REVIEW

Update on iodine status worldwide

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Purpose of review

Salt iodization has been introduced in many countries to control iodine deficiency. The two most commonly used approaches to assessing iodine nutrition on the population level are estimation of the household penetration of adequately iodized salt (HHIS) and measurement of urinary iodine concentrations (UICs). The aim of this review is to assess global and regional iodine status in 2012 by using each of these indicators.

Recent findings

The most recent national data on HHIS were obtained from UNICEF. The most recent data on UICs, primarily national data in school-age children, were obtained from a systematic literature search, the International Council for the Control of Iodine Deficiency Disorders and the WHO Micronutrients Database. The median UIC was used to classify national iodine status and the UIC distribution to estimate the number of individuals with low iodine intakes. Thirty-two countries are iodine deficient based on the national median UIC. Globally, 29.8% of school-age children (246 million) are estimated to have insufficient iodine intake. Out of 128 countries with HHIS data, 37 countries have salt iodization coverage that meets the international goal of at least 90% of households consuming adequately iodized salt and 39 countries have coverage rates of less than 50%. Overall, ≈70% of households worldwide have access to iodized salt.

Summary

Iodized salt programs need to be strengthened and extended to reach nearly one-third of the global population that still has inadequate iodine intakes.

Keywords

children, iodine deficiency, salt iodization, urinary iodine

INTRODUCTION

Iodine deficiency has multiple adverse health effects, all due to inadequate thyroid hormone production, that are termed the iodine deficiency disorders (IDD) [1]. Iodine deficiency during pregnancy and infancy irreversibly impairs growth and brain development and remains a common cause of preventable mental impairment worldwide [2]. Before 1990, only a few countries – Switzerland, some of the Scandinavian countries, Australia, the USA and Canada – were completely iodine sufficient. Over the past 25 years, salt iodization has been introduced in many countries as a safe, cost-effective and sustainable way to eliminate IDD [3■■]: the annual costs of salt iodization are estimated at only 0.02–0.05 US$ per child covered. In 2005, the World Health Assembly (WHA) adopted a resolution that urged their Member States to regularly monitor the iodine situation in their country [4]. Based on the most recent monitoring data from these national surveys, this review provides an update on global iodine status in 2012.

METHODS

Because more than 90% of dietary iodine eventually appears in the urine, the urinary iodine concentration (UIC) is an excellent biomarker of recent iodine intake [2]. UIC, measured in spot urine samples from a representative sample and expressed as the median, is the recommended method to assess iodine status of a population [1]. UIC data do not provide direct information on thyroid function, but they are a reliable measure of exposure, and a low median value suggests a population is at higher risk of developing thyroid disorders. UIC

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KEY POINTS

- Common approaches to assessing iodine nutrition in populations are an estimation of the household penetration of adequately iodized salt and measurement of urinary iodine concentrations.
- Thirty-two countries are currently iodine deficient based on the national median urinary iodine concentration.
- Globally, 29.8% of school-aged children (246 million) are estimated to have insufficient iodine intakes.
- Out of 128 countries with data, 37 countries have salt iodization coverage that meets the international goal of at least 90% of households consuming adequately iodized salt and overall, ≈70% of households worldwide have access to iodized salt.

surveys are usually done in school-aged children (SAC), because they are a convenient population, easy to reach through school based surveys and usually representative of the general population [1]. Therefore, the International Council for the Control of Iodine Deficiency Disorders (ICCIDD)/WHO use UICs from 6 to 12 year-old children in nationally representative surveys, expressed as the median in μg/L, to classify a population's iodine status [1] (Table 1). More countries are beginning to carry out studies in high-risk population groups, that is, women of reproductive age, pregnant women and younger children, however data are limited and the majority of countries still conduct routine iodine monitoring in SAC.

Table 1. Criteria for assessing iodine nutrition in a population of school-aged children based on median and/or range of urinary iodine concentrations in school-aged children

Median UIC (μg/L)	Iodine intake	Iodine status
<20	Insufficient	Severe iodine deficiency
20–49	Insufficient	Moderate iodine deficiency
50–99	Insufficient	Mild iodine deficiency
100–199	Adequate	Optimal
200–299	More than adequate	Optimal, but may pose a slight risk of more than adequate intake in the overall population
≥300	Excessive	Risk of adverse health consequences

Adapted with permission from [1].

Data sources for urinary iodine concentrations

For this review, we used country data on UIC compiled in the WHO VMNIS Micronutrients Database [5], a systematic PubMed literature review and, to identify data from ongoing or unpublished surveys, we contacted iodine scientists around the world. The sampling frame was surveys conducted between 1993 and May 2012. For the analysis, we included only surveys with a cross-sectional population-based sample frame, that used standard UIC assay techniques and reported the median and/or mean UIC (μg/L), or the proportion (%) of the population with UIC less than 100 μg/L. Because population monitoring of iodine status is primarily carried out in SAC, which serves as a proxy for the general population [1], preference was given to studies carried out in SAC. SAC are defined as children 6–12 year old throughout this article. If no national data were available subnational data were used; if two or more subnational surveys in SAC of the same administrative level were available from different locations, the surveys were pooled into a single weighted summary measure. For countries where no UIC data were available, no prevalence estimates were made. We considered each prevalence estimate of inadequate iodine intake as reflective of the whole country, whether from national or subnational data. The data coverage of a given WHO region was calculated as the sum of the SAC population of countries with available data divided by the total SAC population of the respective region. The same procedure was used to calculate the global data coverage for the general population. Additional details have been recently published on the data analysis [6■■], and the data sources for each country can be found online on the ICCIDD website: http://www.iccidd.org.

Estimating national iodine status and the percentage of the population with deficient iodine intakes

The median UIC obtained from the survey data was used to classify countries according to the international threshold criteria of public health importance of iodine nutrition (Fig. 1). National, regional and global populations with inadequate iodine intakes were estimated based on each country's proportion (%) of the population with UIC less than 100 μg/L. For each country, the proportion was applied to the national population of both SAC and the general population. The obtained number of SAC and individuals affected per country was then separately pooled for regional and global prevalence estimates. The United Nations

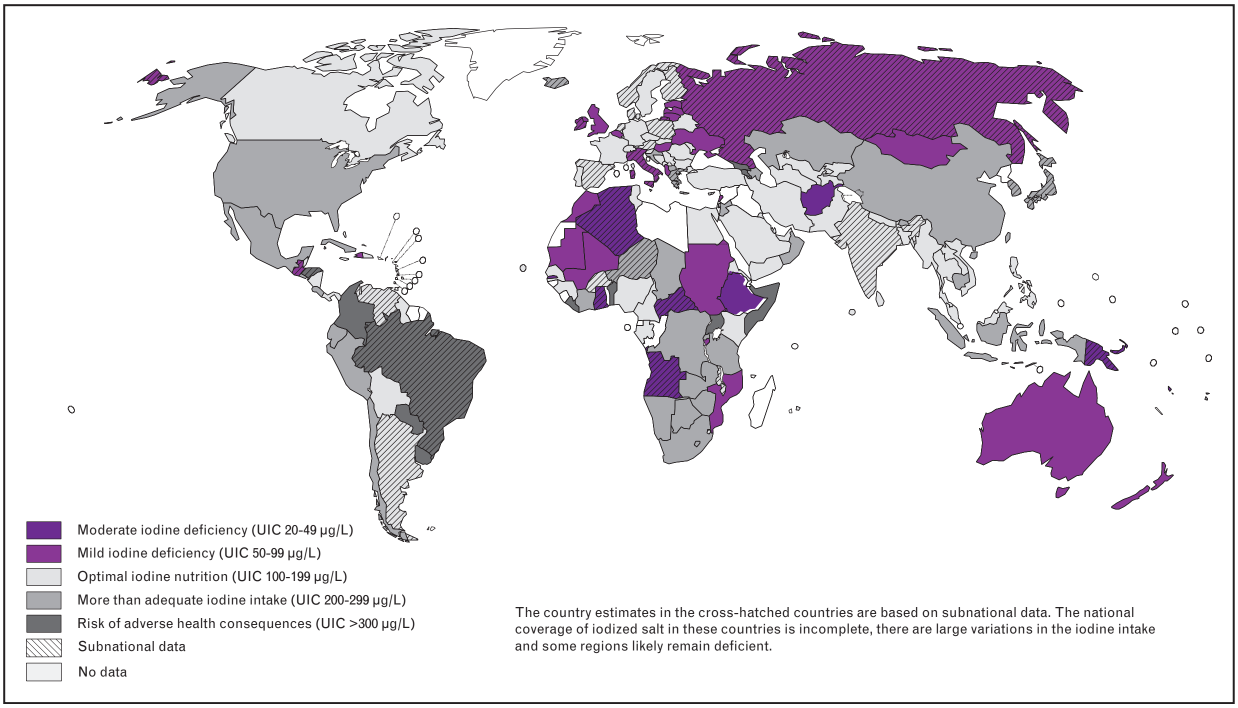

FIGURE 1. National iodine status based on median urinary iodine concentrations in school-age children.

population estimates of 6–12 year-old children and the general population for the year 2010 were used [7].

Monitoring iodized salt programs by measuring the percentage of households using iodized salt

Since the mid-1990s, UNICEF assists countries in collecting health data through its international household survey initiative the Multiple Indicator Cluster Surveys (MICS). Countries may also participate in other standardized household survey programs, such as the Demographic and Health Surveys (DHS) program from the US Agency for International Development (USAID). These surveys have large sample sizes (usually between 5000 and 30 000 households) and typically are conducted about every 5 years, to allow comparisons over time. One of the nutrition indicators in these programs is iodization of household salt. An adequate iodine level in household salt is defined as salt containing 15–40 ppm of iodine [1]. Testing of the iodine content in household salt samples is usually done with simple rapid test kits (RTKs). Data on household coverage with iodized salt is updated and summarized yearly by UNICEF in their State of the World's Children Reports. The data compiled by UNICEF are mainly from developing countries and countries in transition, as household coverage data from industrialized countries are limited. The data on household coverage with iodized salt in this review are drawn from the 2012 study [2] and the UNICEF Child info database [8].

RESULTS

Nationally representative UIC surveys are available for 117 countries, and for 33 countries, subnational surveys are used to make the estimates. There are no UIC data available for 43 countries, and although the majority of these have small populations, larger countries still without adequate UIC survey data include the Democratic People's Republic of Korea, Israel and the Syrian Arab Republic. Available UIC data now cover 97.4% of the world's population of SAC.

Figure 1 shows countries classified by iodine nutrition according to degree of public health importance based on the median UIC. In 2011, iodine intake is inadequate in 32 countries, adequate in 71, more than adequate in 36, and excessive in 11. Of the 32 countries with iodine deficiency, nine are classified as moderately deficient, 23 as mildly deficient and none as severely deficient.

Based on the current estimates, the iodine intake of 29.8%, or 246.2 million of SAC worldwide is insufficient (Table 2). Over one-half of the children with low intakes are in two regions: 78 million

Table 2. Number of iodine-deficient countries, proportion of population, and number of individuals with insufficient iodine intake in school-aged children and in the general population, by WHO region, 2012

	Insufficient iodine intake (UI $<$ 100 μg/L)				
	SAC[a]			General population[a]	
WHO region[b]	Countries (*n*)	Proportion (%)	Total *n* (millions)[c]	Proportion (%)	Total *n* (millions)[c]
Africa	10	39.5	58.1	40.1	322.2
Americas	2	13.7	14.6	13.7	125.7
Eastern Mediterranean	4	38.6	30.7	37.4	199.2
Europe	11	43.9	30.5	44.2	393.1
South-East Asia	0	31.9	78.4	31.7	565.3
Western Pacific	5	19.8	33.9	17.9	319.4
Global total	32	29.8	246.2	28.7	1924.9

[a]SAC defined as children 6–12 years old; general population defined as all age groups.
[b]193 WHO Member States.
[c]Based on United Nations population estimates in the year 2010 [7].

children in South-East Asia and 58 million children in Africa. The smallest proportions with low intakes are in the Americas (13.7%) and the Western Pacific (19.8%), whereas the greatest proportions of children with inadequate iodine intake are in European (43.9%) and the African (39.5%) regions. Inferring from the proportion of SAC to the general population, 1.92 billion people globally have inadequate iodine intakes.

Household coverage with iodized salt

Data on household coverage with iodized salt is available for 128 out of 196 UNICEF member states, most of which are low-income countries. Out of 128 countries with data, 37 countries have salt iodization coverage that meets the international goal of at least 90% of households consuming adequately iodized salt [3■■]. Fifty-two countries have coverage rates of between 50 and 89%, and 39 countries have coverage rates of less than 50%. The world map in Fig. 2 shows countries classified by their household coverage rates. Overall, approximately 70% of households worldwide have access to iodized salt. Those with the greatest access are living in the WHO regions of the Western Pacific and the Americas, and those with the least access are residing in the Eastern Mediterranean region [3■■].

DISCUSSION

At the national level, there has been major progress in correcting iodine deficiency: from 2003 to 2012, the number of countries with adequate iodine

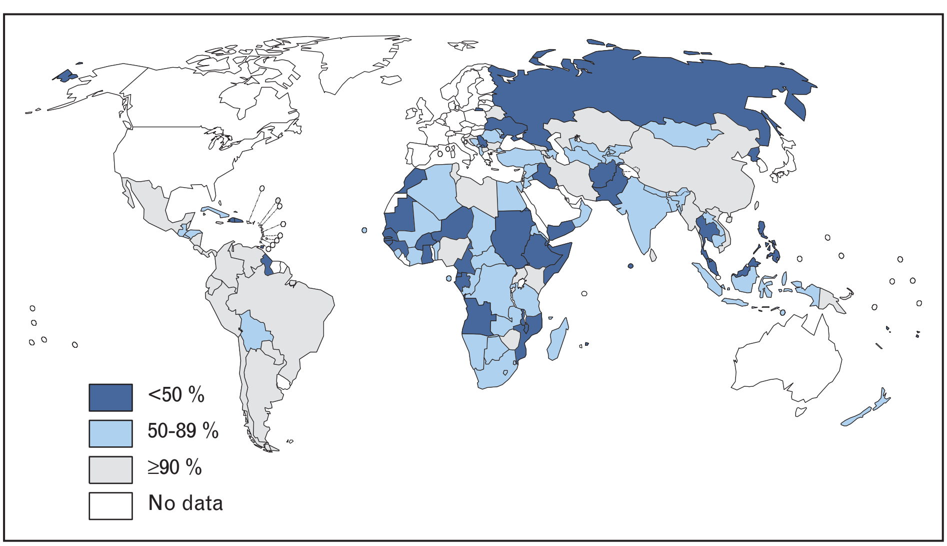

FIGURE 2. Coverage of households with adequately iodized salt [3■■,8].

intake increased from 67 to 107 [6••]. Globally, the overall data quality and coverage of UIC surveys is high, and although data are lacking for 43 countries, these countries (mostly smaller islands) contain only 2.6% of the world's population of SAC. For 33 countries, subnational data were used; for eight countries including India, Italy, Japan, Russia and Spain, multiple subnational data within the country were pooled and weighted based on the sample size of the study to obtain an estimate of the national median UIC. This adds uncertainty compared with national estimates, as large regional differences in iodine deficiency prevalence may exist within these countries. In addition, subnational prevalence estimates, representing 32% of the global population in 2012, can either overestimate or underestimate national prevalence. Another limitation of these estimates is that only a limited number of countries have completed UIC surveys in pregnant women and women of reproductive age, who are important target groups, on the national or large subnational level. This is a major constraint of the current estimate because although the median UIC in SAC may be used to represent iodine status of most of the population, it should not be used as a proxy for iodine status in pregnant women [9,10•].

In contrast to the major achievements at the national level over the last decade, there has been only a modest decrease in the global prevalence in SAC of low iodine intakes: from 36.5% (285 million) in 2003 to 29.8% (246 million) in 2012. The difference between recent progress as judged by changes in prevalence of low intake compared to national classifications can be partially explained by the lack of substantial progress in a handful of countries with very large populations. However, it also highlights a fundamental limitation of applying a population indicator (median UIC) to define the number of individuals affected. In iodine-sufficient countries where most iodine intake comes from iodized salt, UICs show high intra-individual variability, with a day-to-day coefficient of variation of 35% [11•]. Therefore, in an individual whose average daily iodine intake is adequate to maintain thyroidal iodine stores, iodine intake will show wide daily variation that will result in many individual days when a UIC value will be less than adequate. In 2003, the WHO made the decision to classify all children in iodine surveys with a spot UIC less than 100 μg/L as having low iodine intakes [12]. This allowed generation of prevalence data, but leads to the apparent paradox that a country like Switzerland, with a model iodized salt program, a national median UIC of 120 μg/L and a goiter rate of less than 3% in SAC [13], is classified as having 'optimal' country iodine status, but at the same time 36% of the population is classified as having inadequate iodine intake [6••]. In this 2012 prevalence estimate, 75% of children classified as having low iodine intake are living in countries that are iodine sufficient, and only 25% are living in countries classified as insufficient. Thus, it is easier to make progress against iodine deficiency based on national classification using the median UIC than on the percentage of individuals affected. The percentage-affected approach overestimates the true prevalence of iodine deficiency and has contributed to the perception of a global slowdown in progress to control iodine deficiency when looking at trends in numbers affected rather than in changes in national iodine status based on the median UIC.

The percentage of households covered by adequately iodized salt increased from less than 10 to 66% between 1990 and 2002 [14], but progress has slowed in the last decade. Inconsistent production or limitations in quality-controlled iodization technology at the factory, poor packaging and ineffective transport channels may be explanations for varying iodine levels and iodine losses, resulting in inadequate amounts of iodine in salt at the households. Further obstacles to the implementation of effective iodized salt programs are difficulties in enforcing legislation on iodized salt, problems caused by having a high number of small-scale salt producers and the absence of an effective monitoring system. Thus, the marked improvement in iodine nutrition around the world over the past decade as measured by the number of countries with a median UIC indicating iodine sufficiency has not been paralleled by comparable increases in iodized salt coverage. This is due in part to the generally longer lag time in data reporting of iodized salt coverage as household surveys are generally carried out only every 3–5 years, so that recent initiatives to improve iodization programs may not be yet visible in the global statistics. Other reasons for the difference are that salt iodization data are available from only 128 countries whereas UIC data are available from 150 countries [6••]. The salt iodization data are mainly from developing countries and countries in transition, whereas the UIC data also include industrialized countries in Europe and North America. Also, the salt iodization data do not take all dietary iodine sources into account, particularly the contribution of salt in processed foods and dairy products that are important sources in many countries, as well as iodine-rich groundwater found in some regions.

CONCLUSION

Reaching the remaining one-third of the global population not yet covered with iodized salt will not be easy. Although, the key factors to successful national programs have been identified, reaching disadvantaged groups living in remote areas and convincing the food industry and small scale salt producers to use and to iodize their salt are major challenges.

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M.A. and M.B.Z. compiled the data, conducted the data analysis and wrote the article. M.B.Z. had primary responsibility for final content. Both authors read and approved the final article.

Conflicts of interest

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REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

■ of special interest

■■ of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 432–433).

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