Iodine deficiency in 2007: Global progress since 2003

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Abstract

Background. *Iodine deficiency is a global public health problem, and estimates of the extent of the problem were last produced in 2003.*

Objectives*. To provide updated global estimates of the magnitude of iodine deficiency in 2007, to assess progress since 2003, and to provide information on gaps in the data available.*

Methods*. Recently published, nationally representative data on urinary iodine (UI) in school-age children collected between 1997 and 2006 were used to update country estimates of iodine nutrition. These estimates, alongside the 2003 estimates for the remaining countries without new data, were used to generate updated global and regional estimates of iodine nutrition. The median UI was used to classify countries according to the public health significance of their iodine nutrition status. Progress was measured by comparing current prevalence figures with those from 2003. The data available for pregnant women by year of survey were also assessed.*

Results. *New UI data in school-age children were available for 41 countries, representing 45.4% of the world's school-age children. These data, along with previous country estimates for 89 countries, are the basis for the estimates and represent 91.1% of this population group. An estimated 31.5% of school-age children (266 million) have insufficient iodine intake. In the general population, 2 billion people have insufficient iodine intake. The number of countries where iodine deficiency is a public health problem is 47. Progress has been made: 12 countries have progressed to optimal iodine status, and the percentage of school-age children at risk of iodine deficiency has decreased by 5%. However, iodine intake is more than adequate, or even excessive, in 34 countries: an increase from 27 in 2003. There are insufficient data to estimate the global prevalence of iodine deficiency in pregnant women.*

Conclusions. *Global progress in controlling iodine deficiency has been made since 2003, but efforts need to be accelerated in order to eliminate this debilitating health issue that affects almost one in three individuals globally. Surveillance systems need to be strengthened to monitor both low and excessive intakes of iodine.*

Key words: Iodine deficiency, iodine-induced hyperthyroidism, iodized salt, monitoring, urinary iodine

Introduction

Although programs to control iodine deficiency, such as salt iodization, have been effective for decades, iodine deficiency remains a major threat to the health and development of populations around the world, particularly among preschool children and pregnant women in low-income countries.

Iodine deficiency occurs when iodine intake falls below recommended levels and the thyroid gland is no longer able to synthesize sufficient amounts of thyroid hormone. The resulting hypothyroidism (goiter) can occur at any stage of life, but the most devastating consequences of iodine deficiency take place during fetal development and childhood, with stillbirth, miscarriages, poor growth, and cognitive impairment. Although cretinism is the most extreme manifestation, of considerably greater significance are the more subtle degrees of mental impairment that lead to poor school performance, reduced intellectual ability, and impaired work capacity. Iodine deficiency is the world's greatest single cause of preventable brain damage, and this fact is the primary motivation behind the current worldwide drive to eliminate iodine deficiency.

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The most widely used strategy to control iodine deficiency is universal salt iodization (USI). USI means that all salt used for human and animal consumption is iodized [1, 2]. Globally, 68% of households now have access to iodized salt [3], with the greatest access for those living in the World Health Organization (WHO) regions of the Western Pacific and the Americas, and the least access for those residing in the Eastern Mediterranean and Europe. Iodine supplementation previously was restricted to areas in which severe iodine deficiency is endemic and where there is no access to iodized salt [2, 4]. However, it has recently been recommended that supplementation of pregnant women and young children may be necessary in iodine-deficient populations where household access to iodized salt is inadequate (< 90%) [5].

Until the 1990s, total goiter prevalence (TGP) was used as the primary indicator for the assessment of population iodine deficiency. Urinary iodine (UI) is a more sensitive indicator of recent changes in iodine intake and is therefore the preferred indicator for assessing iodine nutrition in the population and monitoring iodine interventions [2]. The population group most often assessed to reflect iodine deficiency in a population is school-age children, because they are the most efficient and practical group to survey and usually reflect the status of the general population [2].

In 2005, the World Health Assembly (WHA) adopted a resolution that the WHO Member States should report on the global situation of iodine deficiency every 3 years [6]. Thus, the first report to the WHA was made in 2007 using revised estimates [7]. Here we present these new global and regional estimates of iodine deficiency, based on UI, using updated information for countries with new data and 2003 estimates for the remaining countries [8]. We also describe the current trends in data collection for both school-age children and pregnant women.

Methods

Data sources—WHO Global Database on Iodine Deficiency

The WHO Global Database on Iodine Deficiency compiles country data on UI and goiter collected from the scientific literature and through a broad network of collaborators, including WHO regional and country offices, United Nations organizations, ministries of health, other national institutions, nongovernmental organizations, and research and academic institutions. MEDLINE (1966–2006) and WHO regional databases are also data sources. The database was established in 1991 and currently holds data from surveys conducted from the 1940s to the present day [9]. With its abundance of data, the database has the potential to assess the global magnitude of iodine deficiency, to evaluate strategies for control, and to track each country's progress toward achieving the global public health goal of the elimination of iodine deficiency [10, 11]. In addition to being the data source for the current estimates, the database provided the data used for the 1993 [12] and 2003 [8] estimates.

A complete, original survey report providing details of the sampling method used is necessary for inclusion in the database. Surveys must use a population-based sample frame and standard UI and goiter measuring techniques [2]. In some instances, authors provide clarification or additional information for surveys entered into the database, and this correspondence is available to users on request.

Data selection and analysis

In 2003, UI data for school-age children (6 to 12 years) collected between 1993 and 2003 and representative of any administrative level within a country were reviewed. For countries with multiple surveys, the use of these data was prioritized as follows: nationally representative data, 1998–2003; subnational data, 1998–2003; nationally representative data, 1993–98; and subnational data, 1993–98. For subnational data, where there were multiple surveys, these were pooled and weighted by the sample size of the survey. In the absence of data for school-age children, data for other population groups were used. More details on the methods can be found in the original publication [8].

In 2007, UI data collected in the previous 10 years (1997–2006) that were unavailable for the estimates produced in 2003 were used to update the estimates. Only data for school-age children that were nationally representative were considered. This criterion was applied because there are an increasing number of countries conducting nationally representative surveys. For countries with no new UI data, the 2003 UI estimates were maintained.

In school-age children, the recommended daily intake of iodine is 120 μg [3]. Classification of iodine nutritional status is based on the population median UI [2]. Iodine deficiency is considered to be a public health problem in countries in which the median UI is below 100 μg/L, since this indicates an insufficient iodine intake [2]. A median UI of 100 to 199 μg/L indicates adequate iodine intake, 200 to 299 μg/L indicates iodine intake that is more than adequate, and iodine intake above 300 μg/L is considered excessive. The iodine nutrition of populations was classified according to the median UI as follows: < 20 μg/L, severe deficiency; 20 to 49 μg/L, moderate deficiency; 50 to 99 μg/L, mild deficiency; 100 to 199 μg/L, optimal; 200 to 299 μg/L, risk of iodine-induced hyperthyroidism in susceptible groups; ≥ 300 μg/L, risk of adverse health consequences.

In pregnant women, the recommended daily intake of iodine is 250 μg [5]. During pregnancy, a median UI of < 150 μg/L indicates insufficient iodine intake, 150 to 249 μg/L reflects adequate intake, 250 to 499 μg/L implies that intake is more than adequate, and at intakes of 500 μg/L or higher there is no added health benefit expected [5].

Estimates of the regional and global prevalence of insufficient iodine intake are based on the proportion of the population with a UI below 100 μg/L. For each country, the proportion is applied to the national population of both school-age children and the general population and then pooled for regional and global estimates. The same principle was applied to generate global estimates. The most recent United Nations population estimates of school-age children were used [13].

Some survey reports provided only one measure of iodine nutrition: the percentage of the population with a UI below 100 μg/L, the median UI, or in some cases the mean instead of the median UI. As was done in 2003 [14], equations to derive one measure from another were developed with the use of data from the database. For the 2007 estimates, data points from nonoverlapping populations from surveys conducted during the time frame for the estimates, and presenting at least two of the measures of UI, were used to generate equations in order to derive one measure from another when information was missing from a survey report. Equations were developed to derive the median from the mean, and the percentage of the population with UI < 100 μg/L from the median. If disaggregated data were provided for a population group, the data were combined, the mean was derived from the median if it was not provided in the report, and the median was then derived from the group mean. On the basis of the equations, a median of 100 μg/L would result in an estimated 47.9% of the population having a median UI below 100 μg/L, and if 50% of the population had a UI below 100 μg/L, the calculated median would be 95.2 μg/L.

Data availability and trends in data reporting

Data availability, i.e., the number of countries with data, was compared between 2003 and 2007. The population coverage of the estimates for a given WHO region was calculated as the sum of the populations of countries with data divided by the total population of the region. The same procedure was used to calculate global coverage, and coverage was compared between 2003 and 2007.

To assess trends in data reporting, we determined the proportion of UI surveys in school-age children for which either the median UI or the proportion of the population with a UI below 100 μg/L was missing and had to be calculated by using the methods described above and previously for the 2003 estimates [14]. Trends in data reporting were compared with 2003.

For pregnant women, data availability was ascertained by quantifying the number of surveys in the database as of December 2006, as well as the number of surveys for this population group in the previous 2 and 5 years, to reveal whether data collection was improving.

Results

New, nationally representative data from UI surveys conducted between 1997 and 2006 were available for 41 countries. These estimates, along with 89 country estimates produced in 2003 (53 of which are nationally representative), allowed global and regional estimates to be made based on data from 130 countries. For 63 countries with no UI data, an estimate could not be made. The available UI data covered 91.1% of the world's population of school-age children (**table 1**).

TABLE 1. Data coverage: school-age children (6–12 years) population coverage by urinary iodine (UI) surveys carried out between 1993 and 2006 and iodized salt household coverage surveys carried out between 2000 and 2006, by WHO region

WHO region[a]	Total no. of school-age children (millions)[b]	Data coverage for school-age children					
		Urinary iodine (UI)			Consumption of iodized salt[c]		
		Countries (no.)	Total no. (millions)	Proportion (%)	Countries	Total no. (millions)	Proportion (%)
Africa	141.3	36	126.8	89.7	44	139.8	98.9
Americas	109.1	21	100.4	92.1	23	76.8	70.4
South-East Asia	241.4	9	238.5	98.8	11	241.3	100.0
Europe	73.8	38	63.4	85.8	20	37.5	50.8
Eastern Mediterranean	88.7	16	77.6	87.5	15	81.9	92.3
Western Pacific	183.2	10	155.9	85.1	8	162.8	88.9
Total	837.5	130	762.6	91.1	121	740.2	88.4

a. 193 WHO Member States.
b. Based on population estimates for the year 2006 (2004 revision). Source [3].
c. Source [4].

TABLE 2. Number of countries, proportion of population, and number of individuals with insufficient iodine intake in school-age children (6–12 years) and in the general population (all age groups), by WHO region, 2007

WHO region[a]	Insufficient iodine intake (UI < 100 µg/L)				
		School-age children		General population	
	Countries (no.)	Proportion (%)	Total no. (millions)[b]	Proportion (%)	Total no. (millions)[b]
Africa	13	40.8	57.7	41.5	312.9
Americas	3	10.6	11.6	11.0	98.6
South-East Asia	0	30.3	73.1	30.0	503.6
Europe	19	52.4	38.7	52.0	459.7
Eastern Mediterranean	7	48.8	43.3	47.2	259.3
Western Pacific	5	22.7	41.6	21.2	374.7
Total	47	31.5	266.0	30.6	2,008.8

a. 193 WHO Member States.
b. Based on population estimates in the year 2006 (2004 revision).
Source [13].

Regional population coverage varied from 85.1% in the Western Pacific to 98.8% in South-East Asia.

Based on the current estimates, the iodine intake of 31.5% (266 million) of school-age children worldwide is insufficient **(table 2)**. Iodine intake is below requirements in 73 million children in South-East Asia and in 57.7 million children in Africa. In the European, Eastern Mediterranean, and Western Pacific regions, the figure is approximately 40 million children, whereas in the Americas, 12 million children do not have enough iodine in their diet. The greatest proportions of children with inadequate iodine intake live in the regions of Europe (52.4%) and the Eastern Mediterranean (48.8%), and the smallest proportions are found in the Western Pacific (22.7%) and the Americas (10.6%). Extrapolating from the proportion of school-age children to the general population, it is estimated that 2 billion people have an insufficient iodine intake (**table 2**).

In **figure 1**, countries were classified according to the six degrees of public health significance with respect to their iodine intake estimated from median UI. Iodine intake was insufficient in 47 countries, adequate in 49, more than adequate in 27, and excessive in 7. Of the 47 countries with insufficient intake, 10 were classified as moderately deficient and 37 as mildly deficient. No countries were categorized as severely deficient.

Complete country-specific data are available in the WHO Global Database on Iodine Deficiency [9, 14].

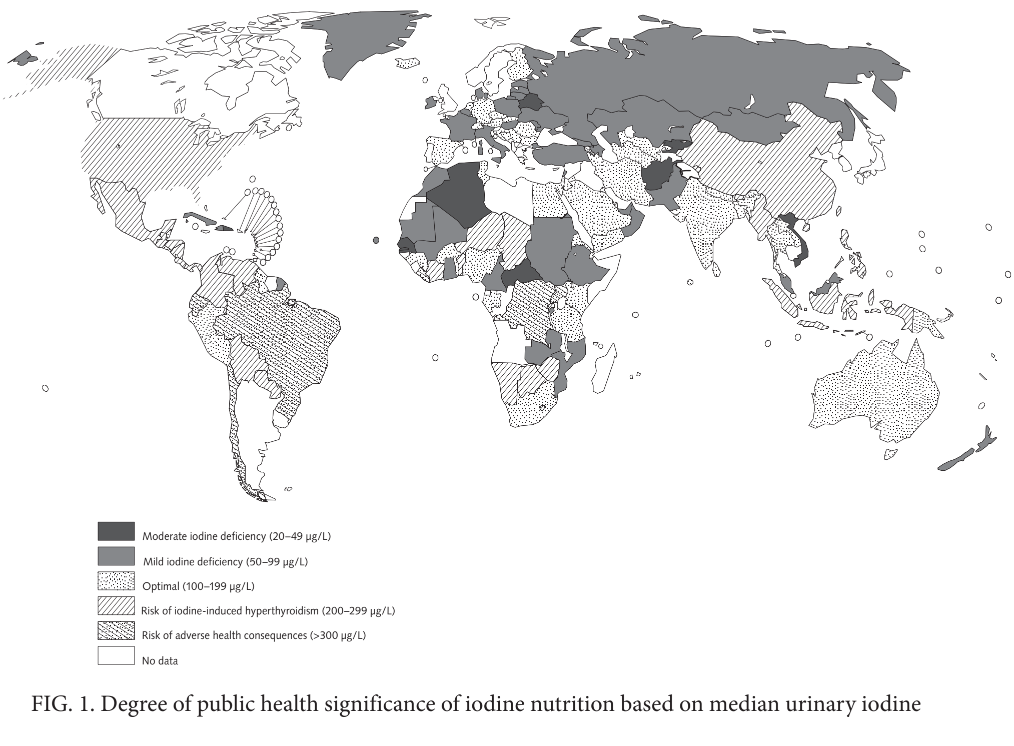

FIG. 1. Degree of public health significance of iodine nutrition based on median urinary iodine

Comparison of data: 2003 and 2007

Of the 37 countries with estimates in both 2003 and 2007, only 2 countries with a median UI above 100 μg/L in 2003 had a UI below 100 μg/L in 2007, whereas 12 of the 16 countries with a UI less than 100 μg/L in 2003 had a UI above this value in 2007. Of the four countries that previously had no data, new data indicate that three have an insufficient iodine intake and the other has an iodine intake that is more than adequate.

The prevalence of insufficient iodine intake in school-age children has decreased by 5% since 2003 **(fig. 2)**. The largest decreases occurred in South-East Asia (9.6%) and in Europe (7.5%). The Americas was the only region that remained stable, with a prevalence of around 10%.

In school-age children, for the 41 countries for which there were new data, about half of the surveys (23) were conducted in the last 3 years. For data reporting in these new surveys, median UI or the proportion of the population with a UI below 100 μg/L was calculated from an alternative measure in 12% of the surveys, representing a decrease from approximately 45% in 2003.

As of December, 2006, the database contained 59 surveys of pregnant women conducted between 1965 and 2005, covering 42 countries. Twenty of these surveys are nationally representative and were conducted in 13 countries. For the period after 2000, there are 28 surveys, 12 of which are nationally representative, conducted in 8 countries. The data were spread over the six different regions, with one-third of the surveys coming from the European region (**table 3**). Due to the limited number of recent surveys of iodine nutrition in pregnant women, a global prevalence for this population group could not be estimated.

In five of the six national surveys recently conducted in both school-age children and pregnant women, the median UI was lower in pregnant women. In three cases, the median for pregnant women was below the cutoff, which suggests insufficient iodine intake in this population group. This is despite the fact that the

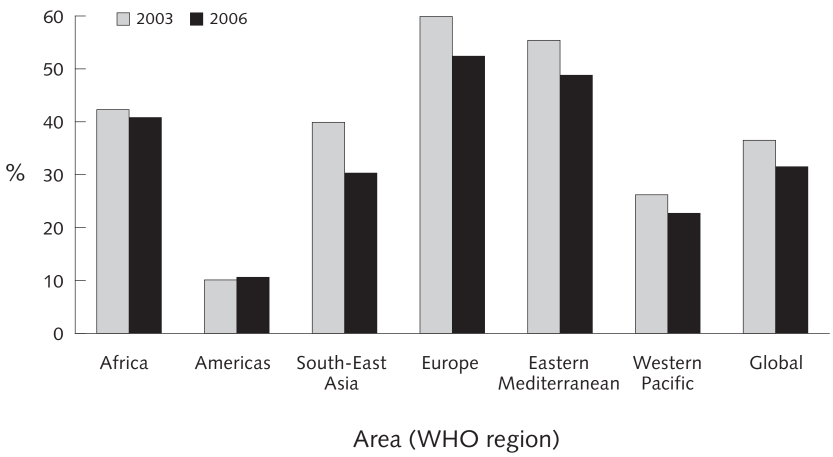

FIG. 2. Change in the prevalence of individuals with an insufficient iodine intake between 2003 and 2006

TABLE 3. Number of countries by region with nationally representative and other surveys (when no nationally representative surveys were available) in pregnant women, pre- and post-2000

	No. of countries with surveys post-2000		Total no. of countries with surveys	
WHO region	Nationally representative	Other	Nationally representative	Other
Africa	1	0	2	6
Americas	1	2	3	3
South-East Asia	1	3	2	4
Europe	4	5	4	10
Eastern Mediterranean	0	0	1	1
Western Pacific	1	2	1	5
Total	8	12	13	29
Countries with any data	20		42	

median UI in school-age children suggested an intake that was adequate or even more than adequate. The median UIs in pregnant women were 73, 134, and 142 μg/L, whereas the corresponding values in school-age children were 102, 144, and 201 μg/L (**table 4**).

Discussion

Estimates of iodine nutrition were calculated based on UI data available from 130 countries, representing 91.1% of the world's population of school-age children **(table 1)**. Data are lacking for 63 countries that represent only 8.9% of the world's school-age population. The proportion of the population with no data ranges from 1.2% in South-East Asia to 14.9% in the Western Pacific. Still, the majority of the population is accounted for in these estimates, and the regional and global estimates are probably an accurate reflection of the current situation.

The global decrease in the prevalence of school-age children at risk for iodine deficiency (5%) represents progress, with the greatest decrease (9.6%) occurring in South-East Asia. Still, 266 million children and 2 billion people worldwide are at risk for iodine deficiency, and almost one-third of school-age children (228 million) do not have access to iodized salt [3].

UI data were compared for countries (classified according to their iodine nutrition status) for the two periods 1993–2003 and 1997–2006. Two countries had a median decrease in UI from more than 100 μg/L to below this cutoff for iodine deficiency in 2007. However, in one country the change in the median was only 5 μg/L, which would be within the range of variability; for the other country, the 2003 estimate was based on local data from 1999, whereas the current estimate is based on national data collected in 2005. Therefore, these changes may only reflect no progress, rather than a deterioration of iodine nutrition within these countries. Of the 12 countries that progressed from inadequate to adequate or more-than-adequate iodine nutrition, 7 had national data for school-age children at both time points, indicating that the data are probably comparable. Although the remaining five countries had data from school-age children in 2003, the data were not nationally representative, and comparison with the more recent nationally representative data is less reliable for assessing progress within the country.

Of the four countries without previous data, three had insufficient iodine intake, a finding that increases the number of countries with inadequate intake and may slightly mask the overall progress that has been made in the countries with data at both time points.

The number of countries in which iodine deficiency is a public health problem decreased from 110 to 54 between 1993 (with TGP as an indicator) and 2003 (with UI as an indicator, and is now (2007) a problem in 47 countries.

Iodine intake was more than adequate or even excessive, with a median UI above 200 μg/L, in 34 countries (an increase from 29 countries in 2003), indicating that susceptible groups within these populations are exposed to the risk of iodine-induced hyperthyroidism.

The current estimates are subject to several limitations. Approximately half of the countries had conducted nationally representative surveys, representing 60% of the world's population. The remainder had made only one or more subnational surveys, or had no data. Subnational data represent approximately 30% of the population covered by these estimates. This may underestimate or overestimate the extent of iodine deficiency, depending on the area surveyed. Iodine-deficiency surveys are often conducted in areas where it is believed there is a problem, resulting in an overestimation of the prevalence of iodine deficiency. Other times, easily accessible areas are surveyed, where the population potentially has greater access to iodized salt, and this may underestimate iodine deficiency. As was reported in 2003, the subnational data for some countries are weak. The use of subnational data has not specifically been evaluated, but subnational data are regarded as the best source for country estimates in

TABLE 4. Nationally representative survey data from the same year in both pregnant women and school-age children, available in the WHO VMNIS, categorized by a discrepancy or agreement on whether there is a public health problem when school-age children are used to represent the entire population, including pregnant women.

Survey agreement?	WHO region	Country	Year of survey	Pregnant women: Median UI	Pregnant women: Public health problem?	School-age children: Median UI	School-age children: Public health problem?
Agreement	Europe	Bulgaria	2003	165	No	198	No
	Americas	USA	2001	173	No	249	No
	Europe	Switzerland	2004	249	No	141	No
Discrepancy	Europe	Romania	2004–05	73	Yes	102	No
	Western Pacific	Philippines	2003	142	Yes	201	No
	South-East Asia	Nepal	1997–98	134	Yes	144	No

Source [15–20].

the absence of nationally representative data.

Another limitation may be that these estimates have not been updated for countries lacking new nationally representative data, even when the previous estimate was based on subnational data and more recent subnational data are available. However, it was deemed more important to move toward using data representative of the entire population.

Finally, another limitation may be that the data available are extracted from publications and reports that present data in inconsistent formats and with varying degrees of analysis. The models developed to standardize the data and derive one measure from another are potential sources of error. However, it is encouraging that the use of equations to derive one indicator of iodine nutrition from another was substantially lower in 2007, because data on UI were reported in the recommended way in most reports (88%). This is a significant improvement from 2003, when only 55% of data were reported in the recommended way.

It is also encouraging that between the 2003 and 2007 estimates, three countries that had no previous data and 14 countries for which the previous estimate was based on subnational data conducted nationally representative surveys. Approximately half of these were conducted in the past 3 years. Increased data collection indicates a growing awareness of the need to collect nationally representative data on iodine nutrition in countries without data, and also to collect data for monitoring in countries that have programs to address iodine deficiency. National data are critical for global assessments, but it is also important to ensure that there is adequate representation from the different geographic regions within a country. Iodine deficiency is often expressed geographically and may cluster in specific areas even when there is no problem at the national level. In addition, there are several countries that still have no data or have not conducted a survey recently.

Many countries have never assessed pregnant women. We found that the median UI was frequently lower in pregnant women than in school-age children. Furthermore, in three out of six surveys that assessed both population groups and were conducted in the past 10 years, the median UI in pregnant women indicated a public health problem, whereas the UI in school-age children indicated optimal iodine status. Because of the well-known effects of iodine deficiency on the developing fetus and the higher iodine requirements during pregnancy, countries should be encouraged to collect data from this population group [5].

Conclusions

The overall global status of iodine deficiency has improved since 2003, reflecting the fact that the current strategy of salt iodization is effective. From a surveillance viewpoint, more countries are collecting data and monitoring their progress, and there has been an increase in the collection of nationally representative data. Nevertheless, more surveys of pregnant women are required because they are the group most susceptible to the effects of iodine deficiency and their condition is not reflected in data collected solely in school-age children.

With regard to iodine status, there are fewer countries where iodine deficiency is considered to be a public health problem in 2007 than there were in 2003. However, 47 countries continue to have problems with iodine deficiency. Conversely, there are a substantial number of countries where the level of iodine intake is too high, which may expose susceptible groups to the risk of iodine-induced hyperthyroidism. In addition to monitoring iodine nutrition, effective surveillance systems should also include monitoring of iodized salt quality at all levels (industrial, retail, and household) to ensure that salt iodization programs are safe and effective in their control of iodine deficiency. Continued focus on these points should yield further improvements at the next assessment.

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