THE GLOBAL CHALLENGE OF IODINE DEFICIENCY[1]

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ABSTRACT

Iodine deficiency affects most of the world's land mass, and consequently puts a large part of the population at risk. The most damaging effects are increased neonatal mortality and retarded brain development, but others are important, including goiter, hypothyroidism, and socioeconomic deprivation. Several good means are available for correcting iodine deficiency, the best being iodized salt; iodized vegetable oil, iodized water, and iodine tablets have an occasional place as well. Major components of successful IDD control include an effective national program, usually in the Ministry of Health, a national advisory commission that represents all sectors involved with iodine deficiency and its correction, a vigorous education and communication program, and regular and reliable monitoring both of people and of iodized salt. Currently 2.2 billion of the world's population are considered at risk for iodine deficiency and its consequences. Overall, about 70% of households consume iodized salt. Only about 20% of the affected countries have adequate monitoring of people, by urinary iodine concentration, or of iodized salt. The major needs now are promoting adequate iodine nutrition in the countries that are still deficient and sustaining achievements of those that are now sufficient. While progress in the last decade has been outstanding, much remains to be done. By maintaining the current momentum, we can reach the virtual elimination of iodine deficiency worldwide, as pledged by the World Summit of Children in 1990.

Keywords: iodine deficiency, IDD

INTRODUCTION

Most of the world is iodine deficient.[1] Iodine is an essential chemical component of the thyroid hormones, thyroxine and triiodothyronine (T_4 and T_3), which are necessary for life, so iodine deficiency is a major threat to health. Seawater had adequate iodine for our evolutionary ancestors, but when man became a terrestrial animal, he had to depend on iodine available in his new environment, mostly from the soil.

Iodine is distributed unevenly over the earth's land mass. New high mountains, inland areas, and regions with frequent flooding are usually defi-cient; prominent examples are the Andes, the Himalayas, and the Alps, but Central Africa, Central Asia, and, large parts of Indonesia, are also in-volved. Iodine deficiency is a geochemical fact for most of the world, and its consequences have been found in virtually every country at some time in its history, although many have now taken corrective actions.

1 Disajikan dalam Temu Nasional GAKY, Semarang 4-5 Nopember 2001

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This article addresses the global challenge of iodine deficiency by discussing why iodine deficiency is important, the means for correcting it, the present global status of iodine nutrition, and current needs and recommendations.

OPTIMAL IODINE NUTRITION

International groups (WHO, ICCIDD, UNICEF[2], and the Food and Nutrition Board, US Institute of Medicine[3]) agree in general on recommended minimal daily intake of iodine (Table 1). ICCIDD/ WHO/UNICEF propose the following daily intakes: 0 to 6 years, 90 mcg; 6 to 12 years, 120 mcg; adults, 150 mcg; pregnant and lactating women, 200 mcg. These recommendations are based on calculations from thyroid hormone utilization and disposal, and on epidemiologic evidence of the minimal levels that prevent clinical manifestations of iodine deficiency in a community.

Table 1. Recommended daily iodine intakes

	WHO/ICCIDD/UNICEF	US IOM
0-8 years	90 mcg	90 mcg
9-13 years	120	120
13 + years	150	150
Pregnancy	200	220
Lactation	200	290

The most reliable measure of iodine nutrition is the median iodine concentration in representative urine samples, because over 90% of the iodine taken into the body eventually is excreted in urine[4]. Casual samples are easy to collect and to analyze. The urinary iodine is used to identify degrees of iodine nutrition (Table 2).[5] This classification in-cludes both iodine deficiency and iodine excess.

Table 2. Iodine nutrition, by iodine concentration

	mcg/L
Severe deficiency	< 20
Moderate deficiency	20-49
Mild deficiency	50-99
Optimal	100-200
More than adequate	201-300
Excess	> 300

Estimation of thyroid size is another useful assessment technique, because enlargement (goiter) is an early and visible feature of iodine deficiency. Palpation of the neck for goiter is a time-honored approach; it is fast and requires no instruments. Most of the older surveys had goiter prevalence as the main indicator of iodine defi-ciency. It was more valid then than now, because with the considerable progress against iodine deficiency, thyroids have become smaller, and it becomes increasingly difficult to distinguish slight enlargement from normal, particularly in the school-age children who are the usual subjects of surveys. Thyroid size can also be estimated by ultrasound, which allows a precise calculation of volume that can be compared with iodine-sufficient peers by international standards; portable ultra-sound machines make it feasible to carry out field determinations, and this has been done in a number of countries, including in the ThyroMobil project in Indonesia.[6,7]

Another useful marker is the incidence of transient hypothyroidism detected in neonatal screening.[8] Most developed countries have univer-sal screening at birth for congenital defects, in-cluding congenital hypothyroidism; this occurs in about one of every 4,000 births in iodine sufficient countries, usually from failure of the thyroid to develop or other congenital anomalies. Iodine defi-ciency increases transient hypothyroidism in the neonate, and this is reflected by elevated TSH levels. If these screening programs are already in place, they offer a useful means of assessing iodine nutrition without conducting additional testing. These screening programs should not be intro-duced solely for the purpose of monitoring iodine nutrition, because urinary iodines are a simpler means and screening programs may not be the first priority for developing countries; but if they are already in place, they can be useful for this purpose.

Various blood tests for thyroid hormone function are generally not helpful in assessing io-dine nutrition in communities, because the overlap within the normal range is great, the tests are expensive, and better assessment techniques exist.

WHY IODINE DEFICIENCY IS IMPORTANT

Iodine deficiency results in inadequate amounts of thyroid hormone for the body's needs. This is the only clearly established role for iodine in the human body. A possible, but unproved benefit is pro-tection of the breast from fibrocystic disease.

The most visible consequence of iodine defi-ciency is goiter. When the thyroid lacks adequate amounts of the raw material (iodine) to make its hormone, the pituitary stimulates the thyroid with its hormone, TSH, which pushes the thyroid to work harder. In responding to this increased de-mand, the thyroid enlarges, just as a muscle does when required to do more work. Thus, the goiter itself can be looked upon as an adaptation. If the iodine deficiency is mild and the adaptation is successful, the individual may have a goiter, but no other obvious consequences.

The worst effects of iodine deficiency are on the fetus and neonate.[9] Iodine deficiency increases complications of pregnancy, fetal loss, low birth weights, neonatal hypothyroidism, and mental retardation. We deal with these in an accompany-ing article, and will not present details here.

Iodine deficiency has important socioeconomic consequences. Affected communities have lower average mental capacity, poorer work productivity, increased mortality, and lower educability. A fre-quently quoted example is from Jixian in China, where correction of iodine deficiency gave dramatic improvement in school performance, fitness for military service, and per capita income.[10] As another example, Germany loses an estimated US $1 billion per year from the increased medical expenses and work time lost from goiter alone, without including the other more serious consequences of inadequate iodine intake.[11] Iodine deficiency affects domestic animals in the same way it does their owners, so they have increased stillbirths and decreased pro-duction of milk, meat, and eggs; this further da-mages economic output.

HOW TO CORRECT IODINE DEFICIENCY

The most important factors in an effective IDD program are: (a) selection of a proper vehicle for iodization; (b) an effective administrative program; (c) education and communication; and (d) moni-toring.[12] We will next consider these various com-ponents.

Vehicles for iodization

The ideal vehicle for delivering iodine to a deficient community should provide the optimal daily amount on a steady basis, reach the entire population regardless of geographical or socioeco-nomic status, be safe, and be inexpensive. We are fortunate in having several tools for delivering iodine, the most important ones being salt, vege-table oil, water, and tablets. Occasionally, other substances, such as sugar, bread, and tea, are iodized, to take advantage of local circumstances and customs.

Salt is usually the best vehicle.[13] Salt is a dietary necessity, so everyone needs it regardless of age, gender, or socioeconomic status. Frequently, it is the only dietary item that a community cannot provide for itself, so iodizing salt at production sites ensures its wide distribution. The technology is simple and can be applied to modern large-scale units but also carried out manually at the village level. In many countries with limited salt sources, introducing an iodization step is strategically easy. In other countries with many small producers scattered over a wide geographical area, salt iodi-zation poses real challenges.

Iodized vegetable oil is another way to deliver iodine.[14] Various oils, such as poppyseed or walnut, can be iodinated by simple chemical processes, so that 1 ml can hold as much as 500 mg of iodine. Administration by intramuscular injection provides adequate iodine stores for several years, and by oral administration, for 6 to 12 months. Iodized oil has its greatest use for the most vulnerable part of the population (women of childbearing age and children) in areas with severe deficiency where iodized salt is unlikely to be effectively introduced in a reasonable period of time. Its limitations are the need to have direct contact with every recipient and its uneven distribution in the body over time.

Iodized water provides another approach.[15] Like salt, everyone needs water daily. Several means of introducing it are available, the simplest being merely to add drops of a concentrated solution into drinking water for schools or houses. The cost of such intervention is minimal. The disadvantage is that it requires responsible oversight to see that the right amount is administered on a regular basis. If molecular iodine (I_2) is used, it can also sterilize polluted water, a frequent problem in many remote rural areas that also have iodine deficiency.

Iodine can also be added as tablets, solutions, or included in mixtures of vitamins and minerals[16]. This approach can provide satisfactory supple-mentation, is inexpensive, and achieves appropriate physiologic doses. The disadvantage is that it re-quires reliability on the part of the consumer to take the pills as prescribed.

National IDD control programs

Effective iodine nutrition requires oversight at the national level. Almost always, this involves the Ministry of Health, through its Division of Nutrition or similar branch. A valuable addition is a National Commission that includes all of the sectors involved with iodine deficiency and its correction - the Mi-nistries of Health, Education, Agriculture, and Commerce, the salt industry, the health sector, and the iodine deficient communities themselves. The National Commission, led by the Ministry of Health, provides advocacy for the program throughout the country and a forum for identifying and solving problems that may affect one of the involved sectors. The program should have an officer with designated responsibilities, and a budget satis-factory for carrying out the program's aims.

Education and communication

These are vital to a successful program. All relevant sectors must understand the consequences of iodine deficiency and the importance of its correction. Advocacy should be aimed at all levels - policy makers, health officials, the salt industry, and most importantly, the communities affected by iodine deficiency. The message should stress the deadly effects of iodine deficiency on human deve-lopment, including mental retardation, repro-ductive damage, and child mortality. While goiter is important, these other consequences should be emphasized because thyroid enlargement may be passed off as merely a cosmetic blemish, trivial compared to other health priorities. Communi-cation efforts must be appropriate for their target, particularly at the community level. When done properly, they help enlist community members, especially women and mothers, to demand ade-quate iodine for themselves and their children.

Monitoring

To be sustainable, an IDD control program must have effective monitoring of iodine nutrition in the community and of iodine levels in the salt, if that is the vehicle. Nutrition is best measured by the urinary iodine concentration from representative samples of the population. The technique is not difficult in experienced hands, and provides a reli-able indicator of whether iodine nutrition is opti-mal. Monitoring of the community should ideally be carried out every two years, and the results should be analyzed and published. Deviations from the optimal range, especially deficiency but also excess, should be promptly investigated and corrected.

Monitoring has been one of the most over-looked parts of IDD control programs. This neglect can lead to a sense of complacency that the problem has been solved, and later deviations from optimal iodine nutrition are not recognized; then the whole program may fail. Several examples of bad effects from inadequate monitoring are Guate-mala, Bolivia, and Colombia.[17] Inadequate monito-ring is the most frequent cause of failure in IDD programs.

IODINE EXCESS

Defining a precise upper limit for iodine intake is difficult, because it varies greatly among indivi-duals. The US Institute of Medicine has set 1100 mcg as the tolerable upper limit for daily iodine ingestion.[3] This is a conservative figure; most indi-viduals can tolerate much higher levels without apparent difficulty.

The most immediate concern about iodine excess is iodine-induced hyperthyroidism.[18] This occurs in populations that have previously been iodine deficient, especially in older individuals with autonomous thyroid nodules; when presented with an excess of iodine these nodules make too much thyroid hormone because they are no longer under adequate control from the pituitary. While this hyperthyroidism is not a trivial complication, it usually has a short duration, and it pales in com-parison to the devastation that iodine deficiency imposes on children. Concern about iodine-induced hyperthyroidism should never be used as an argument against providing adequate iodine for the general population.

Iodine excess may also increase the incidence of autoimmune thyroid disease (Graves' disease, Ha-shimoto's thyroiditis) in a population and the pre-valence of papillary thyroid cancer (mostly micros-copic). Both of these effects are treatable and not major public health issues, although they reinforce the prudence of not taking more iodine than is necessary.

CURRENT GLOBAL STATUS OF IODINE NUTRITION

Endemic goiter from iodine deficiency was recognized as a problem early in the 20th century. During the first half, many countries introduced iodized salt. Some programs were quite successful, but later fell into disuse. In the 1960's and 70's, the medical community became aware that iodine deficiency had more severe effects than merely goiter and that the accompanying brain damage extended throughout the population and was not limited to the relatively few obvious cretins. As a result of these concerns, the International Council for the Control of Iodine Deficiency Disorders (ICCIDD) formed in 1985, and with the World Health Organization and UNICEF, has since pursued a vigorous campaign for correcting global iodine deficiency. These efforts led to a pledge by the World Summit of Children, in 1990, to achieve the "virtual elimination of iodine deficiency by the year 2000."

During the past decade, the efforts have been expanded, and UNICEF, WHO, and ICCIDD have worked vigorously with countries and other agen-cies to achieve this goal. Numerous groups have participated, particularly Kiwanis International, the foreign aid programs of Australia, Canada, the Netherlands, and the US, the Micronutrient Initia-tive, the World Bank, and many others.

Two years ago, the World Health Organization, with assistance from ICCIDD, compiled an overview (Table 3).[19] Of 191 countries, 130 had IDD; 2.2 billion people, over one-third of the world's popu-lation, were at risk; 740 million had goiter; 81% of the countries had a national coordinating body for iodine deficiency; 78% had an action plan; and 75% had iodized salt legislation. Overall, household iodized salt consumption covered 68% of the population. In Southeast Asia, 600 million people are at risk in the nine countries with IDD, and 172 million have goiter; all of the countries have natio-nal coordinating bodies and most have an action plan and iodized salt legislation. Household con-sumption of iodized salt was 70%, similar to the global level.

A rough summary of the current status in 2001, with an emphasis on monitoring and sustainability, is shown in Table 4.[20] Overall, of 156 countries assessed, 54 have adequate iodine nutrition as indi-cated by urinary iodine concentration >100 mcg/L. In 21% of the countries, 90% or more of house-holds are using iodized salt. Adequate monitoring by urine is present in only 23% of countries and adequate monitoring of salt in only 17%. Thus, while the progress with iodized salt in the last decade has been enormous, we are lagging in the implementation of effective monitoring systems, and this will threaten the sustainability of this remarkable achievement.

CURRENT NEEDS

The two major global challenges are: (1) pro-moting adequate iodine nutrition in the countries that have not yet eliminated iodine deficiency, and (2) sustaining the achievements of those that have.

Each of the countries with continuing iodine deficiency first needs a careful analysis to identify the causes, followed by practical measures to correct them. Possible weaknesses are inadequate interest on the part of the government or popula-tion, insufficient funding, unstable environmental or political climate, and complexities in the salt trade. Countries that import all of their salt can assure adequately iodized salt simply by enforcing strict regulations at points of entry. Thus, some countries with difficult political and socioeconomic situations, such as Nigeria and Congo, nevertheless appear to be successful. Other countries may have numerous sources of salt and many small produ-cers, making the introduction of effective iodization a long and complicated endeavor. These countries require a combination of education, inducements to the salt producers, regulations, and enforce-ment.

Table 3. IDD status by region

					Southeast		West	
	Afric a	America s	EMRO	Europe	Asia	Pacific	Total	Percen t
Total # countries	46	35	22	51	10	27	191	
Countries with IDD	44	19	17	32	9	9	130	
Population with goiter (millions)	124	39	152	130	172	124	740	13
Population at risk (millions)	295	196	348	275	599	513	2,22 5	38
Countries with National Coordinating body	35	18	15	20	9	8	108	81
Countries with action plan	36	18	14	18	8	8	102	78
Countries with iodized salt legislatior	36	18	14	20	7	6	98	75
Household iodized salt consumption Overall (%)	63	90	66	27	70	76	68	
By level (# countries) Unknown	9	0	5	10	0	0	22	
0-50%	14	3	3	16	3	5	44	
51-90%	18	6	6	4	5	3	42	
> 90%	3	10	3	2	1	1	20	

Table 4. Iodine monitoring in countries

			Iodized salt	Adequate	
Region	Countries	UI > 100 mcg/L	use > 89%	monitoring	
				Urine	Salt
Africa	46	13	9	10	10
Americas	25	20	12	6	5
China/Far East	3	1	0	1	1
West/Central Europe Eastern Europe/	37	11	5	13	6
Central Asia	16	0	0	0	0
Middle East	16	6	5	3	2
Southeast Asia	13	3	1	3	3
Total	156 (100%)	54 (35%)	32 (21%)	36 (23%)	27 (17%)

Countries that have already achieved iodine sufficiency must now direct their attention to sus-taining their achievement. WHO, ICCIDD, and UNICEF have listed a number of factors to consider as guidelines for sustainability.[5] Briefly, these include the following:

1) An effective functioning national committee responsible to the government.
2) Evidence of political commitment to universal salt iodization and elimination of IDD.
3) Appointment of a responsible executive officer for the IDD elimination program.
4) Legislation or regulations on universal salt iodization; ideally covering both human and agricultural salt.
5) Commitment to assessment and reassessment of progress in the elimination of IDD, with access to laboratories able to provide accurate data on salt and urinary iodine.
6) Programs of public education and social mobilization on the importance of IDD in the consumption of iodized salt.
7) Regular data on salt iodine at the factory, retail, and household level.
8) Regular laboratory data on urinary iodine in school-age children with appropriate sampling for higher risk areas.
9) Cooperation with the salt industry and main-tenance of quality control.
10) A database for recording of results for regular monitoring procedures, particularly of salt iodine, urinary iodine, and if available, neo-natal TSH, with mandatory public reporting.

PROSPECTS FOR THE FUTURE

Although we have still not achieved the goal of virtual elimination of iodine deficiency worldwide, the progress so far has been enormous. While continuing with national efforts in the countries that are still iodine deficient, we must give increas-ing attention to sustaining the progress already made.

I have already discussed the importance of a stable national program, involvement of all relevant sectors, effective education, and regular monito-ring. These are the key ingredients for sustain-ability. Over all rides the need to avoid com-placency, to recognize that iodine deficiency will remain a geochemical fact, and that we must be constantly aware of the risk and protect our countries from it.[17] If we meet this challenge successfully, the iodine deficiency disorders may well become the first noninfectious global disease to be eliminated worldwide, a real public health triumph. It is up to all of us to work towards this goal.

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