

# Global Iodine Status in 2011 and Trends over the Past Decade<sup>1-3</sup>

Maria Andersson,<sup>4,5\*</sup> Vallikkannu Karumbunathan,<sup>4</sup> and Michael B. Zimmermann<sup>4,5</sup>

<sup>4</sup>Human Nutrition Laboratory, Institute of Food, Nutrition, and Health, ETH Zurich, Zurich, Switzerland; and <sup>5</sup>International Council for the Control of Iodine Deficiency Disorders, Zurich, Switzerland

## Abstract

Salt iodization has been introduced in many countries to control iodine deficiency. Our aim was to assess global and regional iodine status as of 2011 and compare it to previous WHO estimates from 2003 and 2007. Using the network of national focal points of the International Council for the Control of Iodine Deficiency Disorders as well as a literature search, we compiled new national data on urinary iodine concentration (UIC) to add to the existing data in the WHO Vitamin and Mineral Nutrition Information System Micronutrients Database. The most recent data on UIC, primarily national data in school-age children (SAC), were analyzed. The median UIC was used to classify national iodine status and the UIC distribution to estimate the number of individuals with low iodine intakes by severity categories. Survey data on UIC cover 96.1% of the world's population of SAC, and since 2007, new national data are available for 58 countries, including Canada, Pakistan, the UK, and the US. At the national level, there has been major progress: from 2003 to 2011, the number of iodine-deficient countries decreased from 54 to 32 and the number of countries with adequate iodine intake increased from 67 to 105. However, globally, 29.8% (95% CI = 29.4, 30.1) of SAC (241 million) are estimated to have insufficient iodine intakes. Sharp regional differences persist; southeast Asia has the largest number of SAC with low iodine intakes (76 million) and there has been little progress in Africa, where 39% (58 million) have inadequate iodine intakes. In summary, although iodine nutrition has been improving since 2003, global progress may be slowing. Intervention programs need to be extended to reach the nearly one-third of the global population that still has inadequate iodine intakes. J. Nutr. doi: 10.3945/jn.111.149393.

## Introduction

Iodine deficiency has multiple adverse effects on growth and development due to inadequate thyroid hormone production that are termed the iodine deficiency disorder (1). Iodine deficiency remains a major global threat to health and development, because it is the most common cause of preventable mental impairment worldwide (2). Pregnant women and young children are particularly susceptible. Only a few countries, Switzerland, some of the Scandinavian countries, Australia, the US, and Canada, were completely iodine sufficient before 1990. Since then, there has been a major effort to introduce salt iodization as a safe, cost-effective, and sustainable strategy to ensure sufficient intake of iodine in deficient areas. Iodized salt programs are now implemented in many countries worldwide, and two-thirds of the world's population (71%) is estimated to be covered by iodized salt (3).

Because >90% of dietary iodine eventually appears in the urine, the UIC<sup>6</sup> is a biomarker of recent iodine intake. UIC can be measured in spot urine samples and is the recommended indicator for assessing iodine status in populations (1). Although UIC data do not provide direct information on thyroid function, a low value suggests a population is at higher risk of developing thyroid disorders. The median UIC in SAC has been used to approximate the iodine status of the general population in countries where salt is the primary vehicle for iodine, because SAC is a convenient population that is easy to reach through school based surveys (1). Therefore, UIC from 6- to 12-y-old children in nationally representative surveys, expressed as the median in  $\mu\text{g/L}$ , is used to classify a population's iodine status (Table 1). More and more countries are beginning to carry out studies in high-risk population groups, i.e., 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. Since 2003, nationally representative data on UIC in SAC, mostly from school-based surveys, have been used to update country, regional, and global estimates of iodine status.

<sup>1</sup> Supported by the International Council for the Control of Iodine Deficiency Disorders, Zurich, Switzerland, UNICEF, and the ETH Zurich, Switzerland.

<sup>2</sup> Author disclosures: M. Andersson, V. Karumbunathan, and M. B. Zimmermann, no conflicts of interest.

<sup>3</sup> Supplemental Table 1 is available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at [jn.nutrition.org](http://jn.nutrition.org).

\* To whom correspondence should be addressed. E-mail: [maria.andersson@hest.ethz.ch](mailto:maria.andersson@hest.ethz.ch).

<sup>6</sup> Abbreviations used: ICCIDD, International Council for the Control of Iodine Deficiency Disorders; SAC, school-age children; UIC, urinary iodine concentration.

**TABLE 1** Epidemiological criteria for assessing iodine nutrition in a population based on median UIC in SAC<sup>1</sup>

Median UIC ( $\mu\text{g/L}$ )	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	Risk of iodine-induced hyperthyroidism in susceptible groups
$\geq 300$	Excessive	Risk of adverse health consequences (iodine-induced hyperthyroidism, autoimmune thyroid disease)

<sup>1</sup> Adapted with permission from (1). SAC, school-age children; UIC, urinary iodine concentration.

In 2005, the World Health Assembly adopted a resolution that urged their member states to regularly monitor the iodine situation in their country (4). The prevalence of iodine deficiency was previously reviewed in 2007 (5) and 2003 (6). Since the 2007 estimate, more than one-third of countries worldwide have collected new data on the iodine status of their populations. Therefore, in this paper, we estimate the national, regional, and global prevalence of iodine deficiency as of 2011 with methods comparable to those previously used in 2007 and 2003 (5,6). We also estimate the prevalence of mild, moderate, and severe deficiency along with the overall prevalence of inadequate iodine intake. We compare the current prevalence to previous estimates to examine trends over the past decade in global iodine nutrition.

## Methods

**Data sources and inclusion criteria.** The 2011 global estimate of iodine status is for the 193 WHO member states and the six WHO regions. The estimates are based on the most recent country data for the 18-y time frame of 1993–2011. This wide period of time was chosen to build on previously generated estimates of deficiency and to be able to compare the 2011 estimate with the 2003 and 2007 estimates (5,6). We used country data on UIC compiled in the WHO Vitamin and Mineral Nutrition Information System Micronutrients Database (5,7) and conducted an additional search strategy (1993–2011) in PubMed, Current Contents Connect, and ISI Web of Science for articles in English, French, German, Spanish, and Russian for the identification of peer-reviewed papers, other reports, and documents (search terms included: country name – urinary iodine, iodine deficiency, iodine status). To identify data from unpublished surveys, we contacted iodine scientists around the world through the ICCIDD network and sought assistance from agencies like WHO and UNICEF headquarters and their regional offices.

For the analysis, we included only surveys with a cross-sectional, population-based sample frame, which used standard UIC assay tech-

niques, and reported at least one of the following criteria (1): median and/or mean UIC ( $\mu\text{g/L}$ ); prevalence of inadequate iodine intake: the proportion (%) of the population with UIC  $<100 \mu\text{g/L}$ ; UIC distribution: the proportion (%) of the population within the categories  $<20$ , 20–49, 50–99, 100–199, 200–299, or  $\geq 300 \mu\text{g/L}$  (Table 1).

For data inclusion, UIC surveys were first selected according to the administrative level. Surveys were considered as national when they were based on a nationally representative sample of the population or subnational when the sample was representative of a given administrative level, namely, region, state (first administrative boundary), district (second administrative boundary), or local. 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 throughout this paper as children 6–12 y old. The obtained data on UIC were selected for each country in the following priority order: data from the most recent national survey carried out in SAC during the time period 2000–2011; data from the most recent national survey carried out in adolescents or adults during the time period 2000–2011; if a recent (2000–2011) national survey was not available for SAC, adolescents, or adults, subnational data from studies carried out in 2000–2011 were used to reflect recent changes in iodine nutrition; if no recent data (2000–2011) were available for SAC, adolescent or adults, national surveys older than 10 y (1993–1999) were used; and in the absence of national data from 1993–1999, subnational data from the same time period were used.

When a potentially relevant survey was identified, based on the criteria listed above, and the full publication or report was obtained, all data were checked for consistency. The study design, population, and setting were assessed. When necessary, authors were contacted for clarification or additional information. The data outlined in the survey reports (as listed above) were used without any additional calculations.

The data for each country are available online (**Supplemental Table 1** and with free access on the ICCIDD Web site: <http://www.iccidd.org>).

**Subnational data.** We excluded subnational data from surveys with a sample of fewer than 100 individuals. This sample size, along with a CI of 95%, would result in an error  $\pm 7\%$  if the prevalence estimate was 50% and the design effect (taking statistical variance in cluster sampling into account) was 2.0. If the sample size was  $<100$ , a larger error would

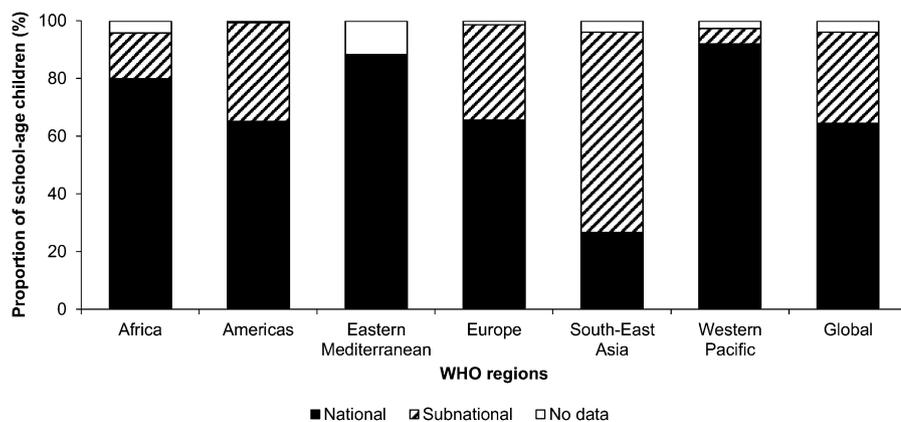
**TABLE 2** Regression equations used to derive missing data points for UIC studies<sup>1</sup>

Variables	Data points used for regression, <sup>2</sup> n	Fit	Regression $R^2$	P value	UIC agreement: (predicted – measured) x 100, (%) <sup>3</sup>
Median UIC vs. mean UIC, $\mu\text{g/L}$	71	Linear	0.97	$<0.001$	0.1
Median UIC vs. percent $<100 \text{ UIC}$ , $\mu\text{g/L}$	182	Quadratic	0.77	$<0.001$	–1.4
Median UIC vs. percent 50–99 UIC, $\mu\text{g/L}$	112	Quadratic	0.44	$<0.001$	–9.5
Median UIC vs. percent 20–49 UIC, $\mu\text{g/L}$	97	Quadratic	0.59	$<0.001$	2.8
Median UIC vs. percent $<20 \text{ UIC}$ , $\mu\text{g/L}$	113	Quadratic	0.32	$<0.001$	13.6

<sup>1</sup> Regression equations were derived from UIC studies carried out during 1993–2010 (7). UIC, urinary iodine concentration.

<sup>2</sup> Each data point represents a single UIC study.

<sup>3</sup> Average median agreement between predicted and measured mean UIC and prevalence values.



**FIGURE 1** Percentage of the total SAC population covered by national and subnational data, by WHO region, 2011. SAC, school-age children.

result. Two exceptions were made for Tunisia and Qatar, for consistency with the previous estimates. To our knowledge, no recent surveys have been conducted in these 2 countries and the same subnational studies used in 2003 and 2007 were included in the present analysis.

When two or more surveys in SAC of the same administrative level were available from different locations (carried out during 2000–2011 or 1993–1999), the surveys were pooled into a single weighted summary measure using the sample size for each survey. The median UIC for each study was first converted into mean UIC by using a regression equation and then pooled (for details, see below; Table 2). The obtained pooled mean UIC was converted back to median UIC using the reverse regression from the same equation.

**Missing data.** For countries where no UIC data were available, no prevalence estimates were made. However, some UIC surveys reported only one measure of iodine nutrition: the median UIC, the percentage of the population with a UIC <100 µg/L, UIC distribution of severity categories, or, in some cases, the mean UIC. For UIC surveys where only one or more summary measures were available, the missing variables were derived by using regression analysis. Regression models were derived from UIC studies compiled in the WHO Vitamin and Mineral Nutrition Information System Micronutrients Database (7). Data points from all country surveys conducted in SAC during the time frame of data analysis (1993–2011), which presented at least two of the UIC measures mentioned above, were used. The regression equations were created to derive the median from the mean and the percentage of the population (UIC <20, 20–49, 50–99, and <100 µg/L) from the median and vice versa (Table 2). The model with the best fit was chosen. The equation

used to calculate the percentage of the population with UIC < 100 µg/L generated reliable results in the median UIC data range of 44–290 µg/L, but the quadratic nature of the regressions limited their use for data-points higher or lower than this range. For countries with low UIC (median UIC <44 µg/L), a value of 87% was assigned for the proportion of UIC <100 µg/L, corresponding to the proportion for a median UIC of 44 µg/L. Countries with high UIC (median UIC >290 µg/L) were assigned 0% for the proportion of UIC <100 µg/L. The estimated prevalence derived from regression analysis slightly overestimates the prevalence of low iodine intake, because the population distribution of UIC curves are skewed to lower UIC values (Table 2).

**Data analysis.** 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 population (SAC or general population) of countries with available data divided by the total population (SAC or general population) of the respective region. The same procedure was used to calculate the global data coverage.

The median UIC obtained from the survey data were used to classify countries according to the international threshold criteria of public health importance of iodine nutrition (Table 1). National, regional, and global populations with inadequate iodine intakes were estimated based on each country's proportion (%) of the population with UIC <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. Similarly, the

**TABLE 3** Number of countries, proportion of population, and number of individuals with insufficient iodine intake in SAC and the general population, by WHO region, 2011<sup>1</sup>

WHO region <sup>3</sup>	Insufficient iodine intake <sup>2</sup>				
	Countries (n)	SAC		General population	
		Proportion (%)	Total n (millions) <sup>4</sup>	Proportion (%)	Total n (millions) <sup>3</sup>
Africa	10	39.3 (38.8, 39.9)	57.9 (57.1, 58.7)	40.0 (39.4, 40.6)	321.1 (316.3, 325.9)
Americas	2	13.7 (12.6, 14.7)	14.6 (13.5, 15.7)	13.7 (12.5, 14.8)	125.7 (114.8, 136.5)
Eastern Mediterranean	4	38.6 (37.0, 40.3)	30.7 (29.4, 32.0)	37.4 (35.8, 38.9)	199.2 (191.0, 207.5)
Europe	11	43.9 (43.1, 44.7)	30.5 (29.0, 31.1)	44.2 (43.5, 45.0)	393.3 (386.8, 399.8)
Southeast Asia	0	31.8 (31.0, 32.7)	76.0 (74.0, 78.0)	31.6 (30.7, 32.5)	541.3 (526.5, 556.0)
Western Pacific	5	18.6 (17.9, 19.3)	31.2 (30.0, 32.4)	17.3 (16.6, 18.1)	300.8 (288.0, 313.5)
Global total	32	29.8 (29.4, 30.1)	240.9 (237.8, 243.9)	28.5 (28.2, 28.9)	1881.2 (1856.2, 1906.4)

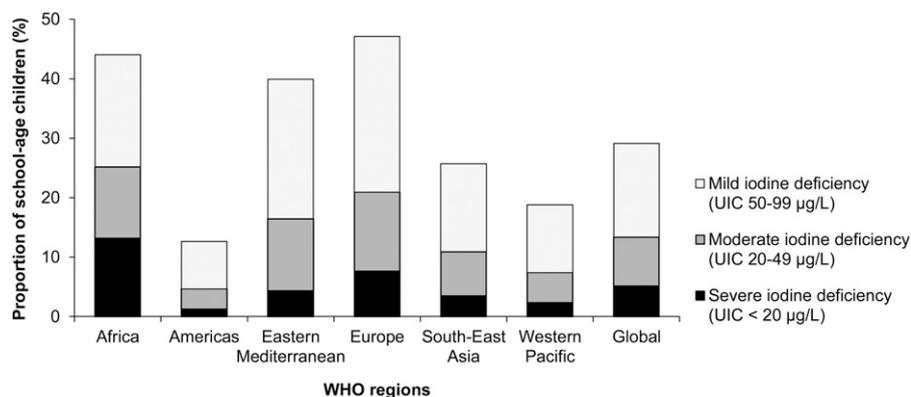
<sup>1</sup> Values are means (95% CI). SAC defined as children 6–12 y old; general population defined as all age groups. SAC, school-age children; UIC, urinary iodine concentration.

<sup>2</sup> UIC <100 µg/L.

<sup>3</sup> A total of 193 WHO member states.

<sup>4</sup> Based on United Nations population estimates in the year 2010 (8).

**FIGURE 2** Proportion (percentage) of SAC estimated to be at risk for mild, moderate, and severe iodine deficiency, by WHO region, 2011. The discrepancy in the overall regional and global percentage < 100  $\mu\text{g/L}$  between this figure and Table 3 can be explained by the use of regression models to fill data gaps for countries not reporting the lower UIC distributions. The regressions slightly overestimate the prevalence. SAC, school-age children; UIC, urinary iodine concentration.



prevalence of mildly, moderately, and severely low iodine intakes was estimated based on each country's proportion (%) of the population with UIC <20, 20–49, and 50–99  $\mu\text{g/L}$ , respectively. The United Nations population estimates of 6- to 12-y-old children and the general population for the year 2010 were used (8).

The 95% CI for the proportion (%) of a population with UIC <20, 20–49, 50–99, and <100  $\mu\text{g/L}$  was calculated as earlier described (9) and used as a measure of uncertainty for the regional and global estimates. Because most surveys utilized a cluster sampling design, the variance estimates were adjusted using a design effect of 2 for cluster sampling (1). For a few countries where the survey sample size was missing ( $n = 18$ ), a sample size of 900 was assumed in agreement with international guidelines for UIC surveys (1). The regional and global international guidelines and the number of SAC with inadequate iodine intake up to 2011 were compared to the previous data from 2003 (6) and 2007 (5).

## Results

Nationally representative surveys conducted between 1993 and 2011 were eligible for inclusion for 115 countries; 58 were newly reported since 2007 (5). In Europe, 23 new national surveys have been carried out since 2007. Worldwide, 19 countries that had no data in 2007 now have UIC data. For 33 countries, subnational UIC surveys were used to make the estimates, because there were no national data. Twenty-eight of the subnational estimates are from single studies and 5 were obtained from pooled data. In 2011, there were no UIC data available for 45 countries, whereas in 2003 and 2007, 66 and 63 countries were lacking data, respectively. Although the majority of the 45 countries without data have small populations, larger countries still without adequate UIC survey data include the Democratic People's Republic of Korea, the Republic of Korea, Israel, the Syrian Arab Republic, and Thailand. Of 148 country estimates, 16 were based on data from population groups other than SAC (4 in adolescents, 11 in adults, and 1 in the general population) but were applied to the SAC population. Available UIC data now cover 96.1% of the world's population of SAC (Fig. 1).

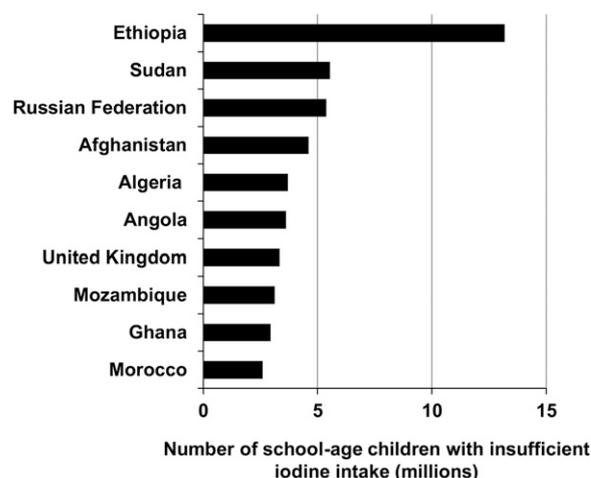
Based on the current estimates, the iodine intake of 29.8% (95% CI = 29.4, 30.1), or 240.9 million (95% CI = 237.8, 243.9), of SAC worldwide is insufficient (Table 3). Of these, 5.2% (95% CI = 5.0, 5.3%) have iodine intakes that are severely deficient (UIC <20  $\mu\text{g/L}$ ), 8.1% (95% CI = 7.9, 8.4) have iodine intakes that are moderately deficient (UIC 20–49  $\mu\text{g/L}$ ), and 15.9% (95% CI = 15.6, 16.2) have mildly deficient intakes (50–99  $\mu\text{g/L}$ ) (Fig. 2). Over one-half of the children with low intakes are in 2 regions: 76 million children in southeast Asia and 58

million children in Africa. The 10 iodine-deficient countries (based on a national median UIC <100  $\mu\text{g/L}$ ) with the greatest number of SAC with insufficient iodine intakes are shown in Figure 3.

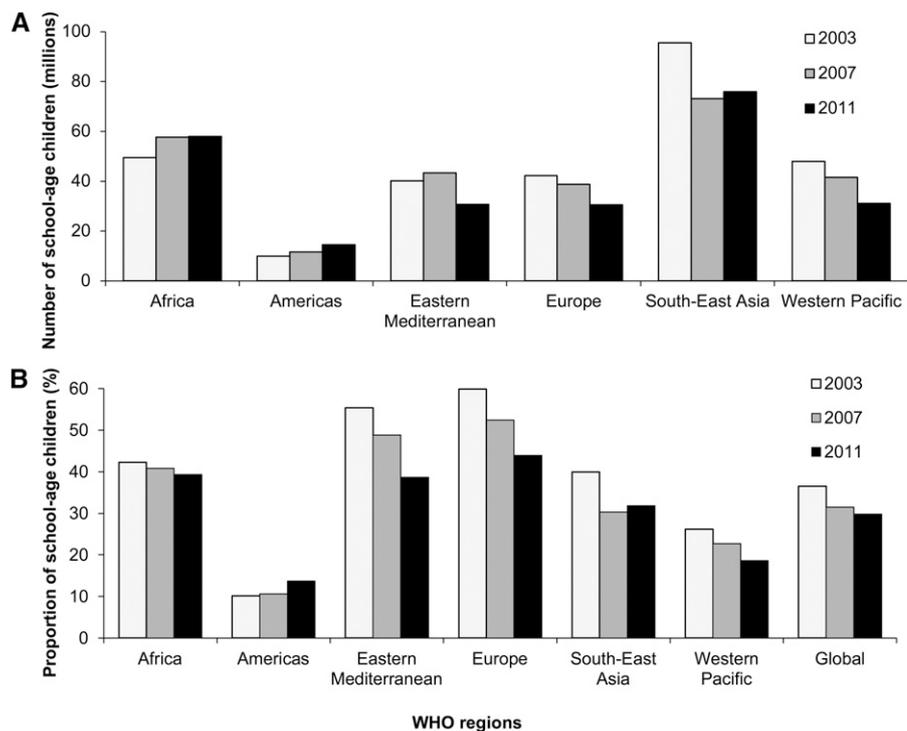
The number and proportion of SAC by region with inadequate iodine intakes in 2003, 2007, and 2011 are shown in Figure 4A and B, respectively. In 2011, the greatest proportions of children with inadequate iodine intake were in European (43.9%) and African (39.3%) regions, whereas the smallest proportions were in the Americas (13.7%) and the Western Pacific (18.6%). Extrapolating from the proportion of SAC to the general population, it is estimated that 1.88 billion people globally have inadequate iodine intakes, a decrease since 2007 of 6.4%.

The global prevalence in SAC of low iodine intakes has fallen over the past 8 y from 36.5% (285 million) in 2003 to 31.5% (266 million) in 2007 and to 29.8% (241 million) in 2011 (Fig. 4B). Large decreases in prevalence between 2003 and 2011 occurred in Europe, the Eastern Mediterranean, southeast Asia, and the Western Pacific. There has been a slight increase in prevalence in the Americas since 2003 but little progress in Africa.

At the national level, 22 countries that were iodine deficient in 2007 improved to iodine sufficiency in 2011; 15 of them now have optimal iodine nutrition, 6 have more-than-adequate in-



**FIGURE 3** The top 10 iodine-deficient countries (based on national median UIC <100  $\mu\text{g/L}$ ) with the greatest numbers of SAC with insufficient iodine intake in 2011. SAC, school-age children; UIC, urinary iodine concentration.



**FIGURE 4** Number and proportion (percent) of SAC with insufficient iodine intake (UIC <100  $\mu\text{g/L}$ ) in millions, by WHO region, in 2003, 2007, and 2011. SAC, school-age children; UIC, urinary iodine concentration.

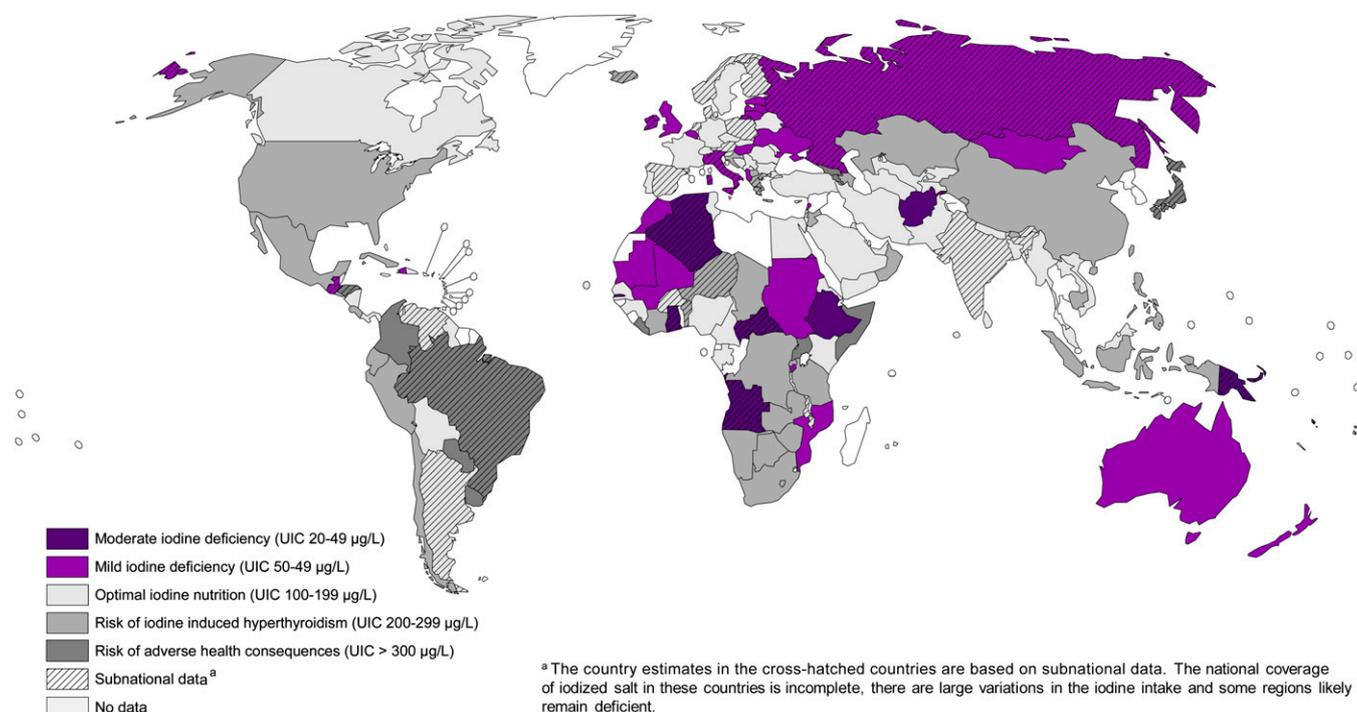
takes, and one has excessive iodine intake. Two countries deteriorated from optimal iodine intake to deficiency.

In 2011, iodine intake is inadequate in 32 countries, adequate in 69, more than adequate in 36, and excessive in 11 (Table 4, Fig. 5). Of the 32 countries with iodine deficiency, 9 are classified as moderately deficient and 23 as mildly deficient. No country is categorized as severely deficient. Since 2003 and 2007, the number of countries with insufficient intake has decreased (Fig. 6); at the same time, the number of countries with adequate

intake increased and countries with more-than-adequate and excessive iodine intake increased (Table 4).

## Discussion

In the years 2003 and 2007, 75 and 94 national surveys, respectively, were used for prevalence estimates. In 2011, 115 nationally representative country surveys were available, of which 107 were conducted in SAC. New estimates were made



**FIGURE 5** Degree of public health importance of iodine nutrition in SAC based on median UIC in 2011. SAC, school-age children; UIC, urinary iodine concentration.

**TABLE 4** Number of countries in terms of iodine status and the total number of country estimates<sup>1-3</sup>

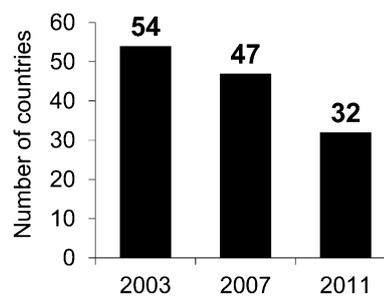
Iodine intake	2003 <sup>1</sup>	2007 <sup>2</sup>	2011
Insufficient: severe iodine deficiency	1	0	0
Insufficient: moderate iodine deficiency	13	10	9
Insufficient: mild iodine deficiency	40	37	23
Adequate	43	49	69
More than adequate	24	27	36
Excessive	5	7	11
Countries with data	126	130	148
Total number of countries <sup>3</sup>	192	193	193

<sup>1</sup> Source (6).<sup>2</sup> Source (5).<sup>3</sup> WHO member states.

for 19 countries that were lacking any UIC data in 2007, e.g., Canada and the UK. The largest amount of new national data are in the European region, with 23 new national studies. For the 33 countries that still lack nationally representative data, including countries like Argentina, India, Italy, Russia, and Spain, data from multiple subnational studies 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 to respective national estimates, because large regional differences in iodine deficiency prevalence may exist within these countries. Further, subnational prevalence estimates, now representing 32% of the global population, can either over- or underestimate national prevalence. In iodine surveillance, subnational surveys are commonly conducted in areas suspected to have problem with iodine deficiency and may be an overestimation of the national prevalence.

In the years 2003 and 2007, 92.1 and 91.1% of the global population, respectively, was covered by iodine surveys included in the prevalence estimates. In 2011, UIC survey data covered 96.1% of the world's population of SAC (Fig. 1), 64% were represented by nationally representative data (up from 60% in 2007), and 90% were represented by surveys conducted within the last 10 y. In 2003 and 2007, 12 country estimates were based on data from population groups other than SAC. In 2011, 16 of the estimates were based on studies conducted in adolescents and adults and one-half of them were nationally representative. Overall, data coverage is high, and although data are lacking for 45 countries, these countries (mostly smaller islands) contain only 3.9% of the world's population of SAC. Taken together, the 2011 regional and global estimates are a comprehensive reflection of the present state of iodine nutrition.

The global prevalence of SAC with low iodine intake fell from 36.5% (285 million) in 2003 to 31.5% (266 million) in 2007 and to 29.8% (241 million) in 2011. Thus, global progress appears to be slowing, but strong regional differences exist (Fig. 4A,B). There has been steady progress in Europe, the Eastern Mediterranean, southeast Asia, and the western Pacific regions over the past 8 y, largely due to strengthened salt iodization programs and improved monitoring (3). There has been negligible overall progress in Africa; since 2003, although the prevalence of SAC with low iodine intake has hovered around 40%, because of population growth, the number of SAC with insufficient intakes has increased about 20%, from ~50 to 58 million.

**FIGURE 6** Number of iodine-deficient countries in 2003, 2007, and 2011.

However, global trends look much more positive if viewed at the national level (Fig. 6). The difference between 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 (Fig. 3). However, it also highlights a fundamental limitation of applying a population indicator (median UIC) to define the number of individuals affected. For example, a country with a median UIC of 100  $\mu\text{g/L}$  would be classified as being nationally iodine sufficient, yet 50% of the population would be classified as having inadequate iodine intake. In iodine-sufficient countries where the major source of iodine is from iodized salt, concentrations of iodine in both spot and 24-h urine collections show high intra-individual variability, with a day-to-day CV of ~35% (10). Therefore, even 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. However, even countries with highly effective iodized salt programs will always have individuals classified with low iodine intakes based on the percentage of UIC <100  $\mu\text{g/L}$ . This is clearly illustrated in the present prevalence estimate, where 74% of children classified as having low iodine intake are living in countries that are iodine sufficient and only 26% are living in countries classified as iodine deficient. Thus, using current methods and UIC cutoffs, it is easier to make progress against iodine deficiency based on national classification using the median UIC than on the percentage of individuals affected. Nevertheless, UIC distribution (percentage of UIC <20, 20–49, and 50–99  $\mu\text{g/L}$ ) indicates severity of low iodine intakes and is more informative than the percent UIC <100  $\mu\text{g/L}$ . It should also be noted that in countries classified as iodine sufficient, some subgroups may still have deficient intakes, e.g., vegans/vegetarians, weaning infants, and those without access to or who choose not to use iodized salt.

Based on national median UIC, in 2011, 11 countries had iodine intakes greater than the 300  $\mu\text{g/L}$  threshold, which WHO classifies as excessive (1). These data emphasize the importance of regular monitoring of iodine status to detect both low and excessive intakes of iodine. However, most people who are iodine sufficient are remarkably tolerant to high dietary intakes of iodine, and intakes up to 1000  $\mu\text{g/d}$  are well tolerated by healthy adults (11). Excessive intake of iodine should be prevented, especially in populations where chronic iodine deficiency has been known to exist, because a rapid increase in iodine intake in such populations may precipitate hyperthyroidism and/or thyroiditis (12). In most people, these disorders are mild and transient and, overall, the relatively small risks of iodine excess are outweighed by the substantial risks of iodine deficiency: pregnancy loss, goiter, and mental retardation.

Only a limited number of countries have completed UIC surveys in pregnant women and women of reproductive age on the national or large subnational level. Thus, there are insufficient data to directly estimate the regional or global prevalence of low iodine intake in these important target groups. This is a major limitation of the current estimate, because although the median UIC in SAC may be used to represent the iodine status of most of the population, it should not be used as a proxy for iodine status in pregnant women (13,14). Further, in populations where a substantial proportion of the total iodine intake comes from milk, UIC in SAC may overestimate the iodine status of the general adult population, because milk consumption usually is higher in children (15). However, in most countries where salt is the primary source of iodine in the diet, the differences between children and adults is smaller and the median UIC in SAC can be used to represent iodine status of the population at large.

In summary, global iodine nutrition has markedly improved over the past decade and the number of iodine-deficient countries decreased from 54 in 2003 to 32 in 2011. Yet despite remarkable progress, 1.88 billion people of the global population, including 241 million school children, still have insufficient dietary iodine intakes. Iodine deficiency has been identified as one of four key global risk factors for impaired child development where the need for intervention is urgent (16). Reaching the remaining one-third of the global population not yet covered will not be easy. Although the key contributors to successful national programs have been identified, reaching economically disadvantaged groups living in remote areas and convincing the food industry and small-scale salt producers to iodize their salt are major challenges. Moreover, communication to health authorities and the public on the need to prevent iodine deficiency by consuming iodized salt must take into account policies to reduce salt consumption (17). An important strategy will be to strengthen national coalitions that include iodine scientists, national ICCIDD focal points, government partners, national and international agencies, the healthcare sector, and salt producers.

### Acknowledgments

The authors thank Lisa Rogers and Juan Pablo Pena-Rosas at the Department of Nutrition for Health and Development of the WHO (Geneva, Switzerland) for their assistance in data collection and for their valuable inputs on the manuscript. M.A., V.K., and M.Z. compiled the data, conducted the data analysis, and wrote the paper; and M.A. had primary responsibility for final content. All authors read and approved the final manuscript.

### Literature Cited

1. WHO, UNICEF, ICCIDD. Assessment of iodine deficiency disorders and monitoring their elimination. A guide for programme managers. 3rd ed. Geneva: WHO; 2007.
2. Zimmermann MB, Jooste PL, Pandav CS. Iodine-deficiency disorders. *Lancet*. 2008;372:1251–62.
3. UNICEF. The State of the World's Children 2011: adolescence: an age of opportunity. New York: United Nations Children's Fund; 2011.
4. Resolution WHO. WHA58.24. Sustaining the elimination of iodine deficiency disorders. In: Fifty-eighth World Health Assembly, Geneva, 25 May 2005. Geneva: WHO; 2005.
5. de Benoist B, McLean E, Andersson M, Rogers L. Iodine deficiency in 2007: global progress since 2003. *Food Nutr Bull*. 2008;29:195–202.
6. Andersson M, Takkouche B, Egli I, Allen HE, de Benoist B. Current global iodine status and progress over the last decade towards the elimination of iodine deficiency. *Bull World Health Organ*. 2005;83:518–25.
7. WHO, Nutrition for Health and Development. The WHO Vitamin and Mineral Nutrition Information System (VMNIS) on Iodine Deficiency Disorders [cited 2009 Nov 24]. Available from: <http://www.who.int/vmnis/iodine/data/en/index.html>.
8. Population division of the Department of Economic and Social Affairs of the United Nations secretariat. World population prospects: the 2010 revision [2011 May 17]. New York: United Nations; 2011. Available from: <http://esa.un.org/unpd/wpp/index.htm>.
9. McLean E, Cogswell M, Egli I, Wojdyla D, de Benoist B. Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. *Public Health Nutr*. 2009;12:444–54.
10. König F, Andersson M, Hotz K, Aeberli I, Zimmermann MB. Ten repeat collections for urinary iodine from spot samples or 24-h samples are needed to reliably estimate individual iodine status in women. *J Nutr*. 2011;141:2049–54.
11. Institute of Medicine of the National Academies. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium and zinc. Washington, DC: National Academy Press; 2001.
12. Laurberg P, Cerqueira C, Ovesen L, Rasmussen LB, Perrild H, Andersen S, Pedersen IB, Carlé A. Iodine intake as a determinant of thyroid disorders in populations. *Best Pract Res Clin Endocrinol Metab*. 2010;24:13–27.
13. Gowachirapant S, Winichagoon P, Wyss L, Tong B, Baumgartner J, Melse-Boonstra A, Zimmermann MB. Urinary iodine concentrations indicate iodine deficiency in pregnant Thai women but iodine sufficiency in their school-aged children. *J Nutr*. 2009;139:1169–72.
14. Wong EM, Sullivan KM, Perrine CG, Rogers LM, Pena-Rosas JP. Comparison of median urinary iodine concentration as an indicator of iodine status among pregnant women, school-age children, and nonpregnant women. *Food Nutr Bull*. 2011;32:206–12.
15. Caldwell KL, Makhmudov A, Ely E, Jones RL, Wang RY. Iodine status of the U.S. population, National Health and Nutrition Examination Survey, 2005–2006 and 2007–2008. *Thyroid*. 2011;21:419–27.
16. Walker SP, Wachs TD, Gardner JM, Lozoff B, Wasserman GA, Pollitt E, Carter JA. Child development: risk factors for adverse outcomes in developing countries. *Lancet*. 2007;369:145–57.
17. WHO. Salt as a vehicle for fortification. Report of a WHO expert consultation. Geneva: WHO; 2008.



#### ERRATUM

Andersson M, Karumbunathan V, Zimmermann MB (2012). Global iodine status in 2011 and trends over the past decade. *J Nutr.* 142:744–50.

There is a typographical error in the color key legend of Figure 5. The color key for “Mild iodine deficiency” now reads “UIC 50–49  $\mu\text{g/L}$ ” and should read “UIC 50–99  $\mu\text{g/L}$ .”