thyroid function have been developed (Zimmermann et al, 2008).

2.1.2. Challenges and Gaps in USI

Although there has been significant success, more effort is required in order to achieve complete coverage of iodized salt across all countries. This is especially important since the groups not yet reached are among the more marginalized of the world's population and in greatest need of protection against IDD. New strategies need to systematically identify bottle-necks and address the constraints that impede universal salt iodization. Strategies are needed to reach the last mile of USI coverage. Some of the key challenges are:

Regulation: ensuring USI where iodization is not mandatory**:** Even though mandatory iodization of consumer salt is the recommended option for all developing countries, salt iodization is not mandated in most West European countries and in the former Soviet Union. While Canada mandates iodization of all table salt, this is not required by law in the USA. In the absence of legislation, voluntary iodization coverage is quite variable: for example USA 65%, Germany 43% and Belgium 10% (Andersson et al 2007). There is also evidence of backsliding among countries that were successful in the past, when political commitment, monitoring and controls are relaxed. In some European countries, iodine deficiency has begun to reemerge as iodization of table salt is not mandatory, consumption of table salt has fallen, and households consume more processed foods (which do not contain iodized salt). Thus, in some of the countries, mandated iodine content in salt is being increased to compensate (Andersson et al 2007).

Another aspect of regulation is which types of salt are required by law to be iodized. With an increasing trend in consumption of processed and restaurant foods, and decreased use of table and cooking salt in homes, use of iodized salt in commercial foods becomes an important factor in sustaining the achievements in USI. There is no consistency as to the mandatory use of iodized salt in processed foods across countries. Food processers are reluctant to use iodized salt stating concerns about its impact on organoleptic properties of their food products as well as trade barriers created by differences in legislation between countries. However, several reviews show that iodized salt does not affect the quality of commonly used food products. National iodine programs that mandate only table salt be iodized should consider expanding the mandate to include salt used in processed foods.

Advocacy: Salt is the best vehicle for delivering iodine to populations, but there are concerns among some clinicians and consumer about the use of salt due to its association with health conditions like high blood pressure. Advocates of USI should make it clear that USI does not encourage increased consumption of salt, rather that the salt that is consumed be iodized. Iodine content can be adjusted easily to lower levels of salt consumption (WHO, 2007).

On a different angle, in some countries there seems to be a perception that only refined salt can be iodized and therefore the drive to achieve salt iodization has led to countries also pushing for salt refining. This perception is incorrect because refining is not necessary and coarse washed salt can also be iodized effectively. Therefore the decision for refining the salt should be left to market driven processes. Since primarily refined salt is iodized and sold in better packaging at higher costs, it has led to the perception that iodization is responsible for the added costs where, in reality, most of the extra cost of the salt is due to branding, marketing, refining and packaging. Iodization of salt would typically increase the price of salt by only about $1 US per ton, which can be easily absorbed within the price of coarse salt.

Technical: ensuring iodization within a heterogeneous salt industry**:** The salt production process and scale range from cottage scale units producing a few hundred tons a year to very large fully automated plants producing several million tons. In the larger units which are generally well organized with quality control systems, integration of iodization has been relatively easy. Overall, large and medium producers account for nearly 75% of all salt for edible consumption in the developing countries. However a small but significant proportion of the salt is produced along coastlines or lake shores as a semi-agricultural operation by many small producers. The smaller units often operate with a minimum of organization and little or no quality control. Very often precise figures regarding even their location, extent of holdings and production statistics are also not available. Iodizing the salt produced in such units is complicated, yet often these are the main salt supplies to the communities most at risk of IDD and are responsible for the 'last mile' of USI coverage.

2.1.3 Recommendations for key stakeholders in developing and developed countries, in extending salt iodization

Since the 2002 UN Special Session on Children, many countries have reported continued progress towards achievement of the USI/IDD goal. However, there are also countries which have not made tangible progress and need additional support to accelerate their efforts towards elimination of iodine deficiency. Every year approximately 38 million children in developing countries are born unprotected from iodine deficiency, 70% of whom live in just 25 countries. Among those 25 countries, 16 countries have been identified for special attention by development agencies based on a high number of unprotected newborns, a low level of salt iodization, large salt export activities, as well as a need for special advocacy and professional support to renew strategies of the national IDD elimination program. These 16 'make-or-break' countries are: Afghanistan, Angola, Bangladesh, China, Egypt, Ethiopia, Ghana, India, Indonesia, Pakistan, Philippines, Niger, Russia, Senegal, Sudan and Ukraine (UNICEF 2008). Most of these countries are also characterized by large numbers of very vulnerable, food insecure population groups, the most needy, 'hard-to-reach' people who usually have very little access to fortified foods, including iodized salt. Available data suggest that if the 16 countries achieve USI, then the overall global average of households consuming iodized salt would be about 85%.

Recommendations for extending and sustaining salt iodization in these countries parallel the six key elements already discussed.

<u>Sustained political commitment to legislation</u>: Strong and continued government commitment and industry motivation are essential. Political commitment needs to be renewed through periodic re-advocacy events. The laws should clearly prohibit production, import and trade of non-iodized salt for human and animal consumption. Depending on the country, this may mean revision of existing legislation and/or strengthening of its enforcement.

<u>Partnership: national oversight coalitions</u>: National and sub-national coalitions provide practical and effective mechanisms to raise and sustain commitment to IDD elimination. Coalitions with clearly defined roles and responsibilities can play a major driving role in reviewing monitoring information for planning and promotion of collaborative work. Producers could form salt associations to facilitate universal supply and access to iodized salt.

<u>Advocacy and communication</u>: Appropriate communication through mass media, schools, the health system and other context specific channels is essential to educate the public and salt producers about elimination of IDD. Potential negative reactions should be anticipated and addressed from the start. For example, in Pakistan, a social marketing group developed a "Retailer's Kit" and distributed it through salt processors and distributors to help consumer awareness and understanding. However, when rumors spread connecting iodized salt with contraception and loss of energy and delayed USI, the marketing team repackaged the materials together with new materials to refute the incorrect and harmful rumors.

<u>Technical: mobilizing small producers</u>: For achieving and sustaining USI, support needs to be provided to small producers requiring a special strategy. A first step would be to identify and locate each individual producer and understand the details of ownership and production capacity. Techniques such as Global Positioning System (GPS) mapping could be useful, and was recently applied successfully in Senegal and Bangladesh (Micronutrient Initiative, 2007).

Small producers often have to be first convinced that they have a role to play in the USI program and that they are capable of doing it. Benefits to them, including economic returns, have to be illustrated. Their limitations and constraints need to be recognized. They cannot be expected to participate only for the good of the country, although this should be developed as a motivating factor. The production of iodized salt must benefit them economically to sustain their compliance.

In order to remain economically viable, small salt producers will have to change with the times. These producers can be advised on different business options and helped to organize into viable units or cooperatives with other producers to absorb technical and financial inputs and to penetrate the salt market. Clustering processors helps to bring down the costs of production and transport, thus putting producers in a better position to compete in the market. It also facilitates quality control which in turn makes it easier to access a market for the salt because the quality can be assured.

Technical training and assistance is often needed, for example in establishing production, quality control sampling and analytical procedures. In some cases, appropriate technology for salt purification needs to be provided. Simpler quality control and analytical techniques, such as test kits, may also be needed.

<u>Technical: retailing and packaging</u>: In some countries raw salt producers supply their un-iodized salt to multiple levels of iodization and packaging. In such situations, multiple small re-packagers take on the task of iodization and packing the salt into consumer-size bags. As with small salt producers, these facilities often do not have the capacity to consistently produce good quality iodized salt. Where this practice occurs, governments should encourage raw salt producers, especially if they are large, to iodize the salt at source. These raw salt producers can thereafter supply large sacks of iodized salt to re-packers for packing into smaller bags. By encouraging iodization at source, the number of facilities that need to be monitored is reduced and large producers can take advantage of economies of scale to implement more dependable and uniform iodization techniques.

<u>Technical: Fortificant (potassium iodate) procurement:</u> Ensuring a sustainable and secure procurement chain for potassium iodate that is affordable and accessible to small producers is a key requirement. Some international agencies provide subsidized or free iodate with parallel assistance to the establishment of a commercial, sustainable iodate procurement system. Sometimes the small producers are supported to access competitive markets, e.g. linking with public food distribution programs in India/Ghana. During the time the subsidy is provided, well designed revolving funds help drive continued procurement. Once the international subsidy ends, it is necessary for domestic funding to continue the program.

<u>Effective monitoring systems</u>**:** A regular and effective monitoring system to ensure adequate salt iodine levels from production to households, and to track iodine nutrition in the population is instrumental to a successful program. Effective monitoring will also help ensure adequate salt iodization levels and can also be used to adjust iodine levels in salt based on population's intake patterns.

The global progress for the elimination of brain damage due to iodine deficiency through Universal Salt Iodization serves as a model to address a variety of health, social and economic problems. The achievement of IDD elimination will be a major public health triumph ranking with the eradication of small pox and polio. It will be a major achievement toward the elimination of a non-infectious disease (World Health Assembly, 1999).

2.2. Iron

2.2.1. Background and current status of iron fortification

Various foods and condiments that are centrally produced and widely consumed could potentially be fortified to deliver adequate amounts of key vitamins and minerals to populations. Also, the global tendency towards urbanization means that increasing proportions of the world's population, including in developing countries, could potentially consume fortified industrially-processed foods. This affords many countries the opportunity to fortify multiple food vehicles to help eliminate different micronutrient deficiencies.

Although reducing the burden of iron deficiency and iron deficiency anemia will likely require fortification of several food vehicles depending upon the target populations and their dietary behaviors and patterns, industrially milled wheat and maize flours are currently the most common products fortified with iron. These staple are widely and regularly consumed, and mostly processed in large industrial mills with established distribution and marketing networks which deliver the products to urban and rural populations in many countries.

The Flour Fortification Initiative (FFI) (http://www.sph.emory.edu/wheatflour/index.php) estimates that in 2008 more than 63 countries are fortifying all or some of their wheat flour with iron, folic acid and other nutrients covering 28% of the global market. In the Americas fortification of industrially milled wheat flour and corn flour is almost universal. The relatively low level of iron deficiency among school age children and women of childbearing age in the U.S. and Canada is partly attributed to flour fortification. Chile has an iron deficiency prevalence of less than 1% in children 2-6 (WHO, 2008), which most observers attribute to a strong national flour fortification program (using ferrous sulphate). More recently, all corn and wheat flour in Venezuela is being fortified with iron (mixture of ferrous fumarate and reduced iron) and a number of vitamins. Fortified flour products currently contribute about 48% of recommended dietary iron for the average Venezuelan, and the nutritional impact of flour fortification in Venezuela has been both swift and dramatic **(Layrisse et al, 1996).**

There is growing interest and action on wheat flour fortification elsewhere in the developing world. In the Middle East and North Africa several countries started fortification by adding at least iron and folic acid to cereal flour. A recent program review by the Micronutrient Initiative reported that while prior to 1998 only one country (Saudi Arabia) was fortifying flour, currently 13 countries in that region produce and consume fortified flour on a national or sub-national scale, reaching more than

81 million consumers (MI WHO-EMRO, 2006). In Asia, national flour fortification is under implementation in Pakistan and Nepal while several states in India are planning to introduce it soon. In Africa fortification of wheat and maize flours has recently been made mandatory in several countries. Fortification is also being extended to cereal flour derivatives and processed baked products, complementary foods, noodles and pastas in various countries.

The biggest challenge in fortifying foods with iron is to use bioavailable forms of iron that are better absorbed in the body, but do not alter the appearance or taste of the food vehicle to which they are added. For example, white insoluble iron phosphate compounds are stable under a variety of storage conditions but are poorly absorbed. In contrast, soluble iron salts like ferrous sulphate are well absorbed but can discolour fortified foods by reacting with some ingredients under certain conditions. Thus, the form of iron should be selected based on maximum bio-availability, at the lowest cost, without adversely affecting the properties of flour and flour products.

One recent concern arose, following studies showing adverse effects when non-deficient individuals received iron supplements in malarial areas. However, it should be noted that the doses of iron from supplements are significantly higher than those delivered by fortification, even in populations with very high flour consumption. Based on a detailed review of all the studies, the expert groups convened by WHO and UNICEF recommended iron fortification of staple foods, condiments and complementary foods with iron as the preferred intervention strategy for populations affected by high malaria transmission rates, because this avoids the need for preventive supplementation.

Scientific reviews also confirmed that fortification of wheat flour (and other food vehicles) with appropriate levels of iron is safe. It causes little, if any risk of adverse consequences, even in the very small proportion of people with clinical disorders relating to iron absorption and storage. For individuals with iron overloading disorders, the increased rate of iron accumulation due to the consumption of iron-fortified flour is small, and poses little additional risk for individuals with clinical disorders such as thalessemia major or hemachromatosis (Flour Fortification Initiative, 2004).

The same key elements affect the success of flour fortification with iron, as that of salt with iodine.

Legislation: The FFI reports that there are wide variations in the form of regulations (Figure 3) and types and levels of iron and other micronutrients added to fortified flour across countries. There are some common regional flour fortification standards in North America, the Caribbean, Central America and Central Asia, which help facilitate trade. This includes. Other regions where common standards are proposed (but not yet implemented) include Southern Africa, East Africa and the South Pacific. As many as 11 different micronutrients could be added to flour, but the most common one is iron (in 86 out of 91 country standards).

Over 40 countries have mandatory regulations requiring the major types of white flour to be fortified. Another 5 countries, including the United States, do not mandate national fortification but regularly practice it. Whole wheat and high extraction flour are generally not required to be fortified and some countries, like South Africa, exclude certain types of white flour from the fortification requirement to allow for limited consumer choice on the type of flour consumed. There are 21 countries with voluntary programs that allow fortification according to government standards, but the amount of flour actually fortified in these countries varies greatly. A few countries have voluntary standards for some micronutrients and mandatory ones for others.

Thus, large proportions of wheat flour are fortified in about 65 countries as a result of mandatory or voluntary programs, covering a combined population of 1.7 billion. Large countries noticeably absent from this total include China, India and Russia. However there are efforts underway to implement fortification of all industrially produced flour in these large nations as well.

More recently, there is a move to add folic acid wherever iron is being added; the cost is very small (less than $0.01 per person per year). Although the addition of folic acid along with iron is very cost-effective, it is not the focus of this paper and not discussed further.

<u>Partnerships:</u> As more and more countries adopt fortification of staple foods and condiments, assurance of the quality of nutrient premix becomes a key factor for the successful implementation of fortification. Barriers that limit the ability of millers to obtain premix of assured quality at the best price include the proliferation of producers and traders with limited technical capacity, lack of a uniform system for quality assurance and lack of clear regulatory guidance. Strategies recommended to address these issues include, the development of national premix standards and specifications, utilization of a "Code of Practice" for premix manufacturers, accreditation of premix suppliers, and training and capacity building for public monitoring and food control agencies, as well as new premix manufacturers. These activities require the private producers to organize themselves, as well as to partner with government. Based on recent technical consultation, the Flour Fortification Initiative has also made available practical recommendations for wheat flour fortification for national governments (FFI, 2008b).

<u>Financial sustainability:</u> The cost of fortification is extremely small in relation to the production cost of flour and flour products. However, the incremental cost of flour fortification may be perceived by millers as significant when the market environment does not enable them to recover the cost, including low consumer demand for fortified products and/or government controls on the price of flour or flour products. In situations when the incremental cost of fortification cannot be sustained by millers or passed directly to the consumer, governments may assist by subsidization, or tax exemptions. Other steps that could be considered include bulk purchasing of premix for distribution to millers. This could also be done a regional basis, when fortification standards are sufficiently compatible across countries.

There are also substantial costs in initiating flour fortification. These typically include industry start-up costs, costs of conducting trials of appropriate micronutrient levels on physical qualities of flour and flour products in some countries, population based situation assessments, including information on potential population coverage of all nationally produced or imported industrial flour, development of appropriate communication and social marketing programs, strengthening capacity of public sector to enforce fortification regulations and monitor the implementation and impact of a flour fortification program. In some countries, such costs have in part been initially subsidized by international support through organizations such as the Micronutrient Initiative (MI) and the Global Alliance for Improved Nutrition (GAIN), as well as other donors.

Advocacy: Even when there is little or no cost differential between a fortified and non-fortified food, consumer awareness is an important issue for the acceptance of a newly fortified product. Consumers must be made aware of the benefits of fortified foods through credible sources. Effective communication to consumers is an often overlooked but an essential part of successful fortification programs.

Technical: wheat and maize flour consumption is not widespread enough throughout the developing world to rely only on these vehicles for fortification with iron. Some countries have rice as their main staple (and there are others such as sorghum, millet, cassava, potato, etc.), and even in some countries where maize is the main staple, processing is very highly decentralized and it is difficult to introduce fortification. Alternatives are being developed, as the next section describes.

Monitoring costs for flour fortification are not particularly high (between 5-10% according to Fiedler et al, 2008), but this presupposes the existence of some local system of quality assurance, as well as local laboratories capable of doing simple tests. With appropriate support and diligence, national food safety and quality control systems could be strengthened.

2.2.2. Extending iron fortification to foods other than wheat and maize flour

In this section we discuss five alternatives to commercial wheat and maize flour fortification, namely fortification of rice, double fortification of salt, fortification of condiments, voluntary fortification of processed foods, and home fortification.

Rice is a logical choice for fortification, since it is a staple food for more than half the world's population and the main component of the diet in many countries where nutritional anemia remains highly prevalent. Efforts in iron fortification of rice have been ongoing since 1949 in the Philippines. In Papua New Guinea, a formulation that includes iron with B vitamins is used. It is noteworthy that in spite of these positive experiences there are no large-scale national programs in operation. Rice has not been as technically easy to fortify as wheat or maize flours, and also suffers from consumer acceptability as most of the iron compounds can change the physical characteristics of fortified rice. A method in which the vitamins are sprayed over the rice grain as a coating is in practice in North America, but is not a feasible option in most of the developing countries where rice is washed prior to cooking, and the added nutrients are lost. A new extrusion technology can be used to produce simulated rice-shaped premix of iron and other micronutrients (synthetic fortified grains). This premix is then dry-mixed with regular rice at a predetermined ratio. A recent study in India proved the efficacy of the simulated rice premix made with micronized ferric pyrophosphate. There is a renewed interest to implement rice fortification in China and India.

From a programmatic point, it is necessary to examine patterns of rice processing and capacity of centralized processing facilities when assessing the feasibility of large-scale fortification in a country.

Salt is consumed by all populations, and due to the success of USI in improving iodine status of populations, fortification of salt with iron was also considered. The quality and packaging requirements for iron fortification of salt are however much more stringent than for iodine. During the mid seventies, a combination of using ferrous sulphate with stabilizers like was tested extensively both in the laboratory and in field trials (Ranganathan, 1992). The iron-fortified salt showed good bio-availability and stability. A few companies in South India have commercially produced this product in limited quantities but it needed extensive promotion and governmental support.

However, given that salt is already fortified with iodine in many countries where iron deficiency is also quite prevalent, research and development efforts have recently focused developing a formulation that would permit the addition of both iodine and iron to salt. Efforts by MI, with technical assistance from the University of Toronto, led to the development of one cost effective technology for adding both iron and iodine to salt. Following successful testing for stability, consumer acceptability, bioavailability, efficacy and cost effectiveness, the product is ready to be scaled up. The large-scale application of available technology for the double fortification of salt could represent a major breakthrough for combined iron and iodine delivery. Double-fortified salt is currently being produced in India using both the MI-assisted and other formulations and has the potential to be distributed through commercial channels and public programs to reach the poor. Ensuring bio-availability of iron along with maintaining iodine stability are the two important factors for double fortification of salt.

Condiments such as fish sauce and soy sauce are widely consumed in large parts of Asia. In Thailand iron fortified fish sauce, which is consumed in many parts of the country, has been shown to be efficacious in improving iron status. Iron fortified fish paste has also been reported as an efficacious vehicle in improving iron status in the Philippines.

Following a series of studies which established the feasibility, efficacy and effectiveness of soy sauce fortification, the government of China selected iron fortified soy sauce as one strategy to improve iron nutrition because 70% of the country's population consumes soy sauce. However coverage is as yet quite low, and fortification remains voluntary.

Based on similar process, Vietnam identified fish sauce as the vehicle for iron fortification. Fish sauce is a good vehicle for iron fortification programs because 80% of the population consumes it regularly. There is a network of fish sauce factories which used to be under the supervision of the Ministry of Fishery. Efficacy studies confirmed that fish sauce fortified with 100 mg iron as sodium iron EDTA per 100 mL fish sauce significantly improved the iron status of the target population. The cost of fortifying fish sauce has been estimated to be US$ 0.02/L but there is not as yet full scale commercial production.

Condiments are particularly attractive vehicles to deliver micronutrients to populations in countries where rice is the dietary staple, and in countries where centrally processed rice is not consumed by rural populations who produce their own rice. The same also applies to poor rural maize consumers in Africa. Fortification of sugar, sauces, seasonings and other condiments may provide a solution when such products are industrially produced and consumed in sufficient amounts by target populations.

Processed foods such as noodles and breakfast cereals are increasingly being fortified on a voluntary basis. Fortified weaning foods for children are also becoming popular. Elemental iron of small particle size is being used for the fortification of processed cereals in several developed countries. In Mexico chocomilk powder is fortified with iron and the *Oportunidades* program includes fortified complementary food (LeRoy et al, 2008). In Tanzania and Bangladesh pilot studies with a fortified orange beverage drink have been effective in improving iron and vitamin A status among school children. These items typically reach the richer consumers in developing countries.

Home fortification of foods is another alternative, to improving vitamin and mineral intakes, particularly for improving the nutrient intake of infants who are fed home prepared complementary foods and do not have access to commercially marketed infant foods. Labeled as complementary food supplements, such "in-home fortificants" are available as water-dispersible or crushable tablets, sprinkles or spreads that can be added to complementary foods just before feeding infants and young children. They are designed to provide 1 to 2 EARs (Estimated Average Requirements) of vitamins and minerals in a small volume and are easily integrated into existing food practices. One such recently-developed product is "Sprinkles™", which was distributed in Indonesia following the tsunami, and more recently is being tried at scale in Mongolia, Pakistan, Bolivia and several other countries. Similar locally developed products (*Anuka and Vita shakti*) are being produced and tested in India through the Integrated Child Development Scheme (*Anuka* is a take home product for under 2 year old children whereas *Vita shakti* is used on-site).

To ensure their success and sustainability, especially in resource-poor countries, food fortification programs should be implemented in concert with poverty reduction programs and other agricultural, health, education and social intervention programs that promote the consumption and utilization of adequate quantities of good quality nutritious foods among the nutritionally vulnerable. Food fortification should thus be viewed as a complementary strategy for improving micronutrient status.

It is usually possible to add one or several micronutrients without a substantial increase in the total cost of the food product at the point of manufacture. In the future it may be appropriate to consider zinc fortification along with iron and folic acid, and currently several fortification projects in Africa also include zinc. As the recommendations for preventive zinc fortification/supplementation are developed, this may become more widespread. There are currently questions around the recommended daily dose of zinc, the populations in which it is indicated, the appropriate zinc compound, and its international availability in adequate supplies at food grade. Work is ongoing to address these questions though not discussed further here.

3 ECONOMIC ANALYSIS

Both iodine and iron fortification have very attractive rates of return, since both are very low cost (around $0.05 per person per year for iodized salt; around $0.12 per person per year for flour fortified with iron), and yet both have large benefits in terms of economic productivity (see calculations and references in Horton, Alderman and Rivera, 2008).

For iodine, the productivity benefits result from the cognitive benefits obtained by children born to mothers who would otherwise have goiter or subclinical iodine deficiency. At a 3% discount rate, the benefit:cost ratio is estimated at 30:1, falling to 12:1 at a discount rate of 6%. This does not include additional benefits due to averting stillbirths etc.

For iron, the largest benefits are in terms of improved adult productivity in all manual labour, but especially heavy manual labour. There are also benefits in terms of improved cognition, hence also schooling and future earnings, for children. The benefit:cost ratio is calculated as 8:1 at a 3% discount rate (7:1 at a 6% discount rate). There are additional benefits in terms of reduced maternal mortality and reduced mortality in the first week of life. For South Asia and sub-Saharan Africa, over 20% of mortality in both groups can be attributed to maternal anemia. The benefits in terms of lives saved are however not included in these particular calculations, since the productivity effects tend to dominate in size.

These ratios are calculated using a (conservative) set of assumptions. For obvious reasons, it is difficult to get random, controlled, double-blind trials involving fortification. These estimates are made using the best program data available.

The benefit:cost ratios vary as costs and benefits vary. Costs will vary for example with population coverage. It is usually feasible to cover 70% (or even 80%) of the population with standard programs, however as described in section 2 additional efforts may be required with the hard-to-reach (the last 20% or so of the population). On the other hand, these hard-to-reach individuals may derive a proportionally higher benefit from fortification, as they are often poorer individuals, with less access to health care etc.

Table 1. Orders of magnitude for fortification costs with different vehicles/different methods

Type of fortification	Estimated cost /person/year	Approximate potential % population covered
Salt iodization, large producers	$0.05	70%
Salt iodization, small plants	$0.10	Up to 80% (S Asia, SE Asia) Up to 90% (SS Africa)
Double-fortified salt	$0.20-0.25	Up to 70%[a]
Wheat/maize flour fortification (with ferrous fumarate or sulphate in roller mills)	$0.12	20% (India); 50% (Pakistan) 80-90% (mid-East, N Africa) 10-50% (Sub-Saharan Africa)
Soy or fish sauce (with NaFeEDTA)	$0.18	Possibly up to 70% in Southeast Asia and China
Rice (using synthetic grains)	$0.53	Not known (only pilot tests)
Sprinkles (home fortification)	$0.90 plus distribution	Not known (early phases)

[a] Double-fortified salt would likely only be used instead of iodized salt, if no suitable local alternative for iron fortification were available.

Table 1 summarizes best estimates of relative costs of different methods of fortification, along with potential population coverage of each. These figures are not exact, and meant more to indicate orders of magnitude. It is estimated that up to 70% coverage with USI can be achieved within a country by fortifying salt from large producers. The coverage may be higher in some countries, for example most countries in sub-Saharan Africa tend to have fewer small salt producers, whereas countries with archipelagos such as Indonesia or the Philippines may have many small, remote producers. The cost of $0.05 per person per year represents the cost of the actual ingredients (only about 20% of this total), plus the cost of amortizing the capital equipment and processing costs.

If salt from small producers if fortified, the capital costs are spread over a smaller volume and this may double the cost of fortification as compared to fortification by larger producers, but may permit another 10% of the population to be reached. Double-fortified salt has not been produced on a large scale, and is about 4 times as expensive as iodized salt and likely more expensive than using iodized salt and iron fortified flour. However, it may be a good option where flour fortification does not reach a majority of the population.

For iron fortification, the cost of the ingredients is again very small, and it is processing and capital costs which increase it to around $0.12 per person per year. Again, this is for large (roller) mills, for both wheat and maize. There have not been many attempts to fortify in smaller mills: this would only become a priority once all large mills have implemented fortification. (It is technically feasible, for example there have been efforts to do local fortification of flour in refugee camps and villages in Africa and Nepal). Coverage therefore depends on the proportion of the population consuming wheat or maize flour, as well as the proportion of this flour being processed in roller mills.

The coverage estimates therefore very considerably by country and region. In India, the low coverage is related to the low proportion of flour produced in roller mills (only around 20%), and also probably only half the population consumes wheat flour (rice is the preferred staple in South India). In Pakistan, the proportion consuming wheat is much higher, and around 50% of production goes through large mills. In sub-Saharan Africa, there is considerable variability by country. Wheat flour is predominantly imported (Tanzania does produce wheat) and processed in large mills, but only a minority of the population consumes wheat products in most countries. Maize flour is the major staple in much of Eastern and Southern Africa, but in most countries a minority of production goes through roller mills. South Africa has probably the highest proportion of flour from roller mills in the region. In West and Central Africa, there is an even greater diversity of staples including rice, cassava, millet, sorghum, plantains, etc. as well as flour, rendering it harder to cover the population with flour fortification alone. However, it remains a high priority to commence fortification in Africa. As the populations urbanize, an increasing proportion of flour passes through roller mills, and consumption of wheat rises.

The estimates for coverage with fortified condiments are speculative, since these fortified products are in early stages of adoption, and the same is true for home fortification.

Table 2: Ballpark estimates of annual costs and benefits of scaling up fortification to reach 80% of population with salt and 50% with flour, South Asia and sub-Saharan Africa*

Micronutrient Fortification	Numbers Affected (millions)	Solution cost/person/ Year	Benefit:cost Ratio used	Cost/ Year (millions)	Benefits/ Year (millions)
Salt iodization	380	$0.05	30:1	$19	$570
Flour fortification	1,390	$0.12	8:1	$167	$1,336

*Source: Horton, Alderman and Rivera, 2008. For flour fortification, reaching 50% of population with fortified wheat/maize flour is optimistic with current share of large scale (roller) mills, but increasing proportions of flour will be milled in such mills in the next 5-10 years; there is also potential for fortification of condiments with iron at a cost not too much higher than flour fortification.

Table 2 shows the annual costs and benefits of scaling up fortification with iodine and with iron, moving up from existing levels of around 70% (iodine) and negligible (iron). The large part of these costs will be borne by consumers. There are however additional one-time costs (not included in the table) covered by international aid, and by national governments. These cover costs such as social marketing, changing legislation, setting up monitoring capability, technical support, mobilization of industry, etc. Exact figures are not available, but estimates suggest that USI over the period 1990-2008, during which coverage in developing countries increased from negligible to 70%, cost approximately $350m (and is projected to require another $200m to reach the USI goal of 90% coverage) (Venkatesh Mannar: author's estimate). If these costs are amortized over the many years when fortification will continue, they do not increase the annual costs substantially.

For flour fortification, the estimated cost of moving from current coverage levels (where around 30% of flour from large mills is fortified worldwide) to the Flour Fortification Initiative goal (80% of maize and wheat flour from large commercial mills is fortified worldwide), is around $300m in one-time funding (in addition to the annual costs above: Venkatesh Mannar – author's estimate). For sub-Saharan Africa and South Asia where coverage lags that of many other regions, that will translate to an increase in population coverage from negligible to 50%.

4 CONCLUSIONS

Fortification of salt with iodine, and of flour (and some other foods) with iron, are high priority interventions to improve health in developing countries. These improvements in turn have large payoffs in terms of improved cognition and productivity. Salt iodization has been a major international success since the USI goal was set in the early 1990's. Since coverage levels are now at 70%, continuing to increase coverage is more challenging, since it involves countries where conditions for government action are more difficult, or countries which have slid back in their commitment, and as reaching the "harder-to-reach" within countries (more remote populations, smaller producers). The success with salt iodization is instructive for other micronutrient interventions. The additional international investment required (estimated at $200m one-time-only) is very worthwhile, since the programs once established can be sustained domestically (usually the very modest recurrent costs can be passed on to consumers).

Flour fortification with iron is at an earlier stage in the developing countries. The Flour Fortification Initiative reports that currently 30% of flour from large mills is fortified with iron, as compared to the goal of 80%, and there is considerable energy being devoted to progressing towards the goal. Even once this goal is achieved, further efforts will be necessary to fortify alternative foods (for example condiments in some rice-consuming countries, double-fortified salt, etc), and likely the proportion of flour fortified in roller mills will increase with development. The estimated international contribution required ($300m one-time-only) is also very worthwhile when compared to the health and productivity benefits which can be sustained.

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