

## GLOBAL ENDOCRINOLOGY

# Global perspectives in endocrinology: coverage of iodized salt programs and iodine status in 2020

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## Abstract

Iodine deficiency has multiple adverse effects on growth and development. Diets in many countries cannot provide adequate iodine without iodine fortification of salt. In 2020, 124 countries have legislation for mandatory salt iodization and 21 have legislation allowing voluntary iodization. As a result, 88% of the global population uses iodized salt. For population surveys, the urinary iodine concentration (UIC) should be measured and expressed as the median, in µg/L. The quality of available survey data is high: UIC surveys have been done in 152 out of 194 countries in the past 15 years; in 132 countries, the studies were nationally representative. The number of countries with adequate iodine intake has nearly doubled from 67 in 2003 to 118 in 2020. However, 21 countries remain deficient, while 13 countries have excessive intakes, either due to excess groundwater iodine, or over-iodized salt. Iodine programs are reaching the poorest of the poor: of the 15 poorest countries in the world, 10 are iodine sufficient and only 3 (Burundi, Mozambique and Madagascar) remain mild-to-moderately deficient. Nigeria and India have unstable food systems and millions of malnourished children, but both are iodine-sufficient and population coverage with iodized salt is a remarkable 93% in both. Once entrenched, iodine programs are often surprisingly durable even during national crises, for example, war-torn Afghanistan and Yemen are iodine-sufficient. However, the equity of iodized salt programs within countries remains an important issue. In summary, continued support of iodine programs is needed to sustain these remarkable global achievements, and to reach the remaining iodine-deficient countries.

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## Invited Author's profile

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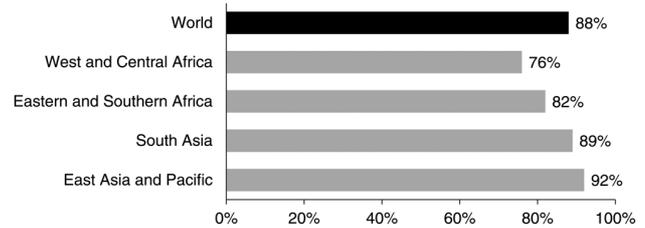
## Introduction

Iodine deficiency has multiple adverse effects on growth and development in humans, collectively termed as the 'iodine deficiency disorders' (IDDs) (1, 2). They result from inadequate thyroid hormone production due to a lack of sufficient dietary iodine. The daily recommended nutrient intakes for iodine are: in children 0–5 years, 90 µg; in children 6–12 years, 120 µg; in adults, 150 µg; and in pregnancy and lactation, 250 µg (2). Most foods have low amounts of iodine, and diets in many countries cannot provide adequate iodine without iodine fortification of salt (1). The WHO's first estimate of the global prevalence of goiter in 1960 suggested that 20% to 60% of the world's population was affected, with most of the burden in low- and middle-income countries (3). Subsequently, the International Child Development Steering Group highlighted iodine deficiency as one of four key global risk factors for impaired child development where the need for intervention was urgent (4). Programs against IDDs are appealing for national governments because the human, economic, and social consequences can be averted by salt iodization, a low-cost and sustainable intervention. Since 1990, the elimination of IDD has been a component of many national nutrition strategies (2, 5).

## Global reach of iodized salt programs

Salt iodization has been introduced in many countries around the world as a sustainable strategy to improve the population level iodine intake and prevent IDD. Between 1942 and 2020, 123 countries introduced mandatory legislation on salt iodization. In 2021, 124 countries have legislation for mandatory salt iodization and at least 21 countries have legislation allowing voluntary salt iodization (6). Mandatory legislation is considered the most reliable approach to ensure effective salt iodization, but voluntary salt iodization can also be effective. The majority of the countries with voluntary fortification are iodine-sufficient at the national level (6, 7). Salt is considered adequately iodized when the fortification level is 15–40 ppm iodine in salt (8, 9).

The reach of current iodized salt programs is remarkable. UNICEF estimates that, based on data collected during the period 2013–2018, in 2018, 88% of the global population used iodized salt (10). As shown in Fig. 1, South Asia and East Asia and the Pacific had the highest household coverage with iodized salt of 89% and 92%, respectively. Western and Central Africa had the



**Figure 1**

Percentage of households consuming salt with any iodine, by UNICEF region 2013–2018. Adapted with permission from (10).

lowest coverage with iodized salt, but still, over three in four households in the region had access to iodized salt.

Despite this rapid progress, there remain concerns. First, UNICEF states there are insufficient recent data available to generate estimates of iodized salt coverage for Central Asia, Latin America and the Caribbean, and the Middle East and North Africa (10). The Global Fortification Data Exchange reports that only 89 of the 145 countries with legislation on salt iodization have gathered recent data on population coverage (6). Secondly, the UNICEF data refer to salt with any amount of iodine (>0 ppm) but the ultimate goal of iodized salt programs is to achieve 'sufficiently' iodized salt, that is, in the range of 15–40 ppm (8, 9). Finally, UNICEF estimates that nearly 1 billion people that may benefit from iodized salt still do not have access (10).

## Monitoring iodine status in populations

The impact of salt iodization on population iodine intake is monitored using biomarkers of iodine status. Several methods are recommended for the assessment of iodine nutrition in populations: urinary iodine concentration (UIC), thyroglobulin concentration in blood and goiter rate (1). These indicators are complementary, in that UIC is a sensitive indicator of recent iodine intake (days), thyroglobulin indicates increased thyroid activity and shows an intermediate response (weeks to months), whereas the goiter rate reflects long-term moderate-to-severe iodine deficiency (months to years) (2). Because >90% of ingested iodine appears in the urine in the following 24 to 48 h, UIC is an excellent indicator of recent iodine intake (11). UIC can be expressed as a concentration (µg/L), in relation to urinary creatinine excretion (µg iodine/g creatinine), or as 24-h urinary excretion (µg/day). For population surveys or cross-sectional studies, it is recommended that UIC be measured in spot urine specimens from a representative sample of the target

group, and expressed as the median, in  $\mu\text{g/L}$  (Table 1) (2). Variations in hydration among individuals generally even out if the sample size is large enough (11, 12).

Although the mUIC is a good indicator of iodine status in populations, its value for assessing individual status is limited by high day-to-day variability in iodine intakes (11). In adults, intra-individual variation in UIC is high for both 24-h collections and spot samples, so that urine samples from  $\approx 10$  different days are needed to assess individual iodine status with 20% precision (12). The distribution of UICs in population studies is often misinterpreted. A common mistake is to assume that all subjects with a spot UIC  $< 100 \mu\text{g/L}$  are iodine-deficient (9). But because individual iodine intakes are highly variable from day-to-day, on any given day, some individuals will inevitably have a low UIC, despite average daily intakes that are adequate to maintain thyroidal iodine stores (12). Recent data suggest that the WHO mUIC categories (Table 1) as 'adequate' and 'more than adequate' iodine intake recommended in children can be combined into a single category ( $100\text{--}299 \mu\text{g/L}$ ) to denote adequate iodine nutrition (13). Although the mUIC does not provide direct information on thyroid function, a low value suggests that a population is at a higher risk of developing thyroid disorders (14).

Pregnant and lactating women have high iodine requirements and may be at a higher risk of low iodine intake. Targeted monitoring of iodine status in these vulnerable groups is important, particularly in countries where the general population has borderline adequate iodine intakes or mild iodine deficiency. In pregnant women, iodine status is monitored using UIC and thyroglobulin (2, 15, 16), whereas iodine status in lactating women should be monitored by measuring the UIC and iodine concentration in breast milk (2, 15, 17).

### The Global Scorecard of iodine nutrition

The Iodine Global Network (IGN) compiles data from UIC studies conducted throughout the world and continually monitors global iodine status (7). The IGN Scorecard presents the most recent UIC data for 194 WHO Member States, plus Liechtenstein and Palestine.

In population monitoring of iodine status using UIC, the WHO recommends that school-age children (SAC) serve as a proxy for the general population (2). Therefore, in the IGN Scorecard, preference is given to studies carried out in SAC. For the purpose of this paper, the UIC data are reported for 194 WHO Member States and have been selected for each country in the following order of

priority: data from the most recent known nationally representative survey carried out between 2005 and 2020 in (i) SAC, (ii) SAC and adolescents, (iii) adolescents, (iv) women of reproductive age, and (v) other adults (excluding pregnant or lactating women). In the absence of recent national surveys, sub-national data are used in the same order of priority.

In the scorecard, adequate iodine intake in SAC, women of reproductive age and other adults is defined based on a mUIC in the range  $100\text{--}299 \mu\text{g/L}$  (13). Although the WHO defines adequate iodine intake in adults as a mUIC value  $\geq 100 \mu\text{g/L}$ , the scientific basis for this threshold is weak (11). Thus, the national classification of iodine status using this threshold in adults should be interpreted with caution.

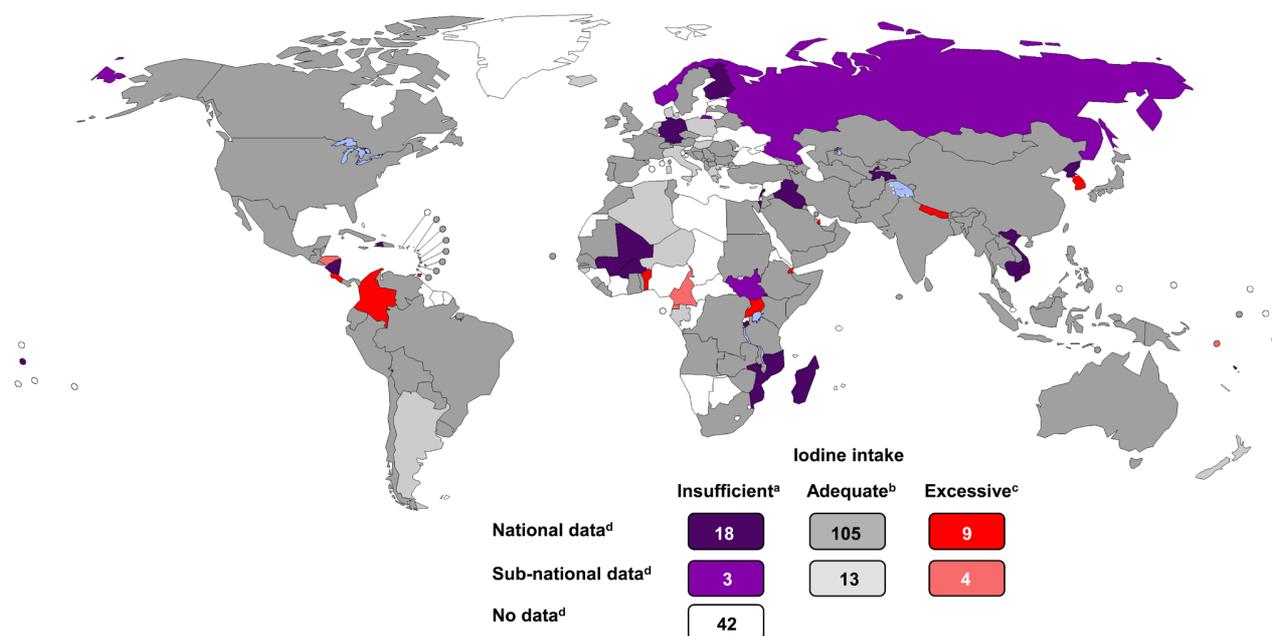
### Countries with adequate iodine nutrition

Cross-sectional UIC studies have been conducted in 152 out of 194 countries in the past 15 years. In 132 countries, the studies were nationally representative. The iodine intake in the general population is adequate in 118 countries (Fig. 1). The number of countries with

**Table 1** Epidemiologic criteria for assessment of iodine nutrition in a population based on median or range of median urinary iodine concentrations (2).

Urinary iodine, $\mu\text{g/L}$	Iodine intake	Iodine nutrition
<b>School-aged children</b>		
$<20$	Insufficient	Severe iodine deficiency
20–49	Insufficient	Moderate iodine deficiency
50–99	Insufficient	Mild iodine deficiency
100–299 <sup>a</sup>	Adequate	Optimum
$>300$	Excessive	Risk of adverse health consequences*
<b>Pregnant women</b>		
$<150$	Insufficient	
150–249	Adequate	
250–499	More than adequate	
$\geq 500^b$	Excessive	
<b>Lactating women<sup>c</sup></b>		
$<100$	Insufficient	
$\geq 100$	Adequate	
<b>Children less than 2 years of age</b>		
$<100$	Insufficient	
$\geq 100$	Adequate	

<sup>a</sup>Adapted with permission from (13); <sup>b</sup>The term excessive means in excess of the amount needed to prevent and control iodine deficiency; <sup>c</sup>In lactating women, the numbers for median urinary iodine concentration are lower than the iodine requirements, because of the iodine excreted in breast milk (15); \*consequences include iodine-induced hyperthyroidism, autoimmune thyroid disease.

**Figure 2**

Estimated iodine nutrition in 194 WHO Member States in 2020 based on national median UIC in school-age children obtained from studies conducted between 2005–2020. <sup>a</sup>Median UIC: <100 µg/L; <sup>b</sup>Median UIC: 100–299 µg/L; <sup>c</sup>Median UIC: ≥300 µg/L; <sup>d</sup>Number of countries. Reproduced with permission from (7). UIC, Urinary iodine concentration.

adequate iodine intake has nearly doubled over the past 20 years from 67 in 2003 (18), to 105 in 2011 (19) and to 118 in 2020, reflecting the effectiveness of the successful

implementation of salt iodization worldwide. The iodine intake in SAC is adequate in the majority of countries where salt is fortified with >15 ppm of iodine. Recent data

**Table 2** Countries with deficient iodine intake in 2020, ranked by increasing median UIC (µg/L). Adapted with permission from (7)<sup>a</sup>.

Country or territory	Median UIC (µg/L)	Date of survey	Data type	Study population
Madagascar	46	2015	National	WRA
Cambodia	63	2014	National	WRA
Lebanon	66	2013	National	SAC
Mali	69	2005	National	SAC
Norway	75	2017–18	Sub-national	WRA
Tajikistan	75	2016	National	WRA
Haiti	77	2018	National	WRA
Vanuatu	77	2017	National	WRA
Burundi	80	2018	National	WRA
Israel	83	2016	National	SAC
Iraq	84	2011–12	National	SAC
Vietnam	84	2013–14	National	SAC
Samoa	88	2013	National	WRA
Germany	89	2014–17	National	SAC, Adolescents
Nicaragua	90	2018	National	WRA
South Sudan	94	2006	Sub-national	SAC
Finland	96	2017	National	Adults
Korea, DPR	97	2009–10	National	SAC
Mozambique	97	2011–12	National	WRA
Burkina Faso	99	2014	National	SAC
Russian Federation	<100	2008–20	Sub-national	SAC

<sup>a</sup>References for the country data available on the IGN Global Scorecard of iodine nutrition (7).

SAC, school-aged children; UIC, urinary iodine concentration; WRA, women of reproductive age.

show that mandatory salt iodization at 25 ppm ensures adequate iodine intake in all population groups, including pregnant and lactating women, who have increased requirements (20). Bouillon cubes containing iodized salt, cow's milk and dairy products are additional important dietary iodine sources, and contribute to adequate iodine intake in many countries (21, 22).

### Countries that are iodine-deficient

In 2020, globally, 21 countries still have insufficient iodine in their diets (Fig. 2). Countries with deficient iodine intake, ranked by increasing mUIC ( $\mu\text{g/L}$ ) are shown in Table 2. Iodine deficiency remains in all regions worldwide and affects populations at all stages of economic development. Iodized salt is available in all iodine-deficient countries, but the coverage is poor or incomplete. The iodine intake is lowest in Madagascar, where the mandatory salt iodization program fell apart due to political instability. In Vietnam, the weakening of the previous mandatory legislation allowed the introduction of non-iodized salt and iodine status decreased. In Cambodia, the production of iodized salt declined when UNICEF stopped supplying potassium iodate and the amount of iodine in fortified salt decreased. Several countries have incomplete nationwide coverage and large regional variations in iodine status, for example, Sudan, Burkina Faso and Russia. In Haiti and Iraq, natural disasters and war, respectively, disrupted the implementation and monitoring of salt production and the distribution chain. The iodine intake is also inadequate in several countries with strong health systems and otherwise successful public health programs (Norway, Germany and Finland). In Norway, iodized salt is not widely implemented and the allowed level of fortification

is only 5 ppm, below the recommended minimum level of 15 ppm. Fish and seafood were assumed to provide adequate iodine intake in the population, but their iodine content is not high enough unless consumed every day, and their consumption is declining. In Germany, a major challenge is the low use of iodized salt in the production of processed foods, which contributes to most dietary salt. Finland had an effective salt iodization program for decades, but decreased consumption of iodized salt and milk resulted in lower iodine intakes. Actions to strengthen the coverage of iodized salt were recently recommended by the Finnish National Nutrition Council.

### Countries with excessive iodine intake

Excessive intake of iodine should be avoided, particularly in previously iodine-deficient areas, since a rapid increase in iodine intake may precipitate a transient increase in hyperthyroidism (14). Conversely, the gradual introduction of iodine to deficient populations can substantially reduce hyperthyroidism due to thyroid autonomy; for example, salt iodization has halved the risk of thyrotoxicosis in Denmark (23, 24). Globally, 13 countries have documented excessive iodine in their diets, as defined by a mUIC  $>300\mu\text{g/L}$ . These countries, ranked by increasing mUIC, are shown in Table 3.

Excess iodine intakes in populations can result from diets that are naturally high in iodine and/or groundwater. In South Korea, the mUIC in SAC and adolescents is  $449\mu\text{g/L}$ , mainly due to high intakes of iodine-rich seaweed (25). Djibouti, in the Horn of Africa, has excess iodine intakes due to very high iodine in groundwater. The median iodine concentration in drinking water is  $92\mu\text{g/L}$  (IQR:  $37\text{--}158\mu\text{g/L}$ ) and the mUIC is  $335\mu\text{g/L}$  in SAC

**Table 3** Countries with excessive iodine intake in 2020, ranked by increasing median UIC ( $\mu\text{g/L}$ ). Adapted with permission from (7).<sup>a</sup>

Country or territory	Median UIC ( $\mu\text{g/L}$ )	Date of survey	Data type	Population surveyed
Cameroon	$>300$	2014–2018	Sub-national	SAC
Trinidad and Tobago	311	2018	National	SAC
Costa Rica	314	2008–09	National	SAC
Nepal	314	2016	National	SAC
Benin	318	2011	National	SAC
Solomon Islands	328	2007–10	Sub-national	SAC
Djibouti	335	2015	National	SAC
Qatar	341	2014	National	SAC
Honduras	356	2005	Sub-national	SAC
Colombia	407	2015–16	National	SAC
Korea, Republic of Korea	449	2013–15	National	SAC, Adolescents
Uganda	464	2005	National	SAC
Equatorial Guinea	564	2007	Sub-national	SAC

<sup>a</sup>References for the country data available on the IGN Global Scorecard of iodine nutrition (7). SAC, school-aged children; UIC, urinary iodine concentration.

and 265 µg/L in pregnant women, despite only 1.6% of Djibouti salt samples being adequately iodized (>15 ppm) (26). The iodine concentration in drinking water is high also in Somalia, with a median concentration of 59 µg/L (IQR: 12–114 µg/L). Despite the low use of iodized salt (7%), the mUIC in women of reproductive age is 261 µg/L (369 µg/L in pregnant women), suggesting overall high iodine intake (27).

Iodine excess can also occur when the level of iodine added to salt is too high considering per capita salt intakes. Salt iodine levels are higher than the recommended 15–40 ppm in several countries that have national mUICs indicating iodine excess. In Cameroon, the iodine level stipulated in the national standard is high, of 100 ppm, and the mUIC is >300 µg/L in SAC. Similarly, in Honduras and Columbia, the iodine levels in the national standards are 83 and 75 ppm, respectively, and the mUICs in SAC these countries are 356 and 407 µg/L, respectively, suggesting iodine excess. In some tropical countries, iodine levels in salt were set high anticipating high losses of iodine from salt from production to the consumer; a study in Ethiopia reported a mean 57% decrease in household iodine content from an initial production level of ≈60 ppm (28). Many factors, including salt moisture and impurities, ambient humidity, light, heat, and the form (potassium iodide or iodate) in which the iodine is present, affect iodine stability in salt. However, properly packaged, good-quality iodized salt, iodized with potassium iodate, loses minimal iodine even during prolonged storage. Currently, the WHO recommends setting the salt iodization level anticipating 30% losses from production to consumption, and based on estimated per capita salt intakes. In populations where the average salt intake per capita is 5 and 10 g/day, salt should be iodized at 40 and 20 ppm, respectively (29). However, many countries have opted for higher iodization levels. In 34% of countries worldwide the legislative standard for iodine in salt is set above 40 ppm; 30 out of 137 countries with mandatory or voluntary standards for iodine in salt have standards between 41 and 59 ppm and 17 countries have a standard ≈60ppm (6).

In situations where monitoring of salt iodization programs suggests excess intakes, the salt iodization level should be reduced to bring the population mUIC <300 µg/L. A good example is Brazil. In response to surveys in 1994–95 showing a 24% goiter rate in SAC, the iodine content in salt was increased to 40–100 ppm in 1998–1999

(30). As a result, in 2000, the mUIC in SAC was 360 µg/L, and the prevalence of goiter had fallen to 1.4%. In the most recent national survey, which began in 2008–2009 and was completed in 2013–2014, the national mUIC was 277 µg/L, ranging from 248 µg/L in the South to 299 µg/L in the Northeast. In response, the fortification level of iodine in salt has been reduced to 15–45 mg (30). These Brazilian data highlight the value of regular monitoring of both salt iodization programs and of population iodine status.

### Fragility and durability of iodized salt programs

In countries that have recently introduced iodized salt programs, sustainability has become a major focus. These programs are fragile, and IDD in children can rapidly return if the iodized salt supply is disrupted (31). Recent countries where programs have slipped are Vietnam and Cambodia (7). Salt iodization programs require a long-term commitment from governments and the salt industry (32).

On the other hand, entrenched iodine programs are often surprisingly durable, even during national crises. Since 2014, Yemen has been devastated by civil war disrupting food supplies and causing widespread acute malnutrition (33). Remarkably, the most recent iodine survey reported that iodine status remains adequate in SAC with a mUIC of 101 µg/L (7). UNICEF estimates that 49% of households had access to iodized salt at the beginning of the crisis (34). Decades of conflict in Afghanistan have caused a chronic humanitarian crisis with high rates of severe acute malnutrition, stunting and anemia (35). In the war-torn country, household coverage with iodized salt has remained at ≈55% (34), and the latest national iodine survey reported iodine sufficiency in SAC, with a mUIC of 171 µg/L (7).

### Iodized salt programs succeed in many countries with the highest burden of malnutrition

Iodized salt programs have been successful in countries with otherwise chronic and severe undernutrition. Of the 15 countries with the highest rates of stunting (34), in which more than 38% of preschool children are stunted from chronic undernutrition, 10 are iodine-sufficient at the national level (Afghanistan, Chad, Democratic Republic of Congo, Guatemala, Malawi, Niger, Papua New Guinea, Sudan, Timor-Leste, Yemen). Only 3 are iodine-

deficient at the national level (Burundi, Mozambique and Madagascar) while the Central African Republic and Eritrea have no recent UIC data.

Nearly half of the world's stunted children (144 million children) live in just three countries: India, Nigeria and Pakistan (34). Despite having unstable food systems that cannot provide adequate nutrition to millions of children, all three countries are iodine-sufficient at the national level and have effective iodized salt programs. Population coverage with iodized salt is a remarkable 93% in India and Nigeria, and 69% in Pakistan. The latest national nutrition survey in Pakistan in 2011 reported little progress on core maternal and childhood nutrition indicators and no gains in reducing most micronutrient deficiencies (36). But one bright spot was the striking improvement in iodine status in children and women; between 2001 and 2011 the mUIC increased from 89 to 124 µg/L in SAC, and from 63 to 105 µg/L in women of reproductive age (36).

### Equity of iodine programs

Around the world, iodine programs are reaching the poorest of the poor. Of the 15 poorest countries in the world, with per capita GDPs of <700 USD (37), 10 are iodine-sufficient at the national level (Afghanistan, Democratic Republic of Congo, Guinea Bissau, Liberia, Malawi, Niger, Sierra Leone, Somalia, Sudan and Togo), 3 are mild-to-moderately deficient (Burundi, Mozambique and Madagascar) and the Central African Republic and Eritrea have no recent data.

Moreover, half of the world's 736 million extremely poor people live in just five countries: India, Nigeria, the Democratic Republic of Congo, Ethiopia and Bangladesh. All five countries are iodine-sufficient at the national level, with high household coverage with iodized salt (HHIS): India (93% HHIS, mUIC in women of reproductive age 178 µg/L), Nigeria (93% HHIS, mUIC in SAC 130 µg/L), Democratic Republic of Congo (82% HHIS, mUIC in SAC 249 µg/L), Ethiopia (86% HHIS, mUIC in SAC 104 µg/L), and Bangladesh (68% HHIS, mUIC in SAC 146 µg/L).

Equity of iodized salt programs has also been assessed within countries. For iodized salt programs to be effective, they need to reach the poorest households in countries. According to UNICEF, out of the 77 countries with equity data on iodized salt, only 40% show equity between the richest and poorest households for consumption of iodized salt; in the remaining countries (58%), the richest had coverage estimates that are at least 10% higher than

the poorest (34). Countries with higher overall coverage tend to have a more equitable distribution of coverage.

### Conclusions and future perspectives

There has been remarkable progress toward increasing iodine intakes and eliminating IDD over the past three decades. Since 1990, the number of iodine-deficient countries has fallen from 113 (38) to 21 (7). This is mainly due to the scale-up of salt iodization in most countries. However, to consolidate and sustain these achievements, and to reach the remaining iodine-deficient countries, refinements in salt iodization programs are required.

The original concept of salt iodization was for it to be universal (i.e. the iodization of all food-grade salt used in households and food processing) (8). However, many national programs have focused mainly on household salt being adequately iodized. The consumption of salt through processed foods is increasing in many countries, and in many middle- and high-income countries most salt is consumed through processed foods (39). If the salt contained in such foods is well-iodized, it can be an important source of iodine (40). National salt iodization programs should encourage and monitor the use of iodized salt in processed foods. Iodine coming from processed foods may help explain why the mUIC is sufficient in populations where household iodized salt coverage is low (18).

There is growing worldwide interest in reducing salt intake to prevent hypertension and other non-communicable diseases. Concerns have been raised that programs to reduce dietary salt could adversely impact programs to prevent iodine deficiency, and, conversely, that iodizing salt could encourage higher salt intakes (41). The WHO has emphasized that these programs are compatible but need to be carefully aligned (29). Both programs have common elements, including program monitoring via urine collections and interactions with the food and salt industries. This provides an opportunity to share and leverage resources and approaches to be more effective and efficient (29). As salt intakes fall, iodine levels can be increased in salt to adjust for the recommended reduction in dietary salt to less than 5 g/day (8).

National level mUIC may hide disparities in iodine intake among sub-groups, including those in a specific geographic region, lower socioeconomic status, with varying diets and/or salt sources. If resources allow, the iodine intakes should be assessed among different subsets of the population, particularly among groups vulnerable

to deficiency, such as the poor in remote areas and those obtaining salt from small-scale salt producers who may not iodize their salt. Such stratified analyses may help identify remaining sub-national challenges and allow refinements to improve programs.

UIC surveys are traditionally done in children, because they are a convenient population, easy to reach through school-based surveys and usually representative of the general population (2). Recently, greater emphasis has been placed on surveying women of reproductive age and pregnant women (9). Pregnant women have sharply higher iodine requirements, and are a key target group of iodine programs. More data is becoming available, suggesting that many pregnant women in both low- and high-income countries, including the United States of America (42) and several European countries (43), have low iodine intakes. However, the mUIC thresholds that indicate iodine deficiency in pregnant and nonpregnant women remain uncertain. More research is needed on evidence-based thresholds for mUIC in these two populations to define iodine status.

#### Declaration of interest

The authors are members of the Iodine Global Network, a non-profit, non-governmental organization based in Ottawa, Ontario, Canada, but declare no further conflicts of interest.

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