ENDOCRINOLOGY RESEARCH AND PRACTICE

SOCIETY OF ENDOCRINOLOGY AND METABOLISM OF TURKEY

Current Iodine Status in Europe and Türkiye in the Light of the World Health Organization European Region 2024 Report: Are We Losing Our Achievements?

REVIEW
Endocrinol Res Pract. 2025.
[epub ahead of print]

ABSTRACT

Iodine is a vital micronutrient and an essential component of the thyroid hormones. Iodine deficiency (ID) causes a wide range of conditions called iodine deficiency disorders (IDDs), consisting of diverse presentations in different age groups. Adequate iodine nutrition is especially important for women during pregnancy and lactation since iodine has a crucial role in the neurodevelopment of the fetus. Iodine deficiency has been cited as the leading preventable cause of mental impairment worldwide. The impacts of ID have imposed enormous, preventable resource costs on healthcare systems globally, which has made it one of the most serious public health problems across the world in the past decades. Several public health programs have been established to combat IDD. Universal salt iodization has been the mainstay of those programs, resulting in a striking decrease in severe ID globally. Nevertheless, mild ID, especially in pregnancy and early life, remains a public health concern in many parts of the world including European countries and Türkiye. Progress toward optimal iodine nutrition worldwide requires sustained efforts, continuous reinforcement, monitoring, and dedication, especially from policymakers and public health workers. In the absence of these measures, the achievements made over a century could be lost in a short period of time.

Keywords: Iodine deficiency, thyroid disorders, urinary iodine concentration, goitre, cretinism

Introduction

Iodine is an essential element for thyroid hormone synthesis, and adequate iodine nutrition is important throughout the human life cycle, especially during pregnancy and early childhood to support brain development. Iodine deficiency (ID) has been a considerable public health problem worldwide. Public health programs, in particular iodine fortification and monitoring strategies, have improved the iodine status and reduced the prevalence of iodine deficiency disorders (IDDs), resulting in both health and economic benefits. Unfortunately, the problem of ID has re-emerged in recent years. This review summarizes iodine metabolism, disorders caused by ID, methods for the population's iodine status assessment, and the present global iodine status with a special emphasis on the current situation in Europe and Türkiye.

Metabolism of Iodine

Daily iodine requirements are mainly met through diet. Almost all dietary iodine (>90%) is rapidly absorbed from the intestine and kept in the thyroid gland by an active uptake through the sodium/iodide symporter. The human body contains nearly 15-20 mg of iodine and stores 70%-80% of it in the thyroid gland.[1] Almost 60% of thyroid hormones consist of iodine. When dietary iodine is adequate, the thyroid gland retains approximately 60 µg of iodine daily.[1] When dietary iodine intake is not adequate, the total amount of iodine in the thyroid gland decreases to 10 µg and the rate of iodine uptake by the thyroid gland increases from 10% to 80%.[1,2] In case of high iodine requirement, the thyroid gland utilizes iodine by repeatedly reabsorbing it from the enterohepatic circulation. Nevertheless, nearly 90% of the excess unused iodine is excreted in the urine 24-48 hours after ingestion.[3] Thus, urinary iodine concentration (UIC) is a reliable marker of short-term iodine intake.

Iodine Deficiency Disorders

Iodine plays a critical role in organ and tissue function through the regulation of overall metabolism via thyroid hormones. It is also crucial for fetal and childhood neurodevelopment.

Sinem Başak Tan Öksüz

Murat Faik Erdoğan

Division of Endocrinology and Metabolism, Department of Internal Medicine Faculty of Medicine, Ankara University, Ankara, Turkiye

Corresponding author:
Sinem Başak Tan Öksüz
sinembasaktan@gmail.com

Received: November 26, 2024
Revision Requested: December 13, 2024
Last Revision Received: December 16, 2024
Accepted: December 18, 2024
Publication Date: February 6, 2025

Cite this article as: Tan Öksüz SB, Erdoğan MF. Current iodine status in Europe and Türkiye in the light of the World Health Organization European region 2024 report: are we losing our achievements?. *Endocrinol Res Pract.* Published online February 6, 2025. doi 10.5152/erp.2025.24594

DOI: 10.5152/erp.2025.24594

Therefore, there is particular importance of adequate dietary intake of iodine during pregnancy and lactation, as well as in the early childhood period. The recommendations of the World Health Organization (WHO) for the daily intake of iodine for each age group are summarized in Table 1.[4]

Recent WHO European Region data obtained from dietary assessments in 14 countries showed that 11 countries had women with iodine intake of less than 150 μg/day. Nevertheless, the number of countries in which iodine intake was below 150 μg/day in men was 6. The findings indicate that women are more susceptible to low iodine intake than men on average. Additionally, within a given country, there may be instances where women have inadequate iodine intake, while men have sufficient levels.[4]

Iodine deficiency causes a wide spectrum of diseases called iodine deficiency disorders (IDDs), consisting of different presentations in every age group, as outlined in Table 2.[1] In adults, ID is associated with goiter, thyroid nodules, and abnormal thyroid function. In areas with severe iodine deficiency, ID is the primary cause of hypothyroidism. During the fetal and neonatal period, it is associated with not only goiter and hypothyroidism but also serious neurodevelopmental impairment. WHO refers to ID as "the single most important, preventable cause of brain damage" worldwide.

Iodine Deficiency in Pregnancy

Pregnant and lactating women and their newborns are more susceptible to complications of inadequate iodine status. Because of increased thyroxine synthesis, iodine transfer to the fetus, and elevated renal clearance, iodine demand rises during pregnancy and lactation.[3] World Health Organization and the Turkish Society of Endocrinology and Metabolism recommend that pregnant and lactating women should receive 250 μg/day of iodine to meet their increased needs.[4,5] Since it is difficult to obtain that amount of iodine through diet alone, iodine supplements (150 μg/day) should be given before or in the early stages of pregnancy. Moreover, iodized salt consumption should continue throughout the pregnancy and lactation period.

Thyroid hormones regulate normal growth and development during fetal life through specific effects on gene expression and cell differentiation pathways. The thyroid gland of the fetus begins to trap iodine and synthesize thyroid hormones after 12 weeks of gestation; thus, the thyroid hormone supply of the fetus during this critical 12-week period is entirely dependent on the mother.[6] However, if iodine intake is inadequate throughout gestation, the mother's production of thyroid hormones will be impaired. An undersupply of thyroid hormones to the developing brain can damage neuronal migration and myelination, causing permanent fetal brain injury.[7] Cretinism is a condition consisting of serious mental retardation along with spasticity, deaf-mutism, and poor growth caused by severe ID *in utero*. Other adverse obstetric outcomes related to severe ID are miscarriage, stillbirth, preterm birth, and neonatal death.[1,3] However, the impact of mild-to-moderate ID throughout the gestation period is uncertain because mild-to-moderate ID can be compensated by thyroid stimulation, depletion of thyroid iodine stores, and hyperplasia of the thyroid gland.

Earlier studies clearly demonstrated that iodine supplementation during pregnancy and in the infancy period in areas of severe ID decreased both mortality and cretinism. A randomized, placebo-controlled trial, which investigated 617 infants in Indonesia, showed that oral iodized oil supplementation reduced mortality by 72% in the first 2 months of life.[8] A landmark trial conducted in Papua New Guinea, a population with a high prevalence of endemic cretinism, demonstrated that iodine supplementation dramatically and even completely reduced the incidence of this condition.[9,10] The Zaire trial, another important study, was conducted in the Ubangi region, a severely iodine-deficient area where the prevalence of cretinism is 4%. While the control group received an injection of vitamins, the intervention group received an injection of iodized oil at the first prenatal clinic visit. At 72 months of age, the mean psychomotor development scores of infants whose mothers received iodized oil were remarkably higher than those of the control group (0.91 vs. 0.82, respectively).[10]

Although evidence from observational studies indicates that iodine status may affect both maternal and infant outcomes in the setting of mild-to-moderate ID, results from intervention trials are inconclusive regarding the benefits of iodine supplementation in this group. In a recent meta-analysis, researchers found that ID in pregnancy may result in both lower birth weight and birth weight centiles standardized for gestational age.[11] However, in 2 separate comprehensive analyses investigating the effects of maternal iodine supplementation on growth and development parameters, no statistically significant differences were found between the iodine-supplemented and non-supplemented groups.[12,13] Regarding the neurodevelopmental effects of ID, although a positive association between maternal iodine status and verbal IQ was observed, evidence to endorse iodine supplementation for pregnant women in mild-to-moderately iodine-deficient areas was insufficient.[13-15] Because the intervention trials differ in study design, primary outcome, location, and degree of ID of the participants, the lack of benefit reported by the meta-analyses may be attributed to their heterogeneity. Additional well-controlled, randomized trials that provide evidence on the timing, dosing, and regimen of the supplementation are required for further clarification.

Table 1. Daily Iodine Intake Recommendations of the World Health Organization for Different Age Groups[4]

Age	Iodine Intake (μg/day)
0-5 years	90
6-12 years	120
>12 years	150
Pregnancy	250
Lactation	250

MAIN POINTS

- Iodine deficiency disorders (IDD) comprise a wide range of manifestations in different age groups.
- Urinary iodine concentration estimated from spot urine samples is a sensitive, cost-effective, and widely used marker to assess the iodine status of a population.
- Although there have been extensive efforts to eliminate IDD in Europe and Türkiye, it appears to remain a public health concern, especially among pregnant women and neonates.

Table 2. Iodine Deficiency Disorders Throughout the Life Span[1]

Age group	Effects of Iodine Deficiency
Fetuses	Spontaneous abortions, stillbirths
	Perinatal mortality
	Congenital anomalies
	Cretinism
	Neurodevelopmental impairment
Neonates	Neonatal goiter
	Neonatal hypothyroidism
	Cretinism
	Neurodevelopmental retardation
	Increased susceptibility of the thyroid gland to the effects of nuclear radiation
Children and adolescents	Goiter
	Hypothyroidism
	Growth retardation
	Impaired mental function
	Increased susceptibility of the thyroid gland to the effects of nuclear radiation
Adults	Goiter
	Hypothyroidism
	Hyperthyroidism (spontaneous or induced by iodine)
	Impaired mental function
	Infertility
	Increased susceptibility of the thyroid gland to the effects of nuclear radiation

Assessment of Iodine Status

There are 4 main measurement tools to assess the iodine nutrition at the community level: goiter rate, serum thyroglobulin (Tg), neonatal serum thyroid-stimulating hormone (TSH), and UICs.[3]

Traditionally, iodine status has been evaluated by goiter rate. According to WHO recommendations, salt iodization programs are expected to reduce the goiter prevalence, as measured by ultrasound (US), to under 5% in school-age children (SAC), thereby eliminating ID.[4] World Health Organization classifies the degree of ID by goiter rate according to the following criteria: <0—4.9%, iodine sufficiency; 5.0—19.9%, mild deficiency; 20.0—29.9%, moderate deficiency; and >30%, severe deficiency.[4] After salt iodization programs began and adequate iodine intake was maintained, the goiter prevalence started to decline. Nevertheless, normalization of thyroid volume could take months or even years after iodine intake becomes adequate, which limits the use of the goiter rate in monitoring studies.[16,17] Thus, results of thyroid volume assessment by palpation or US have become more challenging to evaluate since they reflect both a population's iodine nutrition in the past and its current status.

Intervention studies have proved that Tg measurement is a sensitive and supplementary biomarker of iodine status. It is reported to correlate well with the severity of ID and fall rapidly after iodine repletion.[18] However, there are several limitations to its use. First, it is a non-specific test because any type of thyroid stimulation or injury increases serum Tg concentration. Second, anti-Tg positivity can cause an underestimation of serum Tg concentration, which is not rare on a community basis. Lastly, there is a large variability and poor reproducibility among assays, making it difficult to establish cut-offs and thus define the degree of ID.[19]

Neonatal TSH reflects iodine status when neurodevelopment is particularly dependent on iodine intake. The frequency of TSH concentration values above 5 mIU/L is found to be higher (>3%) in iodine-deficient areas. Additionally, the frequency of TSH correlates with the severity of ID.[20] Transient neonatal hypothyroidism is also more common in the setting of ID than iodine sufficiency.[20] The outcomes of neonatal heel-stick blood TSH screening are regarded as appropriate indicators for iodine status, provided the standardized sample-timing.[4] World Health Organization defines the severity of ID in populations using the following criteria: if the percentage of newborns with a TSH of >5 mIU/L whole blood is <3%, the population is iodine sufficient; if 3—19.9% is mildly deficient; if 20—39.9% is moderately deficient; and if >40% is severely deficient.[4]

Urinary iodine concentration is a sensitive marker of current iodine status and can give information about recent changes in iodine intake because 90% of ingested iodine is excreted in the urine.[3] Since it is not feasible to obtain 24-hour samples in large-scale field studies, UIC is estimated from spot urine samples taken from a representative proportion of the target population. Currently, the most strongly recommended marker for the population's iodine status is UIC since it is a non-invasive test that can easily be performed at a relatively low cost.[4] Table 3 shows the recommended median UIC values for the definition of iodine level adequacy for SAC, pregnant, and lactating women.[4] It is important to note that spot urine samples are not an appropriate method for assessing an individual's iodine status. These samples demonstrate significant variability from day to day or within an individual, which is dependent on the daily iodine intake from food sources at varying levels.

Three target groups for the assessment of iodine status are SAC, pregnant women, and neonates because of their higher vulnerability to ID.[3] The most commonly included group in surveillance studies is SAC because of their easy accessibility. A large number of children can be reached through school-based surveys and can be examined for thyroid size, UIC, and serum Tg. Sentinel sampling of UIC

Table 3. Criteria for Assessing Iodine Status Based on Median Urinary Iodine Concentration Among School-Age Children and Pregnant or Lactating Women[4]

Median UIC (μg/L)	Iodine Status
School-age children	
• <20	Severe iodine deficiency
• 20-49	Moderate iodine deficiency
• 50-99	Mild iodine deficiency
• 100-199	Optimal
• 200-299	More than adequate
• ≥300	Iodine excess
Pregnant women	
• <150	Iodine deficient
• 150-249	Iodine sufficient
• 250-499	More than adequate
• ≥500	Iodine excess
Breastfeeding women	
• <100	Iodine deficient
• ≥100	Iodine sufficient

of pregnant women during prenatal clinic visits may provide a reasonable reflection of their iodine status, which has particular importance for fetal brain development. Neonatal screening programs for congenital hypothyroidism are well-organized in many countries. Regular collection of heel-stick blood samples provides a reliable source of information for IDD surveillance, given the use of TSH as a sensitive biomarker.[3]

Current Iodine Status in Europe

In 1990, it was estimated that nearly 30% of the world's population was iodine deficient, 11.2 million people suffered from overt cretinism, and another 43 million people had some degree of mental retardation.[3] Given its widespread effects, IDD was considered a global public health issue, and eliminating IDD has become an important goal in international health programs over the last decades. In order to combat IDD, global efforts have been made through the introduction of nutrition policies and public health programs such as salt iodization and iodine supplementation. With the help of these tremendous efforts, it is now estimated that almost 90% of the world's population consumes iodized salt, a remarkable increase from 20% in 1990. Indeed, the number of countries with adequate iodine status has increased from 67 in 2003 to 136 in 2023, including 13 countries experiencing excessive iodine intake.[21] Although current data indicate that ID has declined to a great extent, it continues to affect populations worldwide. Not surprisingly, most affected populations are in remote areas with limited resources.

Global iodine status is monitored by the Iodine Global Network (IGN) through the Global Iodine Scorecard, which integrates information from 194 WHO Member States plus Liechtenstein and Palestine (grouped into the 6 WHO regions). According to the 2023 Scorecard, 21 countries did not have any published data on iodine status, and 26 countries were classified as iodine deficient on a global scale.[21] Nevertheless, the reliability of this data is open to question since most of the surveys included in the 2023 Scorecard were more than 10 years old. Additionally, some of the surveillance programs were conducted at the national level, while others were at the subnational level. Furthermore, the surveyed population was heterogeneous, as some studies included only adults, while others included women of reproductive age or SAC. Figure 1 shows the 2023 map depicting iodine status from the Scorecard in Western and Central Europe.[21]

A recent comprehensive report published by the WHO on iodine status in the European Region revealed that the number of Member States with inadequate iodine intake in SAC decreased from 23 in 2003 to 2 in 2023.[4] The report included surveys conducted after 2008. The improvement in iodine status was mostly attributed to salt iodization and iodine provided by milk and dairy products. Moreover, no country in the region was affected by moderate ID or excessive iodine status.[4] Nevertheless, developed European countries such as Norway, Finland, and Germany are still suffering to some extent from ID. Table 4 summarises the recent iodine status of the European Region according to the IGN 2023 Scorecard and the WHO 2024 report.

Switzerland was the first country in Europe to implement a universal salt iodization program for the prevention of goiter in 1922. As a result of the national iodization program, it was shown that there were no newborns with cretinism after 1930, deaf-mutism rates declined dramatically, and goiter was eliminated in children and adolescents.[22] While over a century has passed since the initial salt iodization program, ID is a persisting problem in Europe. As the soil of the continent is naturally low in iodine, it is difficult for the population to get enough iodine solely from dietary resources.[3] Moreover, salt-reduction campaigns for cardioprotective purposes and changing dietary habits toward predominantly plant-based nutrition potentially reduce the adequate dietary intake of iodine. Thus, iodine fortification programs to eliminate IDD are particularly important in this region. Even though there are some regulations for salt iodization, reinforcement and effectiveness vary, and up-to-date information on iodized salt coverage is lacking.[23] In addition, there is considerable heterogeneity among countries in terms of IDD prevention and surveillance programs. The iodization of salt is mandatory in 30 and voluntary in 13 of the 53 Member States of the WHO European Region and Kosovo. Additionally, 5 countries have no regulations in place, and the regulations of 6 countries are unknown.[4] Data on household use of iodized salt after the year 2008 are available for 20 Member States of the WHO European Region, and Kosovo. It suggests that more than 90% coverage of households with iodized salt was reached in 11 out of 13 countries with mandatory programs.[4] Nevertheless, the use of iodized salt may be declining in countries with voluntary regulations, and ID in vulnerable groups is a concern in 21 countries in Europe where the general population is iodine—sufficient.[23]

World Health Organization underlines that an effective European surveillance program is of vital importance for the elimination of IDD, with substantial benefits for the citizens of Europe and the sustainability of healthcare systems. On April 18, 2018, the EUthyroid consortium, representing 22 Member States of the European Union and 5 additional countries (Iceland, Israel, Macedonia, Norway, and Switzerland), released the Krakow Declaration on Iodine, which defines measures and responsibilities to optimize IDD programs. The declaration was in response to increasing concerns about the fact that a remarkable proportion of the European population is at risk of IDD, calling on policymakers to address IDD as a public health problem and prioritize the elimination of ID. It emphasized the importance of harmonized monitoring and evaluation of health programs at regular intervals in European countries to ensure optimal iodine supply for the population.[24] Unfortunately, progress on relevant policies is still slow in countries where neither official IDD prevention programs nor regular monitoring of iodine status is in place. In addition to that, recent data about the iodine status of the general population is lacking, and knowledge is inadequate, particularly among vulnerable individuals.

Current Iodine Status in Türkiye

Türkiye was among the moderately to severely iodine-deficient countries before the mandatory salt iodization program, which started in 1998. An initial epidemiological report by Atay and Onat stated that goiter was endemic in 3 provinces of Türkiye in 1948.[25] Koloğlu[26] from Ankara University conducted studies on endemic goiter in the Black Sea region in the 1960s and found that iodine content in water and food was low. Urgancıoğlu and Hatemi from Istanbul University initiated a large-scale study covering Türkiye that lasted for 8 years, starting in 1980. They collected water samples throughout the country and subsequently investigated the prevalence of endemic goiter in 73 750 individuals. In this study, the goiter rate was found to be 30.5% nationwide, highest in the Black Sea region, and lowest in the Marmara region.[25]

Table 4. Iodine Global Network 2023 Scorecard of the World Health Organization European Region and Kosovo[4,21]

Country	UIC (µg/L)	Year	Surveillance Program	Surveillance Population	Iodine Status
Armenia[a]	242	2016	N	SAC	Adequate
Georgia[a]	298	2017	N	SAC	Adequate
Albania[a]	136	2021	N	SAC	Adequate
Kyrgyzstan[a]	175	2021	N	Adolescents	Adequate
Azerbaijan[a]	135	2009	N	SAC	Adequate
Uzbekistan[a]	141	2017	N	WRA	Adequate
Kazakhstan[a]	183	2011	SN	WRA	Adequate
Tajikistan[a]	75	2016	N	WRA	Adequate
Turkmenistan[a]	188	2006	N	SAC	Adequate
Bosnia and Herzegovina[a]	157	2005	N	SAC	Adequate
Lithuania[a]	75	1995	N	SAC	ID
Belarus[a]	191	2018	N	SAC	Adequate
Latvia[b]	110	2010-2011	N	SAC	Adequate
North Macedonia[a]	236	2016	N	SAC	Adequate
Poland[a]	112	2009-2011	SN	SAC	Adequate
İsrael[c]	83	2016	N	SAC	ID
Serbia[a]	195	2007	N	SAC	Adequate
Türkiye[a]	107	2007	N	SAC	Adequate
United Kingdom[c]	166	2015-2016	N	SAC	Adequate
Ireland[c]	111	2014-2015	N	Adolescents	Adequate
Luxembourg[d]	148	2002	N	Adolescents	Adequate
Iceland[c]	200	2007-2008	SN	Adolescents	Adequate
Finland[b]	96	2017	N	Adults (≥18 years)	ID
Hungary[a]	228	2005	N	SAC	Adequate
Greece[c]	132	2017-2018	SN	Adults	Adequate
Montenegro[a]	174	2007	N	SAC	Adequate
Republic of Moldova[a]	136	2016	N	Adults (≥18 years)	Adequate
Slovenia[a]	140	2003-2005	N	Adults (≥18 years)	Adequate
Slovakia[a]	183	2002	N	SAC	Adequate
Ukraine[b]	75	2019	N	Adults (≥18 years)	ID
Belgium[b]	113	2010-2011	N	SAC	Adequate
Norway[b]	75	2017-2018	SN	WRA	ID
Denmark[a]	145	2015	SN	SAC	Adequate
Cyprus[d]	140	2004	SN	SAC	Adequate
Germany[b]	89	2014-2017	N	Adolescents	ID
Austria[a]	111	2012	N	SAC	Adequate
France[b]	136	2006-2007	N	Adults (≥18 years)	Adequate
Italy[a]	118	2015-2019	N	SAC	Adequate
Netherlands[b]	130	2006	N	Adults (≥18 years)	Adequate
Romania[a]	255	2015-2016	N	SAC	Adequate
Croatia[a]	248	2009	N	SAC	Adequate
Estonia[d]	65	1995	N	SAC	ID
Bulgaria[a]	180	2010	N	SAC	Adequate
Sweden[b]	125	2006-2007	N	SAC	Adequate
Spain[b]	173	2011-2012	N	SAC	Adequate
Czech Republic[b]	163	2010	N	SAC	Adequate
Switzerland[b]	137	2015	N	SAC	Adequate
Portugal[a]	106	2010	N	SAC	Adequate
Russian Federation[a]	<100	2008-2020	SN	SAC	ID
Andorra[d]	–	–	–	–	–
Malta[d]	–	–	–	–	–
Monaco[d]	–	–	–	–	–
San Marino[d]	–	–	–	–	Kosovo[a]
–	–	–	–	–	

ID, iodine deficiency; N, national; SAC, school-age children; SN, subnational; UIC, urinary iodine concentration; WRA, women of reproductive age.
[a]Mandatory salt iodization programs.
[b]Voluntary salt iodization programs.
[c]No national policy.
[d]Unknown national policy.

Before the introduction of the national ID control program in Türkiye, Erdoğan et al. and the Ministry of Health conducted a national survey between 1997 and 1999. Ultrasonographic thyroid volumes and UIC of 5948 SAC from 20 cities were evaluated. National goiter prevalence was found to be 31.8% (ranging from 5% to 56%), and the national median UIC was found to be 36 μg/L. None of the cities had sufficient iodine status; 6 were mildly and 14 were severely to moderately iodine deficient.[27] The survey revealed that endemic goiter was a significant public health concern and that iodine nutrition was insufficient nationwide. Subsequently, a mandatory salt iodization program was introduced in July 1998 through the addition of 50-70 mg/kg KI or 25-40 mg/kg KIO_3 to table salt. The program actively initiated in the year 2000. In 2002, a follow-up survey was conducted in 30 cities, including 20 cities from the first survey, to determine iodine status 2-4 years after salt iodization, and the nationwide median UIC was found to be 53 μg/L.[28] Although there was gradual progress, the result was not enough for the elimination of ID. Another monitoring survey in 2007 revealed that median nationwide UIC was 130 μg/L, and ID had been eliminated in 20 of those 30 cities.[29] An obvious improvement in the iodine status of the country was demonstrated; however, all these surveys were conducted in the city centers, and the results were limited to reflect the situation solely in urban areas.

In order to reflect the overall iodine status of the population, a further field study was conducted, including both urban and rural areas in 2007.[29] Nine hundred SAC, recruited by probability-proportional-to-size sampling, from 7 different regions in Türkiye were surveyed by UIC and household salt content, obtained from different households nationwide. Moderate-to-severe ID was 27.8%, which indicates a decline compared to 2 previous surveys (i.e., 58% in 1997 and 38.9% in 2002). Out of 900 household salt samples examined, 72.5% were iodized, and 56.5% contained adequate levels of iodine (>15 mg iodine/kg salt). Considering the WHO criteria describing iodized salt intake as at least 90% of households, the rate was slightly low for the elimination of ID. More importantly, the median UIC of SAC in urban areas was remarkably higher than that of suburban and rural areas (147 μg/L vs. 46 μg/L, respectively, $P < .001$). The study demonstrated that even though ID has disappeared in most of the urban population, it still exists in rural areas and in particular geographical regions (i.e., Black Sea region, Central and Eastern Anatolia).[29]

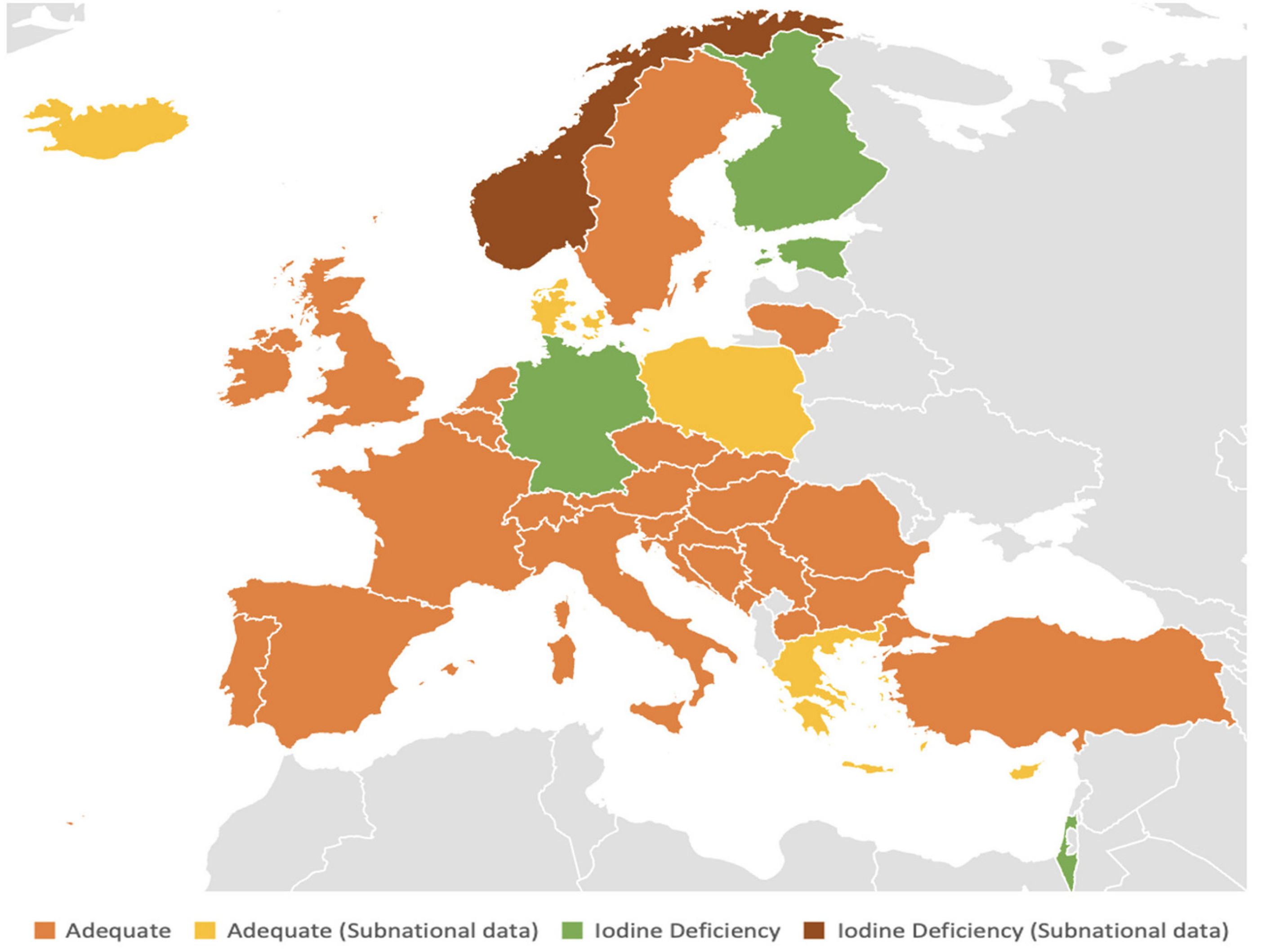

Figure 1. 2023 map of iodine status scorecard in Western and Central Europe.[21]

There has not been any nationwide survey to assess the iodine status of Türkiye since 2007; however, several regional studies have been carried out by different groups. The UIC and sonographic thyroid volumes of 3400 SAC aged between 9 and 11 years in a primary school in Ankara were evaluated before (1997), 5 years (2002), and 10 years (2007) after the introduction of the mandatory salt iodization program.[16] It was found that median UIC increased from 25.5 µg/L in 1997 to 89.5 µg/L and 117 µg/L, respectively, in 5-10 years. Goiter prevalence decreased from 25% to 12.3% during the first 5 years. In 2008, final measurements showed a goiter prevalence of 1.3%, demonstrating that more than a decade of iodine prophylaxis is needed to eradicate goiter in the setting of moderate ID in an urban city.

In a similar study conducted in Isparta (i.e., innerwest Anatolia) in 2006, UIC results indicated inadequate iodine nutrition in the city.[30] After 10 years, although there was a marked increase in median UIC (i.e., from 28 µg/L to 70 µg/L), the goiter prevalence did not change (i.e., from 25% to 26.4%), which may be due to interobserver variations during sonographic measurements.[31]

There have been several promising results from different regions of Türkiye. In a study conducted in a primary school in Istanbul, it was found that inadequate urinary iodine excretion decreased (17.8%) compared to previous studies, and this result was attributed to iodized salt consumption.[32] Accordingly, it was revealed that ID was eliminated in adolescents in the Eastern Black Sea region, but in parallel with this, there was a slight increase in autoimmune thyroiditis and thyroid dysfunction.[33] In Antalya, median UIC increased from 62 to 174 µg/L and goiter prevalence decreased from 34% to 0.3% in SAC due to salt iodization.[34] In a study from Aydın, the median UIC was shown to be 189.5 µg/L and it was stated that only 6% of the subjects had a UIC level below 50 µg/L.[35] According to these results, it could be assumed that ID is eliminated in the country. However, some other studies do not fully confirm this conclusion. In a 2009 study of iodine status in older adults, Atmis et al. found that the median UIC in Ankara was 98 µg/L, indicating that iodine status was still not at favorable levels in the elderly.[36] In a 2014 study evaluating the iodine status of 3 different cities, the median UIC was found to be 77 µg/L in Istanbul, 58.8 µg/L in Isparta, and 69.8 µg/L in Kayseri.[37] Another study from Istanbul showed that 47.4% of the participants had UIC below the normal values for adults, indicating that ID had reappeared in people living in the city.[38]

Iodine Status in Pregnant Women from Europe and Türkiye

In recent years, it has become increasingly evident that ID remains a significant public health concern, affecting vulnerable population groups across the world. In response to studies that indicated low UIC in several countries within the WHO European Region, authorities and researchers conducted surveys in pregnant women. The recent report published by WHO included these surveys, which consist of nationally representative data from 23 Member States and Kosovo (Table 5).[4]

A comprehensive review of iodine status in the United Kingdom emphasized that iodine nutrition is not optimal in pregnant women across the country.[39] Similarly, a cross-sectional population-based study from Sweden showed that the median UIC was 101 µg/L in pregnant women.[40] A recent study aimed at establishing a standardized assessment of UIC in Europe found that pregnant women in 7 (i.e., Croatia, Greece, Hungary, Latvia, North Macedonia, Poland, Portugal, Sweden, and Northern Ireland) out of the 11 countries where the study was conducted, had UIC levels below 150 µg/L.[41]

According to a recent the WHO report, the median UIC of Turkish pregnant women was 94 µg/L.[4] Furthermore, various regional studies with limited numbers of participants showed that median UIC ranged between 77.4 and 137.3 µg/L, and iodine deficiency was observed in over 70% of the screened pregnant women.[42-44] A large-scale study from Istanbul, an iodine-depleted city according to previous surveys, revealed that the median UIC of pregnant women was 73 µg/L, and over 90% of pregnant women were exposed to some degree of ID.[45] In the borderline iodine-sufficient capital, Ankara, the median UIC of pregnant women was found to be 96 µg/L, 78 µg/L, and 60 µg/L in the first, second, and third trimesters, respectively.[46] The study demonstrated that ID deteriorated throughout pregnancy and emphasized the importance of iodine supplementation in addition to the consumption of iodized salt for pregnant women in formerly iodine-deficient areas.

Iodine Status in the Newborn from Europe and Türkiye

Neonatal TSH measurement is the mainstay of screening for congenital hypothyroidism, which is typically defined as thyroid hormone deficiency at birth. A comprehensive meta-analysis revealed that the pooled prevalence of congenital hypothyroidism in Europe was 3.56 per 10 000 neonates between 1969 and 2020.[47] The study also stated that the prevalence of congenital hypothyroidism has been on an increasing trend over the years, which was mainly attributed

Table 5. Median Urinary Iodine Concentration in Pregnant Women in Member States of the World Health Organization European Region and Kosovo[4]

Country	UIC (µg/L)	Iodine Status
Armenia[a]	226	Adequate
Georgia[a]	211	Adequate
Kyrgyzstan[a]	180	Adequate
Azerbaijan[a]	151	Adequate
Uzbekistan[a]	117	ID
Kazakhstan[a]	170	Adequate
Belarus[a]	121	ID
Latvia[b]	69	ID
North Macedonia[a]	168	Adequate
Poland[a]	112	ID
Israel[c]	61	ID
Türkiye[a]	94	ID
Iceland[c]	89	ID
Greece[c]	127	ID
Montenegro[a]	133	ID
Republic of Moldova[a]	173	Adequate
Belgium[b]	124	ID
Norway[b]	79	ID
Romania[a]	131	ID
Bulgaria[a]	170	Adequate
Sweden[b]	101	ID
Czech Republic[b]	98	ID
Switzerland[b]	197	Adequate
Kosovo[a]	183	Adequate

ID, iodine deficiency; UIC, urinary iodine concentration.
[a]Mandatory salt iodization programs.
[b]Voluntary salt iodization programs.
[c]No national policy.
[d]Unknown national policy.

to the lowering of TSH cut-offs and the implementation of national screening programs. A recent surveillance report from Italy showed that after 15 years of iodine prophylaxis, the percentage of neonatal TSH values over 5.0 mIU/L was 5.1%, which was still higher than the WHO's suggested threshold of 3.0%.[48]

In Türkiye, national neonatal screening program was initiated in 2006. The incidence of congenital hypothyroidism was found to be as high as 1:650 in 2008-2010.[49] In 2016, the national prevalence of elevated TSH (>5 mIU/L) was reported to be 7.2%, which supported the fact that Türkiye is still a mildly iodine-deficient country.[49] Moreover, it was revealed that transient congenital hypothyroidism ranged from 25% to 65%, which is substantially higher than the expected rate of 5%-10% for iodine-sufficient populations.[50]

Conclusion

Significant improvement has been made in controlling iodine status worldwide over the past decades through public health programs on IDDs. Unfortunately, this global achievement is underrecognized and even forgotten. Despite the implementation of salt iodization programs in many countries, mild iodine deficiency continues to be a concerning public health problem, particularly affecting the most vulnerable populations, such as pregnant women and their newborns. There are several critical measures needed in order to keep ID under control. Firstly, mild ID should be acknowledged as a health problem. The main focus should be on the diagnosis and correction of ID at the community level of the community rather than at the individual level. Iodine-deficient areas should be determined through well-designed surveys, and iodine-sufficient areas should be periodically monitored for iodine status. Governments should take responsibility for setting up comprehensive public health programs to prevent and control ID disorders. Legislation of salt iodization and evaluating the efficacy of the program through regular monitoring is crucial to ensuring success. Both clinicians and scientists should actively participate in the supervision of IDDs prevention and control programs, seeking and finding appropriate solutions to challenges as they emerge. Additionally, collaborations with international organizations should be established to provide technical assistance and resources to develop effective iodine fortification programs. Not only public health care workers but also patient organizations and the food industry should take an active role in educational campaigns to raise social awareness of the importance of adequate iodine nutrition by promoting the consumption of iodized salt. In the absence of these measures, the achievement made over a century could be lost in a short period of time.

Availability of Data and Materials: The data that support the findings of this study are available on request from the corresponding author.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – S.B.T.Ö., M.F.E.; Design – S.B.T.Ö., M.F.E.; Supervision – M.F.E.; Literature Search – S.B.T.Ö., M.F.E.; Writing – S.B.T.Ö.; Critical Review – M.F.E.

Declaration of Interests: Murat Faik Erdoğan is the Editor-in-Chief at the Endocrinology Research and Practice, however, his involvement in the peer review process was solely as an author. Sinem Başak Tan Öksüz has no conflicts of interest to declare.

Funding: This study received no funding.

References

1. Zimmermann MB, Jooste PL, Pandav CS. Iodine-deficiency disorders. *Lancet*. 2008;372(9645):1251-1262. [CrossRef]
2. Rousset B, Dupuy C, Miot F, Dumont J. Thyroid hormone synthesis and secretion. In: Feingold KR, Anawalt B, Blackman MR, et al, eds. Endotext [Internet]. South Dartmouth (MA): MDText.com; 2015.
3. Creswell J, Eastman MBZ. The iodine deficiency disorders. In: Feingold KR, Anawalt B, Blackman MR, et al, eds. Endotext [Internet]. South Dartmouth (MA): MDText.com; 2018.
4. World Health Organization. Prevention and control of iodine deficiency in the WHO European Region. Cophenhagen: World Health Organization; 2024.
5. Turkish Society of Endocrinology and Metabolism. *Diagnosis and Treatment of Thyroid Diseases Guideline*. Ankara; 2023:51-65.
6. Chan S, Kilby MD. Thyroid hormone and central nervous system development. *J Endocrinol*. 2000;165(1):1-8. [CrossRef]
7. Prezioso G, Giannini C, Chiarelli F. Effect of thyroid hormones on neurons and neurodevelopment. *Horm Res Paediatr*. 2018;90(2):73-81. [CrossRef]
8. Cobra C, Muhilal RK, Rusmil K, et al. Infant survival is improved by oral iodine supplementation. *J Nutr*. 1997;127(4):574-578. [CrossRef]
9. Pharoah P, Buttfield IH, Hetzel BS. Neurological damage to the fetus resulting from severe iodine deficiency during pregnancy. *Int J Epidemiol*. 2012;41(3):589-592. [CrossRef]
10. Zimmermann MB. Iodine deficiency in pregnancy and the effects of maternal iodine supplementation on the offspring: a review. *Am J Clin Nutr*. 2009;89(2):668S-672S. [CrossRef]
11. Greenwood DC, Webster J, Keeble C, Taylor E, Hardie LJ. Maternal iodine status and birth outcomes: a systematic literature review and meta-analysis. *Nutrients*. 2023;15(2):387. [CrossRef]
12. Harding KB, Peña-Rosas JP, Webster AC, et al. Iodine supplementation for women during the preconception, pregnancy and postpartum period. *Cochrane Database Syst Rev*. 2017;3(3):CD011761. [CrossRef]
13. Nazeri P, Shariat M, Azizi F. Effects of iodine supplementation during pregnancy on pregnant women and their offspring: a systematic review and meta-analysis of trials over the past 3 decades. *Eur J Endocrinol*. 2021;184(1):91-106. [CrossRef]
14. Levie D, Korevaar TIM, Bath SC, et al. Association of maternal iodine status with child IQ: a meta-analysis of individual participant data. *J Clin Endocrinol Metab*. 2019;104(12):5957-5967. [CrossRef]
15. Dineva M, Fishpool H, Rayman MP, Mendis J, Bath SC. Systematic review and meta-analysis of the effects of iodine supplementation on thyroid function and child neurodevelopment in mildly-to-moderately iodine-deficient pregnant women. *Am J Clin Nutr*. 2020;112(2):389-412. [CrossRef]
16. Erdoğan MF, Demir O, Emral R, Kamel AN, Erdoğan G. More than a decade of iodine prophylaxis is needed to eradicate goiter among school age children in a moderately iodine-deficient region. *Thyroid*. 2009;19(3):265-268. [CrossRef]
17. Zimmermann MB, Hess SY, Adou P, Toresanni T, Wegmüller R, Hurrell RF. Thyroid size and goiter prevalence after introduction of iodized salt: a 5-y prospective study in schoolchildren in Côte d'Ivoire. *Am J Clin Nutr*. 2003;77(3):663-667. [CrossRef]
18. Zimmermann MB, de Benoist B, Corigliano S, et al. Assessment of iodine status using dried blood spot thyroglobulin: development of reference material and establishment of an international reference range in iodine-sufficient children. *J Clin Endocrinol Metab*. 2006;91(12):4881-4887. [CrossRef]
19. Spencer CA, Wang CC. Thyroglobulin measurement. Techniques, clinical benefits, and pitfalls. *Endocrinol Metab Clin North Am*. 1995;24(4):841-863. [CrossRef]
20. Li M, Eastman CJ. Neonatal TSH screening: is it a sensitive and reliable tool for monitoring iodine status in populations?. *Best Pract Res Clin Endocrinol Metab*. 2010;24(1):63-75. [CrossRef]

21. Iodine Global Network. Available at: https://www.ign.org. .Accessed August 10, 2024.
22. Fischer L, Andersson M, Braegger C, Herter-Aeberli I. Swiss iodine study collaborators. Iodine intake in the Swiss population 100 years after the introduction of iodised salt: a cross-sectional national study in children and pregnant women. *Eur J Nutr*. 2024;63(2):573-587. [published correction appears in *Eur J Nutr*. 2024;63(4):1387]. [CrossRef]
23. *EUthyroid*. Available at: https://www.euthyroid.eu. .Accessed August 8, 2024
24. The Krakow declaration on iodine: tasks and responsibilities for prevention programs targeting iodine deficiency disorders. *Eur Thyroid J*. 2018;7(4):201-204. [CrossRef]
25. Urgancıoğlu İ, Hatemi H. *Endemic Goitre in Turkey*. İstanbul: Emek Publications; 1989.
26. Koloğlu S. *Endemic Goitre in Turkey*. Ankara: Emek Publications; 1984.
27. Erdoğan G, Erdogan MF, Emral R, et al. Iodine status and goiter prevalence in Turkey before mandatory iodization. *J Endocrinol Invest*. 2002;25(3):224-228. [CrossRef]
28. Erdoğan G, Erdoğan MF, Haznedaroglu D, et al. Improving iodine status in Turkey. 29th Annual Meeting of European Thyroid Association, Edinburgh: ICCIDD Satellite Meeting; 2003.
29. Erdoğan MF, Ağbaht K, Altunsu T, et al. Current iodine status in Turkey. *J Endocrinol Invest*. 2009;32(7):617-622. [CrossRef]
30. Cetin H, Kisioglu AN, Gursoy A, Bilaloglu E, Ayata A. Iodine deficiency and goiter prevalence in Turkey after mandatory iodization. *J Endocrinol Invest*. 2006;29(8):714-718. [CrossRef]
31. Nagehan Aslan HK, Pirgon Ö. Urine iodine excretion and iodine deficiency status in school age children at Isparta Province. *J Clin Anal Med*. 2015;6(5):612-616.
32. Baştemir MB. *Urinary Iodine Excretion and Prevalence of Goiter in Primary School Students in Bakırköy Region*. Bakırköy Dr. Sadi Konuk Education and Research Hospital [Thesis]; 2005.
33. Emral R, Bastemir M, Erdogan G, Gullu S. High prevalence of thyroid dysfunction and autoimmune thyroiditis in adolescents after elimination of iodine deficiency in the eastern Black Sea Region of Turkey. *Turk J Endocrinol Metab*. 2006;1:13-20.
34. Çelmeli G, Çürek Y, Özen Küçükçetin İ, et al. The results of 16 years of iodization: assessment of iodine deficiency among school-age children in Antalya, Turkey. *J Clin Res Pediatr Endocrinol*. 2020;12(3):256-260. [CrossRef]
35. Deveci Sevim R, Gök M, Öztürk S, et al. Thyroid volume in Turkish school-age children living in an iodine-sufficient region. *J Pediatr Endocrinol Metab*. 2024;37(3):228-235. [CrossRef]
36. Atmis V, Bülbül B, Bahşi R, et al. Iodine concentration and prevalence of thyroid disease in older people after salt iodization in Turkey. *East Mediterr Health J*. 2021;27(2):151-158. [CrossRef]
37. Ozpinar A, Kelestimur F, Songur Y, et al. Iodine status in Turkish populations and exposure to iodide uptake inhibitors. *PLoS One*. 2014;9(2):e88206. [CrossRef]
38. Gokcel A, Mustafa S, Coşkun A, Unsal I. Iodine deficiency has recurred in Istanbul, Turkey. *Endocrinol Metab Int J*. 2017;5(1):172-175.
39. The Lancet Diabetes Endocrinology. Iodine deficiency in the UK: grabbing the low-hanging fruit. *Lancet Diabetes Endocrinol*. 2016;4(6):469. [CrossRef]
40. Manousou S, Andersson M, Eggertsen R, Hunziker S, Hulthén L, Nyström HF. Iodine deficiency in pregnant women in Sweden: a national cross-sectional study. *Eur J Nutr*. 2020;59(6):2535-2545. [CrossRef]
41. Ittermann T, Albrecht D, Arohonka P, et al. Standardized map of iodine status in Europe. *Thyroid*. 2020;30(9):1346-1354. (https://doi.org/10.1089/thy.2019.0353) [published correction appears in *Thyroid*. 2022;32(5):603]. [CrossRef]
42. Egri M, Ercan C, Karaoglu L. Iodine deficiency in pregnant women in eastern Turkey (Malatya Province): 7 years after the introduction of mandatory table salt iodization. *Public Health Nutr*. 2009;12(6):849-852. [CrossRef]
43. Çetinkaya K, İngeç M, Çetinkaya S, Kaplan İ. Iodine deficiency in pregnancy and in women of reproductive age in Erzurum, Turkey. *Turk J Med Sci*. 2012;42(4):675-680. [CrossRef]
44. Anaforoğlu İ, Algün E, İnceçayır Ö, Topbaş M, Erdoğan MF. Iodine status among pregnant women after mandatory salt iodisation. *Br J Nutr*. 2016;115(3):405-410. [CrossRef]
45. Oral E, Aydogan Mathyk B, Aydogan BI, et al. Iodine status of pregnant women in a metropolitan city which proved to be an iodine-sufficient area. Is mandatory salt iodisation enough for pregnant women?. *Gynecol Endocrinol*. 2016;32(3):188-192. [CrossRef]
46. Köse Aktaş A, Gökçay Canpolat A, Aydin Ü, et al. Intensifying iodine deficiency throughout trimesters of pregnancy in a borderline iodine-sufficient urban area, Ankara, Turkey. *Biol Trace Elem Res*. 2022;200(6):2667-2672. [CrossRef]
47. Liu L, He W, Zhu J, et al. Global prevalence of congenital hypothyroidism among neonates from 1969 to 2020: a systematic review and meta-analysis. *Eur J Pediatr*. 2023;182(7):2957-2965. [CrossRef]
48. De Angelis S, Medda E, Rotondi D, et al. Fifteen years of iodine prophylaxis in Italy: results of a nationwide surveillance (period 2015-2019). *J Clin Endocrinol Metab*. 2024;109(2):e495-e507. [CrossRef]
49. Kara C, Günindi F, Can Yılmaz G, Aydın M. Transient congenital hypothyroidism in Turkey: an analysis on frequency and natural course. *J Clin Res Pediatr Endocrinol*. 2016;8(2):170-179. [CrossRef]
50. Çaylan N, Tezel B, Özbaş S, et al. Neonatal thyroid-stimulating hormone screening as a monitoring tool for iodine deficiency in Turkey. *J Clin Res Pediatr Endocrinol*. 2016;8(2):187-191. [CrossRef]