TECHNICAL BRIEF

Key Barriers to Global Iodine Deficiency Disorder Control: A Summary

Michael Zimmermann, M.D.

THE SCIENTIFIC BASIS OF CURRENT POLICIES TO CONTROL IODINE DEFICIENCY

Iodine deficiency is a major global public health problem, particularly for young children and pregnant women. The most serious effect of iodine deficiency is mental retardation. It is one of the world's major causes of preventable cognitive impairment, posing a threat to the social and economic development of countries. This is the motivation behind the current worldwide drive to eliminate iodine deficiency.

The primary cause of iodine deficiency is a low dietary supply of iodine, typically in environments where the soil lacks iodine due to past glaciation, often compounded by the leaching effects of precipitation or flooding. These remove iodine from the soil, and plants and livestock become iodine deficient. Iodine deficiency may be aggravated by intake of natural goitrogens in staple foods such as cassava, which contains thiocyanate that inhibits thyroid iodide transport. Deficiencies of selenium, iron, and vitamin A also exacerbate the effects of iodine deficiency. Glutathione peroxidase and the deoidinases are selenium-dependent enzymes. In selenium deficiency, accumulated peroxides may damage the thyroid, and deiodinase deficiency impairs thyroid hormone synthesis. These effects have been implicated in the etiology of myxedematous cretinism. Iron deficiency reduces heme-dependent thyroperoxidase activity in the thyroid and impairs production of thyroid hormone. In goitrous children, iron deficiency anemia blunts the efficacy of iodine prophylaxis while iron supplementation improves the efficacy of iodized oil and iodized salt. Vitamin A deficiency in iodine-deficient children increases the thyroid stimulating hormone (TSH) and risk for goiter, probably through decreased vitamin A-mediated suppression of the pituitary TSHβ gene.

Iodine deficiency produces a spectrum of abnormalities, grouped under the heading of iodine deficiency disorders (IDD), which reflect thyroid dysfunction. Goiter and cretinism are the most visible manifestations; the others include hypothyroidism, decreased fertility rate, increased perinatal death and infant mortality. Impaired neurocognitive development is the most important effect of iodine deficiency. Lack of iodine resulting in hypothyroidism during the vulnerable period of brain development, that is, fetal life and the first year, can cause irreversible impairment in brain structure and function.

In areas of severe iodine deficiency, cretinism can affect 5 to 15 percent of the population. Individuals living in areas of mild or moderate iodine deficiency exhibit more mild neurological and intellectual deficits. A meta-analysis estimates that severe iodine deficiency is responsible for a mean IQ loss of 13.5 points in affected populations. Correction of iodine deficiency in a population reduces or eliminates all its consequences. Recurrence of IDD occurs predictably when an effective IDD control program lapses in a previously iodine deficient population.

The recommended indicators for assessing the severity and extent of iodine deficiency in a population are the median urinary iodine (UI) concentration and the total goiter prevalence. The median UI is recommended for monitoring interventions for IDD control, rather than goiter prevalence, because it responds faster to the correction of iodine deficiency and is sensitive to current iodine intake. According to WHO, IDD is a public health problem in populations where median UI is <100 μg/l, or in areas where more than five percent of children aged 6 to 12 years have goiter.

However, often these two indicators are discrepant in the years following introduction of iodized salt due to a lag in goiter resolution.

IDD control programs should focus on pregnancy, lactation, and infancy. However, the assessment of iodine status during these life stages is challenging and monitoring these groups has historically been underemphasized. There are no established reference criteria for median UI for pregnancy, lactation, or infancy. Although a median UI in school-age children (SAC) and adults in the range of 100-199 μg/L indicates adequate iodine intake, this criterion has not been validated in pregnant and lactating women or infants, and may, if applied to these target groups, underestimate the true burden of IDD.

A recent WHO expert meeting on this issue recommended an increase in the current FAO/WHO RNI for iodine during pregnancy and lactation from 200 μg/day to 250 μg/day. A daily intake greater than this is not necessary and preferably should not exceed 500 μg/day. The RNI for infancy has not changed, remaining at 90 μg/day. These recommendations are based mainly on theoretical considerations of the physiology of iodine nutrition, as there is little data from these population groups. The median UI is recommended as the best indicator to use in population surveys to assess the iodine nutrition of pregnant and lactating women, and of children less than two years of age. The median UI that indicates adequate iodine intake in pregnant women was estimated to be 150 – 249 μg/L, and in lactating women and children aged zero to two years old, ≥100 μg/L. In lactating women, the figures for median UI are lower than the iodine requirements because of the iodine excreted in breast milk. In countries or regions in which systematic neonatal screening for congenital hypothyroidism is done using the concentration in blood of the thyroid stimulating hormone (TSH), an elevated concentration of TSH reflects an insufficient supply of maternal and/or fetal thyroid hormone to the developing brain and indicates a risk of irreversible brain damage.

Most of the effort in producing and marketing salt iodization, in implementing policies, in educating people and leaders, and in monitoring has been undertaken by national entities, with the support of the international agencies—the International Council for Control of Iodine Deficiency Disorders (ICCIDD), UNICEF, the World Health Organization (WHO), the World Food Program (WFP), and the Micronutrient Initiative (MI). Kiwanis International, USAID, CIDA, AUSAID, and the Gates Foundation have channeled funds through UNICEF for these efforts. The Fifty-Eighth World Health Assembly (WHA) in 2005 reaffirmed the importance of controlling iodine deficiency indicated in previous WHA resolutions (WHA 49.13 and WHA 52.24) and endorsed by the 2002 UN GASS resolution on sustained elimination of IDD. For salt iodization to be successful there needs to be close interaction with the salt industry. The Network for the Sustained Elimination of Iodine Deficiency was formed in 2002 to foster this interaction. At the moment the Network functions mainly as a clearing house for country services by ICCIDD, WHO, and UNICEF; its future role needs to be better defined.

In 2001 the CDC established a program, Ensuring the Quality of Urinary Iodine Procedures (EQUIP), designed to improve the quality of UI measurements worldwide. The CDC, using the reference method for UI, ICP-MS, and UI laboratories worldwide participate in a round robin measuring unknown samples provided by the CDC. CDC uses the results to prepare a statistical report for the participating laboratories, and this feedback provides external control regarding performance. In this way, EQUIP provides important quality control for laboratories active in the process of monitoring the elimination of IDD around the world.

The global control of IDD through universal salt iodization (USI) constitutes one of the most cost effective development efforts contributing to economical and social development. The international community has made substantial progress in USI coverage, and more than two billion more people have adopted the use of iodized salt in the last decade. During this period, the world population's household access to iodized salt has risen from <20 percent to >70 percent. Despite this, WHO estimates that 54 countries out of 126 still have inadequate iodine nutrition (i.e. median UI <100 μg/l), and 23 million babies each year globally are still born with inadequate iodine nutrition. One third of the world's population still remains at risk, mostly in the poorest and economically least developed areas. The most affected regions, by absolute number of people affected and in decreasing order of magnitude, are South-East Asia, Europe, the Western Pacific, Africa, the Eastern Mediterranean and the Americas. Mild iodine deficiency is currently re-emerging in areas where it was believed to have been eliminated, such as Australia. This underscores the need to sustain IDD control efforts.

CURRENT SCIENTIFIC ISSUES

Iodine nutrition in pregnancy and infancy
The optimal indicators to assess iodine nutrition during pregnancy, lactation, and infancy need to be identified. The use of newborn serum thyroid stimulating hormone (TSH) concentration as an indicator of iodine status in pregnancy needs further validation. Other potential IDD indicators in pregnancy and infancy, such as dried-blood spot thyroglobulin and/or breast milk iodine levels need to be evaluated. Where universal salt iodization (USI) has been effective for at least two years, it is assumed that the iodine needs of pregnant and lactating women, and infants, are covered. More data are needed to support this assumption. The bioavailability of iodine in iodized oils, and the optimum dose of iodized oil for pregnant women, lactating women, and infants need to be determined. Also, what are effective complementary feeding strategies to provide iodine to weaning infants?

Adverse effects on cognitive development
What are the effects of mild to moderate IDD during pregnancy on the cognition of the offspring? The benefits of iodine supplementation during pregnancy on intellectual outcomes in randomized, controlled trials need to be demonstrated. In areas of IDD, what are the relative contributions to mental impairment of in-utero hypothyroxinemia vs. later acquired subclinical hypothyroidism in childhood?

Safe upper limit of iodine intake
Does the WHO cut-off for excess iodine intake in adults, (a median UI >300 μg/l) need to be revised considering recent evidence from China's IDD control program suggesting that a median urinary iodine (UI) of ca. 240 μg/l is associated with an increased prevalence of subclinical hypothyroidism? What is the median UI that corresponds to excessive iodine intake for pregnant and lactating women, and children under two years of age? Large scale trials looking at the correlation between community iodine intake and autoimmune thyroid disease or papillary thyroid cancer are needed.

Laboratory methods for monitoring salt iodine content
An evaluation of the impact of the EQUIP program and the international reference laboratory network is needed. To accurately determine household/retail salt iodine levels, available rapid test kits (RTK) for iodine in salt need to be improved. The performance of the WYD Iodine Checker needs to be thoroughly validated against titration.

Metabolic interactions of iodine and other micronutrient deficiencies
The affects of vitamin A, iron, zinc, and selenium deficiencies in the setting of iodine deficiency should be investigated.

PROMISING STRATEGIES TO PREVENT AND CONTROL IDD

Supplementation

In some regions, iodization of salt may not be feasible for the control of IDD, at least in the short term. This is particularly likely to occur in remote areas where communications are poor or where there are numerous small-scale salt producers. In such areas, supplementation with iodized oil to correct IDD should be considered. Iodized oil is prepared by esterification of the unsaturated fatty acids in seed or vegetable oils, and addition of iodine to the double bonds. It can be given orally or by intramuscular injection. A single dose of iodized vegetable oil (e.g., Lipiodol) delivers 200–480 mg of iodine that provides sufficient coverage for 6–12 months (oral administration) or longer (intramuscular administration).

Iodized oil is recommended for populations with moderate-to-severe IDD and is usually targeted to women of child-bearing age, pregnant women, and children (see discussion below). Iodized oil can be given immediately without waiting for changes in the salt trade. For example, a program in Bolivia in the late 1980s delivered ca. 1.5 million doses of iodized oil over several months to cover the population while iodized salt was introduced into a complex commercial system. Its disadvantages are an uneven level of iodine in the body over time and the need for direct contact with individuals with the accompanying increased costs.

Iodine can also be given as KI or KIO3 as drops or tablets, and in drinking or irrigation water. Single oral doses of potassium iodide monthly (30 mg) or biweekly (8 mg) can provide adequate iodine for school-age children. Lugol's iodine and similar preparations are often available as antiseptics in rural dispensaries in developing countries and offer another simple way to deliver iodine locally.

Special target groups for supplementation: pregnancy and childhood

In countries or regions within countries affected by IDD that have weak or negligible iodized salt distribution, supplements should be given to pregnant women, lactating women, and infants. There are two main ways to give supplementary iodine to these groups on a daily basis, typically using potassium iodide, or on a semiannual basis, using iodized oil, and the approach used depends on the accessibility of the population. For populations in remote areas, it may not be possible to deliver a daily iodine supplement, so giving iodized oil may be a better option. The following is recommended:

- Women of child bearing age should be given a single annual oral dose of 400 mg of iodine as iodized oil; or a daily oral dose of iodine as potassium iodide should be given so that the total iodine intake meets the RNI of 150 μg/d of iodine.
- Women who are currently pregnant or lactating should be given a single annual oral dose of 400 mg of iodine as iodized oil; or a daily oral dose of iodine as potassium iodide should be given so that the total iodine intake meets the new RNI of 250 μg/d iodine. Iodine supplements should not be given to lactating women who have already been given iodized oil during their current pregnancy or to pregnant women who have already received iodized oil up to three months before the current pregnancy started.
- Children aged zero to six months should be given iodine supplements only if the mother was not supplemented during pregnancy or if the child is not being breast-fed. In this age group iodine can be given as a single annual oral dose of 100 mg of iodine as iodized oil; or a daily oral dose of iodine as potassium iodide should be given so that the total iodine intake meets the of 90 μg/d of iodine.
- Children aged 7 – 24 months old should be given a single annual oral dose of 200 mg of iodine as iodized oil as soon as possible after reaching seven months of age; or a daily oral dose of iodine as potassium iodide should be given so that the total iodine intake meets the RNI of 90 μg/d of iodine. In countries or regions where USI is successful and the population is considered to be iodine sufficient, children aged 0 – 24 months do not require iodine supplements. The amount of iodine stored in the thyroid of a newborn of a mother who is iodine sufficient, when added to the iodine intake from the mother's breast milk, is likely to be sufficient to meet a child's need for iodine for the first six months of life and up to 24 months of age.

Salt Fortification

There are two forms of iodine fortificant, iodate and iodide, which are usually added as the potassium salt. Iodate is less soluble in water than iodide and more resistant to oxidation and evaporation. For these reasons, iodate is preferred to iodide, particularly in hot and humid climates, although it is more expensive. It also is recommended as the compound of choice in tropical countries and those with low-grade salt. Historically, countries in Europe and North America still use KI, while most other countries use KIO3.

Universal salt iodization (USI) is the iodization of all salt for human (food industry and household) and livestock consumption. It is the recommended strategy for control of IDD because: 1) salt is one of the few foodstuffs consumed by everyone; 2) salt intake is fairly regular through the year; 3) in most countries, salt production/importation is limited to a few sources; 4) iodization technology is easy to implement and has a low cost in the developing world (0.2-0.3 US cents/kg, or 1 US cent per person/year); 5) the addition of iodine to salt does not affect its color or taste or; and 6) the quality of iodized salt can be simply monitored at the production, retail, and household levels. Solid rock deposits are the main source of salt in North America, Europe, and Australia while in Africa, Asia, and South America, solar evaporation of sea or lake water and underground brines is common. Crude salt is usually refined to increase its purity from 85-95 percent NaCl to 99 percent NaCl.

Iodine is usually added after the salt has been dried. Two techniques are used: 1) the wet method, where a solution of KIO3 is dripped or sprayed at a regular rate on to salt passing by on a conveyor belt; 2) the dry method, where KI or KIO3 powder is sprinkled over the dry salt. The dry technique is more demanding as it requires a salt made of small homogenous crystals and thorough mixing of the salt after addition of the iodine compound. Poor quality addition and/or mixing are major causes of inappropriate salt iodization. Iodine stability when added to salt depends on salt moisture, acidity, and purity. To reduce losses during storage, iodized salt should be as dry as possible and properly packaged. Optimally, packaging should be in HDPE bags, either laminated with LDPE or lined with a film. In a multi-country study, high humidity combined with porous packing (e.g., jute bags) resulted in a 30-80 percent loss of iodine within six months.

Safety
Iodine fortification is generally very safe. The Joint FAO/WHO Expert Committee on Food Additives affirmed that KI and KIO3 can be safely used for salt fortification. Iodine intakes up to 1000 µg per day are well tolerated by most adults, as the thyroid is able to adjust to a wide range of intakes, and regulate the synthesis and release of thyroid hormones. However, an acute, excessive increase in iodine intake can increase the risk of iodine-induced hyperthyroidism (IIH) in susceptible individuals who have had chronic iodine deficiency. IIH primarily affects the elderly who have longstanding nodular goiter. It may be the most common complication of iodine prophylaxis, and has been reported in the introductory phase of several USI programs, including an outbreak in Zimbabwe and the Democratic Republic of Congo due to excessively iodized salt. It is nearly always transient and its incidence reverts to baseline after one to ten years of intervention. IIH prevention includes careful monitoring of salt iodine levels and training of regional health staff in IIH identification and treatment. Iodine-induced thyroiditis (IIT) may be caused by increasing iodine intakes, but the data are equivocal on the relationship between USI programs and IIT. The benefits of correcting IDD far outweigh the potential risks of IIH and IIT, and these adverse effects can be almost entirely avoided by careful, sustained monitoring of a USI program.

Effectiveness
USI is clearly effective. In the U.S., large scale iodization of salt in Michigan reduced the goiter rate from 40 percent to <10 percent. In Switzerland in the early twentieth century, IDD was severe with goiter affecting nearly 100 percent of school children and a prevalence of cretinism as high as 0.5 percent. After introduction of salt iodization in 1922, the prevalence of goiter and deaf mutism in children was sharply reduced, and cretinism was eliminated. Since then, the carefully monitored Swiss USI program has eliminated IDD as a public health problem.

Cost-benefit
The key economic effects of IDD are assumed to be on birth outcomes. The WHO, in calculations of the cost-benefit of USI, has used goiter rate as the indicator of iodine deficiency. The average percentage productivity loss per birth to a mother with goiter is estimated to be 10.27 percent. Thus the per capita productivity loss in a country where the goiter prevalence in women is 15 percent, is estimated to be $2.65. If cost of iodine fortification is $0.10 per person per year, then the benefit-cost ratio of iodine fortification is 2.65:0.10 or 26.5:1. Where the costs are as low as $0.01 per person per year (e.g., in Central America), then a USI program will have a benefit-cost ratio ten times higher. This is a very high benefit-cost ratio. However, this calculation assumes USI is 100 percent effective, i.e. that USI completely eliminates goiter in the population in the long run.

Because USI is simple to implement, inexpensive, and effective, rapid progress has been made worldwide. In the past decade, the proportion of households consuming iodized salt has increased from 10 percent to 68 percent (see Table 1). In 1999, out of 130 countries affected by IDD, 98 had legislation on USI.

Table 1: Progress in salt iodization coverage in WHO regions

WHO Regions	% of household coverage	Number of countries with legislation on iodized salt
Africa	63	34
Americas	90	17
South East Asia	70	7
Eastern Mediterranean	66	14
Europe	27	20
Western Pacific	76	6
Total	68	98

Sources: WHO/UNICEF/ICCIDD

Policy Issues Relating to Iodized Salt Programs

Building consumer demand for iodized salt
Effective strategies to create consumer demand for iodized salt, particularly among lower income consumers in competitive markets, are needed. What are effective strategies to empower consumer organizations to work with government and industry to ensure quality assurance and monitoring of USI?

Monitoring and sustainability of USI
Strategies to motivate countries to redouble their commitment to the sustained elimination of IDD through USI, as an integral part of their regular public health programs and anti-poverty efforts, are needed. Within regions, effective strategies to reach the poorest groups, often in remote areas not covered by USI, are urgently needed. Methods to empower small-scale salt producers to effectively implement salt iodization, or alternatively, to switch to other

agricultural production, also are needed. How do successful countries that have eliminated IDD organize their national monitoring systems? Several countries now receive excess dietary iodine, usually from improperly iodized salt; how can this problem be minimized in the future through regular monitoring?

High priority countries
UNICEF and the Network for Sustained Elimination of Iodine Deficiency have agreed on a list of 'make or break' countries for iodine nutrition globally based on their high number of unprotected infants, poor USI programs, or the presence of a major regional salt producer in the country. This list should serve as a focus for coordination of international agencies, such as the Micronutrient Initiative (MI), the Global Alliance for Improved Nutrition (GAIN), the World Food Programme (WFP), and the International Council for Control of Iodine Deficiency Disorders (ICCIDD).

Other Fortification Vehicles

Bread
Bread has been used as a vehicle for iodized salt, and is technically a good carrier that has been shown to be effective. Since 1942, iodine fortification in the Netherlands has been through baker's salt enriched with iodine made specifically for bread. This approach has also been used in the past in a few other countries, including Russia and Tasmania.

Water
Although water can be a useful vehicle for iodine fortification, sources of drinking water are ubiquitous and iodization is therefore difficult to control. Also, iodine has limited stability in water (< 24 hours) so regular daily dosing is required. A number of methods have been tried. The simplest is to add KI or KIO3 at a specified concentration to water in a vessel used for drinking, a widely-used method in schools in Thailand. Another method is the addition of iodine in porous polymer containers into the water supply, in hand pumps or in open well water. The containers release the iodine solution slowly into the water and must be replaced annually. This method has been effectively used in the Central African Republic, Sudan, Sicily, Mali, Malaysia, and Thailand. A third approach is to divert pipe water through a canister containing iodine crystals, and then reintroduce this iodized water into the main water stream. A fourth method is addition of iodine to river water. In China, five percent KI solution directly added into a river supplying water to an isolated population improved the median UI in children and increased soil iodine content, which was stable over time. Although iodizing water can be effective, the higher cost and the complexity of monitoring iodine content are disadvantages compared to USI.

Milk and other foods
Iodine-containing milk is a major adventitious source in countries such as the United Kingdom and the United States, due to the use of iodophors in the dairy industry, rather than to the deliberate addition of iodine. Iodized sugar has been tried in pilot studies in Sudan, and iodine has been added to fish sauce in South-East Asia. In Finland, iodine-fortified animal fodder has increased the iodine content of foods derived from animal sources.

Complementary foods
In countries affected by IDD, whenever possible, iodine should be routinely added to complementary foods. An appropriate level would be to supply ca. 90 μg of iodine per day, in a convenient form, to meet the guidelines for recommended daily iodine intakes as set forth by ICCIDD and WHO.

KEY BARRIERS TO SUSTAINABLE CONTROL OF IDD

Iodine Nutrition in Pregnancy and Infancy

Monitoring
Most large systematic iodine deficiency surveys have been done in school-age children or the general adult population, and have only rarely included pregnant and/or lactating women, or infants. Monitoring of iodine status during pregnancy, lactation, and infancy is difficult as there are no established reference criteria for UI concentration for these groups.

1. The optimal indicators to assess iodine nutrition during pregnancy, lactation, and infancy need to be identified. Although the latest WHO recommendations state the median UI remains the best indicator for these groups, what is the median UI that indicates adequate iodine intake? At what stage of pregnancy should UI be measured? How often?

2. The relationship between the iodine status of school children and the iodine status of pregnant women and infants in the same location needs to be investigated. Can the median UI and/or the goiter rate in school-aged children, the usual indicator group, be

used to monitor the iodine status of pregnant women and infants?

3. There is a need for better prevalence data on mild-to-moderate iodine deficiency in pregnant and lactating women, and infants.

4. The use of newborn serum TSH concentration as an indicator of iodine status in pregnancy needs further validation, to establish and then standardize when and how to collect blood samples after birth, and more data are required to establish a threshold to interpret the results.

5. Is there a role for other potential indicators in pregnancy and infancy, such as dried-blood spot thyroglobulin concentrations, and/or breast milk iodine levels?

Approaches to Controlling Iodine Deficiency

1. The bioavailability of iodine in iodized oils, and the optimum dose of iodized oil to give to pregnant women, lactating women and infants, needs to be determined.

2. USI remains the key strategy to eliminate IDD in pregnancy and infancy. Where USI has been effective for at least two years, it is assumed that the iodine needs of pregnant and lactating women, and infants are covered. More data are needed to support this assumption.

3. Iodized salt may not provide enough iodine to meet a child's needs during complementary feeding, especially if the mother is only marginally iodine sufficient, unless complementary foods are fortified with iodine. What are effective complementary feeding strategies to provide iodine to weaning infants?

Adverse Effects

1. Studies that have attributed a reduction in IQ to iodine deficiency were done in areas of severe IDD, which are now rare. What are the adverse effects of mild-moderate IDD during pregnancy on cognition in the offspring? What are the benefits of iodine supplementation on cognitive development and intellectual outcomes, as evaluated through randomized, controlled trials?

2. Regarding the adverse effects of IDD on cognition, what are the relative contributions of the in-utero effects of fetal hypothyroxinemia (assumed irreversible) vs. later acquired deficits due to subclinical hypothyroidism in childhood (probably reversible)?

Risk Factors

1. What is the influence of smoking on iodine status and breast milk iodine concentration?

Safe Upper Limit of Iodine Intake

1. What is the median UI that corresponds to an excessive iodine intake for pregnant and lactating women, and children less than two years?

2. Is the recommendation for excess iodine intake in adults, that is, a median UI > 300 ug/l, correct? A recent Chinese study has shown that a median UI of 243ug/l is associated with an increased prevalence of subclinical hypothyroidism of 2.9 percent (vs 0.9 percent for mild iodine deficiency). Solid epidemiological evidence suggests subclinical hypothyroidism increases one's risk of coronary heart disease.

3. More data from large studies of the impact of iodine intervention programs on iodine-induced thyroiditis and iodine-induced hyperthyroidism would be valuable.

4. Is there a correlation between community iodine intake and autoimmune thyroid disease or papillary thyroid cancer?

Laboratory Methods for Monitoring Salt Iodine Content

1. Has the EQUIP program and the reference lab network actually improved the quality of urinary iodine measurements around the world?

2. In order to be able to accurately determine household/retail salt iodine levels, rapid test kits (RTK) for iodine in salt need to be improved. These kits must be able to: a) distinguish between salt containing more than or less than 15 ppm of iodine; b) accurately avoid overestimation of iodine content; c) improve storage stabilization of the reagents; d) have clear instructions on the ppm range,

the required sample weight, the number of reagent drops to be used and the expiration date, and the color chart should be clear and uniform; e) include a recheck solution for acidifying alkaline salt samples, or include an acid as part of the reagent solution; and f) have their performance in coarse salt evaluated

3. The Chinese WYD Iodine Checker (a rapid and portable spectrophotometric method) is potentially useful and needs to be validated against titration and potentiometry methods on a wide range of iodine concentrations (0 to 150 ppm), in both fine and coarse salt, and using different sample weights.

Investigation of Vehicles other than Salt for Iodine Fortification

As the WHO pushes internationally for a reduction in population salt intake to reduce the risk for hypertension, should other fortification vehicles be investigated for their potential as a vehicle for salt?

Metabolic Interactions of Iodine and Other Micronutrient Deficiencies

What are the metabolic interactions between iodine and other common micronutrient deficiencies (vitamin A, iron, zinc, and selenium) in the setting of iodine deficiency?

Miscellaneous

The potential role of iodine in fibrocystic breast disease, and the potential effect of iodine nutrition on the immune response should be investigated.

Building Consumer Demand for Iodized Salt

1. Effective strategies to create consumer demand for iodized salt, particularly among lower income consumers in competitive markets, are needed.
2. What are effective strategies to empower consumer organizations to work with government and industry to ensure quality assurance and monitoring of USI?
3. There is a need for effective health promotion strategies to ensure the use of iodized salt becomes a standard practice based on awareness of the need for iodine for normal development, especially for expectant mothers and infants.

MONITORING AND SUSTAINABILITY

Globally, the elimination of iodine deficiency is within reach, but about one-third of the population remains iodine deficient. Effective strategies to reach this remaining third, mostly the poorest and economically least advantaged groups, often in remote areas not reached by USI, are urgently needed.

Strategies to empower small scale-salt producers to effectively implement salt iodization, or to switch to other agricultural production, are needed.

There is a need for simple, operative, comparative and functional monitoring designs with a global oversight group not only to implement the 2005 World Health Assembly (WHA) Resolution but to have some oversight over it. Iodized salt should be viewed as a means to an end— adequate iodine nutrition—rather than as an end in itself. Databases are moving toward UI as a key indicator (because it tracks improvements in iodine intake more rapidly than goiter). This trend needs to be accelerated. At present, data are not available for all countries.

The global databases on iodine nutrition need to be strengthened. How do successful countries that have eliminated IDD organize their national monitoring systems? Is there a need for regional monitoring?

Several countries now receive excess dietary iodine, usually from improperly iodized salt; they risk iodine-induced hyperthyroidism, autoimmune thyroid disease, and possibly papillary cancer. How can this problem be minimized in the future through regular monitoring?

Countries should redouble their commitment to sustained elimination of IDD as part of their regular public health programs and anti-poverty efforts through USI. A critical component of this is to establish multidisciplinary national coalitions that include salt producers and the education and media sectors, to monitor the state of iodine nutrition every three years and report to the WHA on their progress.

Sustainability requires national commitments. At the end of the day, when foreign aid agencies go home, two major entities will remain in national positions of influence and interest: the producers and traders in salt, and members of the local IDD control committees. There is often a lack of key knowledge on IDD-related mental impairment by policy makers, who may think, "What is the problem? I do not see any goiters." There is a need to increase iodized salt production and then to think in market terms not epidemiological terms (i.e., 'customers not reached' as opposed to 'coverage').

HIGH PRIORITY COUNTRIES

UNICEF has recently produced a list of 'make or break' countries for iodine nutrition (see Table 2). The criteria of selecting the countries included: a) a high number of unprotected infants; b) an IDD/USI program that is not progressing; and/or c) the presence of a major regional salt producer in the country. However, there are several similar lists from other international agencies, such as the Micronutrient Initiative (MI), GAIN, the WFP, and the IDD Network. There is a need to coordinate efforts between the major agencies, in focusing efforts where they are most needed.

Table 2. 2006 UNICEF/Network high priority countries for IDD control

Country	Total Population (thousands)	Annual Births (thousands)	Households using adequately iodized salt (%)	Infants Unprotected from IDD (thousands)
Russia	143,899	1,511	35	982
Ukraine	46,989	391	32	266
Indonesia	220,077	4,513	73	1,219
China	1,307,989	17,372	93	1,216
Philippines	81,617	2,026	56	891
Ethiopia	75,600	3,064	28	2,206
Angola	15,490	749	35	487
Sudan	35,523	1,163	1	1,151
Egypt	72,642	1,890	56	832
India	1,087,124	26,000	50	13,000
Pakistan	154,794	4,729	17	3,925
Bangladesh	139,215	3,738	70	1,121
Afghanistan	28,574	1,395	28	1,004
Niger	13,499	734	15	624
Ghana	21,664	679	28	489
Senegal	11,386	419	16	352

AUTHOR

Michael Zimmermann, M.D., Human Nutrition Laboratory, Swiss Federal Institute of Technology Zürich (ETHZ)

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