Dynamic monitoring of iodine sufficiency in Belarus: results and problems

© Tatiana V. Mokhort1, Natalia D. Kolomiets2, Sergei V. Petrenko3, Ekaterina V. Fedorenko4, Alena G. Mokhort1

1Belarusian State Medical University, Minsk, Republic Belarus; 2Belarusian Medical Academy of Postgraduate Education, Minsk, Republic Belarus; 3International Sakharov Environmental University, Minsk, Republic Belarus; 4Republican Centre for Hygiene, Epidemiology and Public Health, Minsk, Republic Belarus

The strategy for elimination of iodine deficiency in the population was developed and implemented in the Republic of Belarus. It is based on acceptance of recommendations that iodized salt is a unique source of iodine support. Currently, adequate iodine consumption is achieved. The prevalence of thyroid gland diseases caused by iodine deficiency was significantly decreased. In 2013, the International Council for Control of Iodine Deficiency Disorders (ICCIDD), a global non-profit non-governmental organization established to eliminate iodine deficiency and its negative consequences, published the results of iodine status assessment in the world. According to these data, the Republic of Belarus provides adequate iodine intake. In 2016, Iodine Global Network published maps characterizing iodine supply for the two main categories — school-age children and pregnant females. These data have confirmed that the Republic of Belarus refers to countries with sufficient iodine consumption according to the results of subnational studies. Despite the achieved successes, new issues are raised: quality of iodine sufficiency monitoring, risks of excessive salt intake, and need for new approaches to diagnosing thyroid pathology due to iodine deficiency.

Keywords: iodine deficiency disease (IDD), urine iodine excretion, thyroid, daily intake, iodine deficiency.

A unique strategy to eliminate iodine deficiency has been developed and implemented in the Republic of Belarus, which had been an iodine-deficient region, since 2000. This strategy is based on the use of iodized salt and iodine enrichment of other food items. The unique feature of the Belarusian national strategy for elimination of iodine deficiency is the fact that it is developed “in reverse”: the adequate iodine sufficiency has been achieved in the absence of a law on universal salt iodization, which made it possible to achieve an adequate level of dietary iodine intake.
The analysis of the indicators identified by the Iodine Global Network, which include such parameters as the median urine excretion of iodine in schoolchildren and pregnant women over 100 μg/l; the proportion of farms using adequately iodized salt; measures to change the approach to salt iodization; the proportion of iodized salt, to meet the national demands using local products or through imports; lack of differences in the price of iodized and non-iodized salt; the existence of a national law on the use of iodized salt; testing of samples of salt for the sufficient amount of iodine, etc., allowed the experts to recommend that the International Council for the Control of Iodine Deficiency Disorders (ICCIDD) classify Belarus as a country with iodine sufficiency in 2013 [1,2].

During the entire observation period, studies on a comprehensive assessment of the excretion of iodine in the urine have been carried out in selective limited groups of the population; the proportion of patients who consumed iodized salt, as well as the proportion of patients with an increase in the size of the thyroid gland were analyzed. All determinations of urinary excretion of iodine were carried out by spectrophotometric cerium-arsenite method, adopted by WHO as a standard international method, in a duly certified laboratory included in the external quality control system for CEE/CIS countries [3]. The availability of baseline WHO data (1999) [4,5] has been taken into account when selecting a study group. Since 2001, the results has been showing the absence of iodine deficiency, the median ioduria exceeded 100 μg/L in all studies. Dynamics of urinary iodine excretion values in Belarus from 2001 to 2016 (based on selective studies) are presented in Fig. 1. The results include data from both national studies and studies on small groups of children and pregnant women. In the last study dated back to 2016, the median ioduria of the most important risk group, pregnant women, was 149.1 μg/l [6.7].

The next group of criteria to assess the effectiveness of the program to combat iodine deficiency in food products includes an evaluation of indicators characterizing the production of iodized salt, the market share of iodized salt, the quality of iodized salt and the price of iodized and non-iodized salt. In the Republic of Belarus, salt is produced at salt plants in the towns of Mozyr and Soligorsk, which are capable of completely covering the country’s demand for salt. These plants produce high-quality iodized salt with no significant differences in the price of iodized and non-iodized salt. The share of sales of iodized salt in the Belarusian market has increased from 31.5% in 2001 to 74% in 2008 and remains at this level with insignificant fluctuations in various regions (81.5% in 2016).

Following the upgrade of the production facilities, the switch from using potassium iodide to potassium iodate and changing its concentration in salt from 25 ± 15 to 40 ± 15 mg/kg, the quality of iodized salt has been at the level required by the standards since 2005 (Fig. 2) The share of non-standard samples was 0 in 2013, 0.04% in 2014, and 0.05% in 2016 (Fig. 3). According to national regulations, the iodine content in salt should not be less than 0.04 mg/g [8.9]. The monitoring of the sales did not take into account the sales of sea salt with natural iodine content. Sea salt was not included in the analysis of sample quality.

The dynamics of incidence of some thyroid diseases, which are traditionally considered to be “iodine deficient diseases”, are of interest in terms of assessing the impact of adequate iodine intake with food (which is a feature of
the national strategy for the elimination of iodine deficiency) [5, 10]. The raw data presented for analysis of the dynamics of the situation in Belarus assume iodine deficiency of mild to moderate severity [11]).

One of the most reliably estimated indicators is the frequency of simple non-toxic goiter in the general population and in children under 18 years of age. The primary incidence of simple non-toxic goiter decreased from 325.0 per 100,000 population in 2000 to 59.9 per 100,000 population in 2016 (Fig. 4). Less significant results in terms of reducing primary incidence have been reported in children under 18 years of age: in this category, the incidence decreased to 194.54 per 100,000 (Fig. 5) [12—16].

The “hard” assessment criterion for the adequacy of iodine intake is the incidence of primary congenital hypothyroidism (PCH) diagnosed during screening. The PCH has been recommended as an accurate indicator of the neonatal and maternal status of iodine nutritional support [17,18]. It is recommended to achieve the earliest possible identification of all newborns with all forms of primary hypothyroidism (mild, moderate, severe) and early treatment in order to achieve an acceptable IQ. In Belarus, screening for the PCH has been conducted since 1991. Until 2010, it was not mandatory for endocrinolo-
gists to specify the results of the primary screening for thyroid dysfunctions, therefore, at the stage of implementing the national strategy, the results of primary screening are presented not by the proportion of hypothyroidism, but by the identification of thyroid dysfunctions. The corresponding data for the 1994—1998 period and after the implementation of the national strategy for the elimination of iodine deficiency indicate a decrease in the incidence of pathology by a factor of ten [14]. Following the stabilization of the situation with iodine sufficiency, which has been achieved in 2003, the decrease in the incidence of primary hypothyroidism continued. Currently, the screening steps are adapted to the 2014 consensus of the European Society of Pediatric Endocrinologists [19]. Overall, the dynamics of detection of thyroid dysfunctions indicate the achievement of values corresponding to the level of prevalence of pathology in the European region in the absence of iodine deficiency. In 2014, this incidence was 1:4216 newborns. The dynamics of the primary incidence of congenital hypothyroidism, based on the confirmation of the diagnosis at the second stage of screening (Fig. 6), indicates achievement of a stable result (in 2006, the primary incidence of PCH was 1.96 per 100,000, in 2016 it was 1.27 per 100,000 population).

In 2016, Iodine Global Network published maps characterizing iodine supply for the two main categories — school-age children and pregnant females. These data have confirmed that the Republic of Belarus refers to countries with sufficient iodine consumption according to the results of subnational studies (Fig. 7, 8) [20]. Despite the achieved successes, new issues have been raised. From the position of medical monitoring, these issues include quality of iodine sufficiency monitoring, risks of excessive salt intake, and the need for new approaches to diagnosing thyroid pathology due to iodine deficiency.

There were issues due to a lack of understanding of the absolute need to achieve adequate iodine intake with food at the stage of implementation of the national strategy. People referred to “human rights” to choose the type of salt to be used as well as to the impossibility of using iodized salt in home canning. With time the awareness campaign (leaflets, banners, social advertising on television, etc.), ensured that the overwhelming majority of the population decided in favor of using iodized salt. The non-iodized salt and sea salt, whose iodine content does not meet the standards, is available in Belarus which provides the population with alternative choices.

The results of the assessment of iodine intake with the main food groups, shown in Table 2, indicate that the

### Table 1. Dynamics of the frequency of detection of congenital thyroid dysfunctions (TD) based on the screening results (before eliminating iodine deficiency in the period of 11994—1998 and after achieving adequate iodine intake in 2004—2008)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of subjects</td>
<td>The number of transient disorders</td>
</tr>
<tr>
<td>Minsk</td>
<td>55535</td>
<td>363</td>
</tr>
<tr>
<td>Minsk Region</td>
<td>48912</td>
<td>1264</td>
</tr>
<tr>
<td>Brest Region</td>
<td>58863</td>
<td>2104</td>
</tr>
<tr>
<td>Grodno Region</td>
<td>39271</td>
<td>408</td>
</tr>
<tr>
<td>Vitebsk Region</td>
<td>41311</td>
<td>2310</td>
</tr>
<tr>
<td>Mogilev Region</td>
<td>41101</td>
<td>1627</td>
</tr>
<tr>
<td>Gomel Region</td>
<td>53602</td>
<td>1163</td>
</tr>
</tbody>
</table>

**Fig. 5.** Diffuse goiter: primary incidence in children (per 100 thousand population).
“average” diet provides 222 μg of iodine per day. Based on calculations of the intake of iodized salt and food, it was concluded that the dietary intake of 10% of food products that were enriched with iodine in industrial conditions, even without taking into account the use of iodized salt for finishing salting, met the physiological requirement (150 μg per day) for the specified trace element in adults.

At the same time, there were concerns about the dangers of excess iodine intake and its potentially negative impact on health. It is known that the maximum allowed levels of iodine intake differ in different countries and amount to 600–1100 μg per day. We calculated the iodine intake in the diet of adults with different levels of food intake (Table 3). According to the obtained results, the model that allows for 100% use of products made using iodized salt provides 683.1 μg iodine per day, if the maximum percentile of intake is chosen. These data indicate the safety of the chosen strategy and had led to a weakening of the negative attitude towards the use of iodized salt in the industrial production of food.

Quality of iodine intake monitoring studies

Despite the adequate methodology (excretion of iodine with urine, ultrasound imaging with determination of the size of the thyroid gland, assessment of the use of iodized salt), the changes in dietary patterns over the past ten years and the use of selected cohorts sufficient to assess iodine availability substantiates the need for a nationwide study.

Fig. 6. Dynamics of primary incidence of PCH according to the screening results.

Fig. 7. IGN data for 2016: Median urine excretion of iodine in schoolchildren [20].
Risks of excess salt intake
A high level of salt intake is associated with an increased risk of cardiovascular disease; therefore WHO Resolution 66.10 provides for reducing salt intake to less than 5 g per day by 2025 to reduce the incidence of hypertension by 25%. The Republic of Belarus is one of the countries with high salt intake, therefore the campaign aimed at reducing the use of salt and processed food, which are the main sources of salt in the diet, is gaining momentum in the country. The potential implementation of measures developed by the Global Iodine Network, which imply an increase in the iodine content in salt, requires the analysis of the amount of salt intake by different population groups and the development of a differentiated approach to various age groups and risk groups for developing iodine deficiency disorders.

Diagnosis of thyroid pathology due to iodine deficiency
There are difficulties with the verification of the diagnosis of “simple non-toxic goiter” and “endemic goiter”. To date, the question remains of how to deal with patients

Table 2. The results of the assessment of the iodine consumption with basic food groups

<table>
<thead>
<tr>
<th>Food group</th>
<th>Daily intake, g/day</th>
<th>Iodine content, μg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bakery</td>
<td>162,7</td>
<td>64</td>
</tr>
<tr>
<td>Sausages</td>
<td>50,0</td>
<td>64,1</td>
</tr>
<tr>
<td>Dairy</td>
<td>280,0</td>
<td>54,1</td>
</tr>
<tr>
<td>Vegetables</td>
<td>430,5</td>
<td>17,2</td>
</tr>
<tr>
<td>Cereals and pasta</td>
<td>162,7</td>
<td>10,2</td>
</tr>
<tr>
<td>All types of meat</td>
<td>112,9</td>
<td>7,5</td>
</tr>
<tr>
<td>Potatoes</td>
<td>98,3</td>
<td>4,9</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>222,0</td>
</tr>
</tbody>
</table>

Table 3. The level of iodine in the diet of adults with different levels of food intake according to the assessment of various dietary models

<table>
<thead>
<tr>
<th>Level of intake</th>
<th>Iodine intake with food, μg/day without enrichment</th>
<th>Iodine intake with the rate of enriched:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average (median intake)</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>92,0</td>
<td>161,7</td>
</tr>
<tr>
<td>High (90 percentile of intake)</td>
<td>234,2</td>
<td>470,6</td>
</tr>
</tbody>
</table>

Fig. 8. IGN data for 2016: Median urine excretion of iodine in pregnant women [20].
who have been diagnosed earlier, during the period of iodo
dine deficiency? This question should be answered by a
doctor.

Errors are often made in the assessment of the func
tional state of the thyroid gland due to the inaccuracies of
many laboratories and the establishment of a diagnosis
based on only one indicator, the level of thyroid stimulat
ing hormone (TSH). This leads to a significant increase
in the number of patients with manifested and subclinical
hypothyroidisms, which are classified as Hypothyroidism
in the endocrinological service report. The use of diag
nostic kits of various degrees of accuracy in various health
care institutions also contributes to the increase in the
incidence of hypothyroidism (the third-generation kits,
which ensure high accuracy of the result, are used very
rarely).

It is impossible to explain the primary diagnosis of
congenital hypothyroidism in adults with adequate men
tal and physical development who were not treated until
adulthood. An analysis of several cases suggests that iodo
nine deficiency is considered to be the cause of hypothy
roidism in patients with elevated levels of TSH merely
due to the absence of proper medical history.

Sonographic studies

It is known that using palpation to determine the size
of the thyroid gland often overstates the result. The mea
surement error may exceed 40%. The results of palpation
studies are influenced by the structural features of the
neck, the thickness of the muscles and the subcutaneous
fat layer, the possible total or partial retrosternal location
of the thyroid gland, the comparison of the sizes of the
palpable thyroid gland with the phalanx of the finger and,
finally, the age of the patients.

An indication for an ultrasound is the presence of fo
cal lesions in the thyroid gland, i.e. differential diagnosis of
nodular and diffuse goiter, as well as epidemiological studi
es [21-23]. However, the use of ultrasound does not solve
all the problems. It is believed that the average volume of
the thyroid gland does not differ among representatives of
different ethnic groups in case of adequate nutrition and
iodine intake. Ultrasound allows more accurate assess
ment of the size of the thyroid gland and calculation of its
volume, but, unfortunately, it uses different standards. Ac
cording to international standards, goiter in adults is diag
osed with a gland volume of more than 18 ml in women
and more than 25 ml in men. In children, this indicator
varies more significantly. It has been demonstrated that the
size of the thyroid gland depends on age (both in children
and adults), height, weight, and body surface. It is difficult
to accept that the size of the thyroid gland in assessing de
viations from the standard indicator should be the same for
patients of the same age and height with a BMI of 17 and
45 kg/m². The rise in the prevalence of obesity contributes
to changes in the size of the thyroid gland. Therefore, the
ultrasound protocol should indicate the height and weight
of the patient.

Existing regional standards have been developed in
times of iodine deficiency and need to be revised to
achieve adequate iodine availability. Studies conducted
in countries where adequate intake of iodine with food
has been achieved demonstrate that WHO’s thyroid size
guidelines are not consistent with the median urinary ex
cretion of iodine. Regional standards show smaller vol
umes of thyroid in children.

Thyroid nodules

Another problem with ultrasound of the thyroid
gland is related to the diagnosis of nodular goiter. Capa
bilities of modern sonographic methods allow detecting
minimal changes in the structure of the thyroid gland.
Performing an ultrasound scan not within the framework
of an epidemiological study, but for dynamic control or at
the request of the patient (due to oncologic vigilance)
does not reduce the detectability of micro-nodules, in
cluding microcysts. According to the latest update of the
recommendations of the American Association of Clini
cal Endocrinologists, the American College for the diag
nosis and treatment of thyroid nodes [24], the situation
will develop “onward and upward”. These recommenda
tions noted that the risk of developing cancer is some
what higher in nodes of >4 cm, but the size of the node
does not indicate its benignity or malignancy and at pres
time approximately 50% of thyroid tumors are micro
odes <10 mm in diameter [25,26].

Autoimmune thyroiditis

The incidence of autoimmune thyroiditis (AIT) ex
ceeds all imaginable limits. Despite strict diagnostic cri
tera: primary hypothyroidism (manifested or persistent
subclinical), the presence of antibodies to thyroid tissue
and ultrasound signs of autoimmune pathology, the AIT
is often overdiagnosed. It can be attributed to the lack of
understanding of the presence of athyreoid antibodies
and thresholds to diagnose the increase in their level. Any
abnormalities in the structure of the thyroid gland de
tected by ultrasound, are often considered by doctors as
AIT “without dysfunction”. Another problem is misdi
agnosis of Graves disease as the AIT: there are patients in
whom the differential diagnosis is only performed when

Finally, the conclusion of a specialist in sonographic
diagnostics should not contain a diagnosis, since the di
agnosis of any pathology, including thyroid pathology, is
the result of an analysis of the totality of the data of med
ical history, checkup and physical examination. If the
doctor conducting the ultrasound scan is ready to estab
lish a diagnosis and make recommendations for treat
ment, he must fully examine the patient, collect medical
history and reflect this in the medical records.

The period of implementation of the national strate
gy for the elimination of iodine deficiency coincided with
the widespread introduction of ultrasound and the test
ing of hormones and antithyroid antibodies levels into
clinical practice, which made it impossible to compare the results of the incidence assessment.

Conclusion

Even though the Republic of Belarus can be considered as a state with adequate iodine availability, it can be stated that there is a need to:
— conduct an epidemiological study to assess the size of the thyroid gland in Belarus after the elimination of iodine deficiency;
— standardize ultrasound protocols (to determine the size of the thyroid gland and its structural changes) in all medical institutions of the Republic of Belarus;
— include clear criteria for the verification of subclinical hypothyroidism andAIT in national protocols for the diagnosis and treatment of diseases of the endocrine system.

One can discuss the negative contribution of selenium deficiency in the formation of pathology of the thyroid gland; the insufficiency of this element in the Republic of Belarus is beyond doubt [27,28].

Supplementary information

Conflict of interests. The authors declare the absence of obvious and potential conflicts of interest related to the publication of this article, which require declaration.

Contribution of authors: Mokhort T.V. — analysis and processing of the data obtained, leading the preparation of the manuscript, editing the text of the manuscript at all stages; Kolomie S.D. — analysis of food rations, analysis of the data obtained; Petrenko S.V. — determination and assessment of the level of iodine excretion with urine in the examined groups; Fedorenko E.V. — calculation and assessment of iodine content in food rations; Mokhort E.G. — collection of research materials, processing of the data, writing the manuscript.


