

# SOCIO-ECOLOGICAL AND MEDICAL PROBLEMS OF IODINE DEFICIENCY AMONG THE POPULATION OF UKRAINE

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**ABSTRACT. Aim.** Study of iodine supply in different segments of the population throughout Ukraine, establishment of the morbidity level caused by iodine deficiency, analysis of preventive measures and their effectiveness and development of adequate ways of mass, group and individual prophylaxis of iodine deficiency in the body, which will reduce morbidity in areas of endemic iodine deficiency.

The article considers the most important results of long-term epidemiological studies of iodine supply in different categories of the population of almost all regions of Ukraine. Significant volume of work was performed with the support of the Ministry of Healthcare of Ukraine, UNICEF Ukrainian office, and the CDC in Atlanta (USA), which for more than 19 years has provided external quality control of the study of iodine status of the population of Ukraine. The data on iodine content in food and biological fluids of the population affected by the Chernobyl accident are given and the dependence of the irradiation dose of the thyroid on the body supply with stable iodine and on the optimization of the latter after the adoption of the State Programme for Iodine Deficiency Prevention for 2002-2005 is shown. The effectiveness of mass iodine prophylaxis by using universally iodized table salt is emphasized. The article presents data on suggested and implemented ways of mass, group and individual iodine prophylaxis, studies of their effectiveness and shows the positive dynamics of changes in providing the population with dietary iodine. The need for constant consumption of food products with sufficient iodine content, including iodized salt, is proven. Significant changes in the prevalence and incidence of thyroid pathology, socio-ecological and medical benefits of prevention of iodine-dependent disorders are described. The article was prepared as a scientific information material for family doctors, endocrinologists, obstetricians and gynaecologists, hygienists, the public, the Ministry of Healthcare of Ukraine in connection with the need for a legislative solution to the prevention of iodine-dependent disorders in Ukraine.

**Materials and Methods.** To study the problem and assess the state of iodine deficiency in Ukraine the criteria recommended by the WHO and the United Nations Children's Fund (UNICEF) were applied for the first time, a method for determining the iodine content in the body was developed and implemented, which allowed to join the international "Equip" system of iodine supply control in the world and in Ukraine. This made it possible to move from indirect to direct methods of determining the intake of iodine in the body.

**Conclusions.** A detailed study of iodine supply in different segments of the population of Ukraine proved the negative effects of iodine deficiency on health; in particular, it was found that the overall decrease in productivity of the generation of children in iodine deficiency populations is 5%.

Measures to eliminate iodine-dependent disorder among the population of Ukraine have been developed and implemented.

The development and production of iodized food salt, adequate to the needs of the population, has been carried out.

The result of these measures, developed and implemented to eliminate iodine-dependent disorders and to improve the nation's intelligence, is, according to the official data, the improvement of iodine supply of the population, significant reduction in the number of thyroid disorders, especially among those affected with <sup>131</sup>I, which, even just because of this indicator, has significant social-economic effect.

**Key Words:** Chernobyl accident, iodine deficiency, iodized salt, population, prevention, regions.

**Introduction.** Iodine deficiency in human body is familiar to many countries around the world. This global problem affects all segments of the population, and its consequence is iodine deficiency disorders (IDDs). The most notable

among them are the abnormalities of the central nervous system (CNS), which affect the level of intellectual and physical development of children and the nation, living in areas of endemic iodine deficiency, as a whole. In general, more than 2

billion people on the Earth live in the IDD risk zone, as well as residents of all of Ukraine. Residents of radioactively contaminated by Chernobyl accident areas are of particular concern. Disorders caused by iodine deficiency, in addition to goitre, include hypothyroidism, infertility, miscarriages, stillbirth, congenital anomalies, increased perinatal and infant mortality, cretinism, and retarded physical and mental development, mental disorders in children and adults, decrease in work capacity, hypersensitivity to ionizing radiation [1–7].

As acknowledged by the experts of the World Health Organization (WHO), iodine deficiency disorders and their elimination are among the priorities of modern medicine [8]. Elimination of disorders associated with deficiency of iodine, vitamin A, heme iron in the body, according to WHO experts, is more important than such an achievement as the elimination of smallpox. With a significant iodine deficiency in the body, there are pronounced forms of goitre in almost all residents of the endemic area [9–12]. At the same time, there is a significant prevalence of cases of intellectual impairment, up to its extreme manifestation – cretinism. These disorders have for some time been considered signs of iodine deficiency [13–16]. However, insufficient intake, assimilation, intrafollicular transport and organification of iodide are the main causes not only of endemic goitre, but also of hypothyroidism, sporadic forms of nodular and diffuse goitre, where intrathoroidal iodine deficiency is an independent factor in the proliferation of the thyrocytes. It also facilitates the increase in the number of poorly differentiated thyroid carcinoma cases. Inadequate iodine prophylaxis can cause autoimmune thyroiditis and iodine-induced thyrotoxicosis [17].

Equally important is the assessment of (iodine deficiency) endemic psychomotor disorders. Average indicators of mental development in regions with severe iodine deficiency in soil and drinking water are 15–20% lower than in iodine non-endemic regions. Iodine deficiency in adults results in weakened immunity, impaired memory and decrease in work capacity. All these disorders are caused by a decrease in the functional activity of the thyroid gland resulting from iodine deficiency in the human diet. The urgency of the problem is determined by the prevalence of pathology caused by iodine deficiency and a clear delineation of its development.

In 1990, the UN summit took a decision to coordinate the actions of member states governments to eliminate iodine deficiency among the population of all countries. These tasks have been taken up by the WHO, the UN Children's Fund UNICEF, the International Council for the Control of Iodine Deficiency Disorders (ICCIDD), and a number of other international charities, including the Kiwanis Foundation, which focus on the elimination of iodine deficiency disorders.

In some countries precautionary measures to eliminate iodine deficiency in the body and, as a consequence, to prevent iodine deficiency disorders have been introduced at the state level. The main coordinators of these programmes are the relevant national committees, coordinating councils, the WHO, UNICEF, ICCIDD. Nowadays such programmes operate in 118 countries, the positive consequence of which is the elimination, in most of them, of iodine deficiency [18–22].

**Aim.** Study of iodine supply in different segments of the population throughout Ukraine, establishment of the morbidity level caused by iodine deficiency, analysis of preventive measures and their effectiveness and development of adequate ways of mass, group and individual prophylaxis of iodine deficiency in the body, which will reduce morbidity in areas of endemic iodine deficiency.

**Materials and Methods.** To study the problem and assess the state of iodine deficiency in Ukraine the criteria recommended by the WHO and the United Nations Children's Fund (UNICEF) were applied for the first time (Table 1) [23], a method for determining the iodine content in the body was developed and implemented, which allowed to join the international "Equip" system of iodine supply control in the world and in Ukraine. This made it possible to move from indirect to direct methods of determining the intake of iodine in the body.

The study of iodine supply of the population of Ukraine was carried out in accordance with modern criteria and methods within the Ukrainian-Belarusian-Russian WHO project according to the general approved protocol and research scheme [24]. The choice of settlements to be studied was in most cases determined by the WHO protocol and performed for both the areas contaminated by radioactive releases during the Chernobyl accident and other regions of Ukraine. Examined by expedition teams which included epidemiologists, paediatric endocrinol-

Table 1

**Criteria for the severity of iodine deficiency (WHO)**

Indicators	Reference population	Degree of severity		
		Light	Moderate	Severe
Median urinary iodine concentration, $\mu\text{g/l}$	Children	50 - 99	20 - 49	> 20
The incidence of goitre, according to palpation and ultrasound data	Children	5 - 19.5	20 - 29.9	> 30
Blood serum thyroglobulin median, $\text{ng/l}$	Children and adults	10 - 19.9	20 - 39.9	> 40
The frequency of TSH in blood > 5 mIU/L at neonatal screening, %	New-borns	3 - 19.9	20 - 39.9	> 40

ogists, ultrasound diagnostics specialists and laboratory diagnostics specialists. The results of these studies are represented in many publications [2, 7, 25 - 30]. In total, more than 20,000 children were examined. A significant number of studies of iodine supply of the population have been performed in the regions affected by the Chernobyl accident as a part of the Ukrainian-Belarusian-American project [31 - 34]. Within the framework of this project, a cohort of children with irradiated thyroid was formed in the affected areas for long-term follow-up. In total, the Ukrainian cohort included 13,243 people who were between 0 and 18 years old at the time of the 1986 Chernobyl accident. The survey was conducted in four cycles, according to a protocol agreed by the institutions of Ukraine and the United States. During the first cycle (1998 - 2000) urine samples of 11 926 persons were studied, during the second (2001 - 2003) – 11 997, in the third (2003 - 2005) – 10 868, in the fourth (2005 - 2007) – 8 083.

Iodine supply of new-borns was determined by the level of thyroid-stimulating hormone (TSH) in the serum on the 3rd - 5th day of birth in full-term, and on the 7th - 14th day in premature infants, with the application of the immunoenzyme method, and "IMMUNOTECH TSH IRMA" test system, in accordance with the WHO recommendation [23]. To determine the situation with iodine supply of the population of Ukraine and the effectiveness of iodine prophylaxis national studies of iodine supply in 30 clusters throughout Ukraine were performed in accordance with the CDC agreed protocol and the corresponding scheme [35, 36].

Long-term the effects of the increase in consumption of iodized salt by the population were studied by analysing the incidence of diffuse and nodular goitre in the population of Ukraine [37] for the period from 2002 to 2016. For each indicator, the average standard error was calculated annually and the significance of changes compared to previous years was determined. Data were processed in accordance with the recommendations of statistical research in medicine and using the SPSS 21.0 software. The iodine content in urine was determined by the Dunn modification of the Sandell-Kolthoff cerium-arsenite method [38, 39]. The results of the study were interpreted according to WHO criteria – normal range of iodine excretion in the urine at the level of 100-200  $\mu\text{g/l}$ , the value of excretion from 50 to 100  $\mu\text{g/l}$  is insufficient and is treated as mild iodine deficiency; excretion rates from 20 to 50  $\mu\text{g/l}$  correspond to iodine deficiency of moderate severity, below 20  $\mu\text{g/l}$  – severe iodine deficiency. Excretion rates higher than 300  $\mu\text{g/l}$  correspond to excessive intake of iodine. Studies of ioduria are under constant external quality control at the CDC, Atlanta (USA) and have the appropriate international certificates.

Ultrasound examinations of the thyroid gland were performed using a Terason 2000 scanner with a linear sensor with a frequency of 10 MHz (Terason Ultrasound, Burlington, MA, USA). The size of the thyroid gland was determined according to Brunn recommendations [40].

The actual nutrition of the population was studied using a questionnaire, and the provision of essential nutrients, including vitamins and minerals – in accordance with WHO recommenda-

tions, using the DanKost-2 programme [41, 42].

Results and Discussion. The authors of this work conducted large-scale clinical and epidemiological studies of iodine supply of the population throughout Ukraine, studied the epidemiological characteristics of the prevalence of thyroid pathology in the most vulnerable to iodine deficiency groups of population.

In 1995–2001, with the support of the WHO and the UNICEF Children’s Fund, the population of the whole territory of Ukraine was massively examined for thyroid pathology caused by alimentary iodine deficiency: 14.5 thousand children from 45 settlements in all regions of Ukraine. It is established that almost all the entire population of Ukraine does not receive the required amount of alimentary iodine [25-30]. There are areas with severe iodine deficiency (iodine intake of about 20 mcg per day), moderate iodine deficiency (20-50 mcg/day) and with mild iodine deficiency (50-100 mcg per day) (Fig. 1).

The consequences of the deficiency are thyroid disorders, pathology of pregnancy, abnormalities in children. In almost all regions of Ukraine, the incidence of goitre in children at that time exceeded 5%. In some settlements of the Northern and Western regions of Ukraine the frequency of goitre reached 40-60% of the examined children. And even in Yalta (the Black Sea coast, where high levels of iodine in food and drinking water are assumed), where preventive measures are not taken, iodine deficiency is observed, and the incidence of goitre among the population during the survey reached 10%, and iodized salt was consumed by 0.5 to 2% of the total number of respondents. Abnormalities of

the physical and mental development of children were also observed in these areas.

Our research shows that during pregnancy, iodine deficiency deepens in women living in a region of mild endemicity, where the population’s consumption of this microelement is on the verge of normal. In order to study the supply of pregnant women with minerals 77 women were examined in the spring of 2008, deficiency of iodine was found in 47 people (61%), calcium – 44 people (57.1%), iron – 28 people (35%), selenium – 26 people (34%), zinc – 25 people (32.5%), copper – 21 people (27%), magnesium – 18 people (23%), phosphorus – 13 people (16.9%), potassium – 13 people (16.9%), manganese – 9 people (11.7%), chromium – 6 people (7.8%), sodium – 4 people (5.2%), molybdenum – 4 people (5.1%). In 47 people with iodine deficiency, 27 women had low selenium content. It is known that selenium, which is a part of iodotyronine deiodinase, is involved in iodine metabolism in the body. 12 of 44 women with calcium deficiency, also had phosphorus deficiency and 5 women had phosphorus and magnesium deficiency. Of the 28 women with iron deficiency, 13 had copper deficiency, 12 had zinc deficiency, and 3 had iron, manganese, and copper deficiencies. Among pregnant women with zinc deficiency in 12 people a lack of copper and iron, in 4 – of iron and selenium, in 6 – of manganese were also found. The most common were three- and four-component deficits.

It is established that the lack of a number of essential nutrients causes the development of thyroid pathology, reduction of physical and mental work capacity, resistance to various dis-



Fig. 1. Alimentary iodine supply among the population of Ukraine.

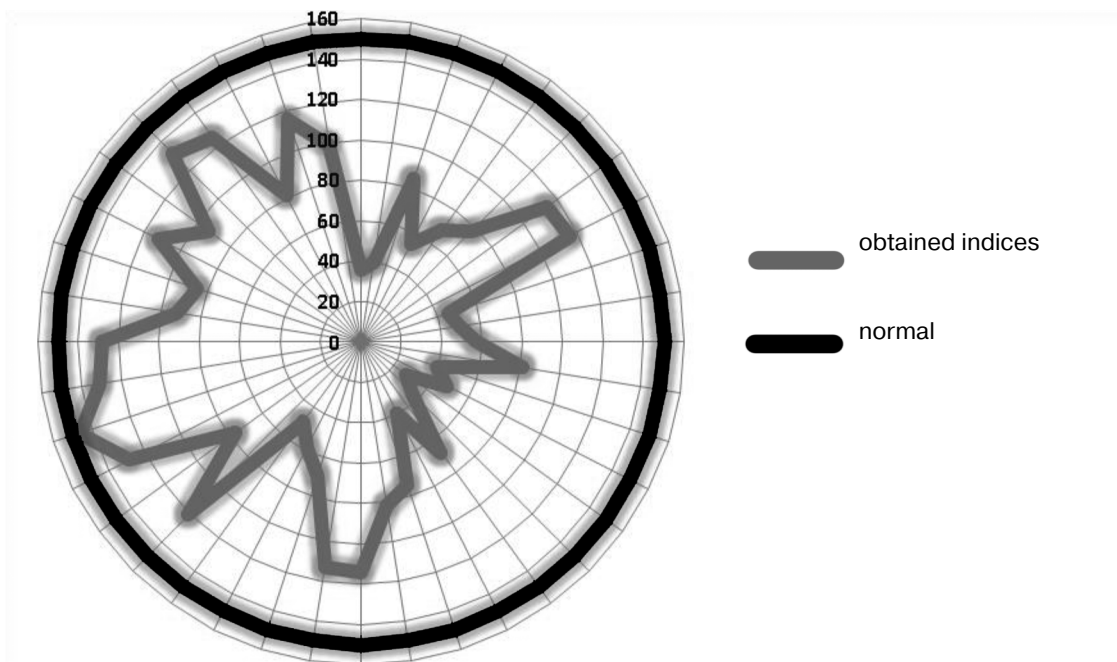
eases; exacerbates the negative effects of adverse environmental and industrial factors, increased emotional stress, sensitivity to ionizing radiation and as a consequence – a reduction in life expectancy. Insufficient iodine supply of the mother has been proven to cause the development of CNS pathologies in babies, lower scores on the Apgar scale, birth of a large number of children with anaemia and malnutrition. Our screening studies of TSH levels indicate a deeper degree of iodine deficiency in new-borns than in general population. Thus, screening examination of 755 new-born babies in Lviv region showed that 37.9% of children were born with pathologies and transient neonatal hypothyroidism was detected in 7.4% of infants which indicates a dangerous condition – moderate iodine deficiency [43]. In iodine-deficient regions, the incidence of transient hypothyroidism in new-borns is on increase, ranging from 1.7 to 14%.

Large-scale epidemiological studies of the state of iodine supply and thyroid gland were carried out in the regions affected by the Chernobyl accident. We surveyed 10,682 children aged 6 to 18 years. It was found that due to iodine deficiency there was a high incidence of goitre in children – from 20 to 60% of those examined. Studies show the presence of iodine deficiency of varying severity: from mild in Kyiv to moderate in Zhytomyr, Chernihiv and Rivne regions, and in some settlements – even acute (or severe) degree of iodine deficiency.

Main characteristics of prevalence and incidence of diffuse euthyroid goitre were determined, the parameters of iodine supply of the populations of the regions affected by the Chernobyl accident were defined [25-30] (Fig. 2).

The results of clinical and epidemiological studies became the basis for the development of a programme for the prevention of iodine-dependent disorders and on September 26, 2002 the Resolution of the Cabinet of Ministers of Ukraine “On the approval of the State Programme for Prevention of Iodine Deficiency among the Population in 2002-2005” was issued.

According to this programme, with the support of the Centre for Disease Prevention and Control (USA) and the United Nations Children’s Fund (UNICEF) clustered national studies of micronutrient supply of population were conducted throughout Ukraine [35, 36]. As a result of the study the iodine consumption index of the population of Ukraine was established for the first time at the national level. Iodine excretion was 87.4  $\mu\text{g/l}$  of urine, which corresponded to a mild degree of iodine deficiency – although the clusters with iodine deficiency of moderate level were observed. In general, this indicator showed the presence of iodine deficiency throughout Ukraine. At the same time, there was a positive trend of the improvement of iodine supply in a number of settlements of Ukraine. There is a 30% increase in the consumption of iodized salt



**Fig. 2.** Indices of urinary iodine excretion in examined children living in iodine endemic regions and regions affected by the Chernobyl accident ( $\mu\text{g/l}$ )

among the surveyed women in a number of settlements in Ukraine. During the implementation of the Ukrainian-Belarusian-American project in the first and second cycles it was found that in settlements with severe iodine deficiency the dose of  $^{131}\text{I}$  irradiation of the thyroid gland was higher than in settlements with moderate and mild iodine deficiency. After the adoption of the State Programme for the Prevention of Iodine Deficiency among the Population, there have been positive developments towards the improvement of iodine supply of the population of the northern regions of Ukraine, which were affected by the Chernobyl accident. Consumption of iodized salt by the population has increased almost 10 times, and the ioduria median for most settlements has increased by 20-30%. After the Programme was adopted there were no registered settlements where people with severe iodine deficiency lived [33, 44]. As part of the State Programme for the Prevention of Iodine-Dependent Disorders, regional studies of iodine status among the most vulnerable to iodine deficiency categories of the population (children and women of childbearing age) were conducted. They proved that iodine deficiency affects not only the thyroid gland, but also delays the physical and mental development of a child, and, as a consequence – a decrease in intelligence, and in women leads to the pathology of pregnancy [45].

The iodine status of new-borns was studied; the relationship between the sufficiency of this micronutrient during foetal development and frequency of perinatal pathology was established. Lack of alimentary iodine in the diet of a pregnant woman negatively affects the supply of this nutrient to the new-born: 78% of children, whose foetal development occurred with iodine deficiency, are born with iodine deficiency of varying severity [56].

We have proved the effect of insufficient supply of stable iodine to the mother's body on the formation of the CNS pathology in babies, decrease of scores on the Apgar scale, birth of a large number of children with anaemia and malnutrition. The frequency of perinatal pathology correlates with the iodine supply of the pregnant woman. Thus, 51.1% of children whose foetal development took place under the conditions of iodine deficiency had CNS defects, 44.4% of new-borns had intrauterine growth retardation. It was found that in the region of light iodine endemic pregnancy aggravates iodine deficiency

in women which affects the reproductive function, generates significant complications during pregnancy and state of health disorders of the new-borns [56].

Assessment of the importance of iodine deficiency at the stage of early development of a child according to the results of screening studies of thyroid-stimulating hormone levels in new-borns indicates a deeper degree of iodine deficiency in the latter than in general population, the frequency of pathological values was 30.5%.

The level of intellectual development of preschool children is determined. It is shown that the defects of deep differentiation of the CNS during the foetal period of a child's life under mild iodine deficiency are manifested in the further weakening of the child's cognitive abilities and ability to learn. It was found that a third of children aged 3 to 7 years did not receive the required amount of iodine. In 6.7% of children mental development was insufficient for their age, and the median urinary iodine excretion was 71.58  $\mu\text{g/l}$ , which indicates a weak iodine deficiency [45].

The correlation between iodine supply and harmonious physical development of pupils was examined using the results of a comprehensive, randomized study of children in Western Ukraine. It is shown that the number of children with disharmonious development is probably higher in clusters with insufficient iodine supply. Enlarged thyroid (50% of normal) results in the increase of a number of children with extreme forms of disharmonious development [46]. It is known that under the conditions of iodine deficiency there is a transition of thyroid homeostasis to a lower level, which requires the introduction of the most effective and targeted prevention of iodine deficiency in humans. As a result, methods of mass and group prevention are suggested and implemented in health care practice, their effectiveness is studied, and the positive dynamics of changes in iodine supply of the population and the need for constant maintenance measures are shown [47–50].

The level of iodization of table salt for mass iodine prophylaxis is scientifically substantiated. By studying the correlations between ioduria indices and the level of iodization of salt consumed by women and children in all regions of Ukraine (in 30 settlements) it was statistically proven ( $p \leq 0.01$ ) that the level of iodization of salt from 15 to 30 mg/kg is the most favourable,

because it prevents the risk of extreme levels of ioduria in the population and fully meets the iodine needs of the body.

The advisability of group prophylaxis with iodine-containing drugs (at a dose of 200 µg/day) during pregnancy and breastfeeding is substantiated. For non-pregnant women and children living in areas with mild iodine deficiency in the biosphere, it is necessary to carry out mass iodine prophylaxis by using iodized salt [51-53].

Epidemiological studies conducted in recent years have shown that the situation with iodine supply in Ukraine, is improving (increase in the consumption of iodized salt), but due to iodine deficiency thyroid pathology and mental and developmental disorders in children are still observed. In most regions mild iodine deficit was observed, but there are areas of moderate iodine deficiency, and in some mountainous areas of Western Ukraine (Mizhhiria and Rakhiv) there is even severe iodine deficiency. Children in mountainous areas in terms of height lagged significantly behind their peers throughout Ukraine. At the same time, a notable decrease in the level of verbal intelligence of children was recorded. Most children from the surveyed settlements (68% – lowland area, 93% – mountainous area) had a low level of intelligence – less than 79 IQ units and only 6% had sufficient intelligence, and in mountainous areas there were no such children at all [54]. The determining indicator of the prevalence of pathology associated with iodine deficiency is the prevalence of diffuse euthyroid goitre, although this indicator, according to experts, is only the tip of the iceberg of iodine deficiency disorders. Today in Ukraine, according to official data, there are more than 1.5 million patients with thyroid disorder, of which 850 thousand adults and more than 220 thousand children have diffuse euthyroid goitre. Therefore, the problem of improving iodine consumption by the population has to be addressed immediately [55].

On the basis of clinical and epidemiological studies of the iodine supply of the population of Ukraine orders of the Chief State Sanitary Doctor of the Ministry of Healthcare of Ukraine #58 of May 24, 2001 “On the introduction of priority measures to overcome iodine deficiency in Ukraine” and #67 of October 25, 2001 “On Additional Measures to Overcome Iodine Deficiency in the Population of Ukraine” were issued, and the Resolution of the Cabinet of Ministers of Ukraine “On Approval of the State

Programme for Prevention of Iodine Deficiency among the Population in 2002-2005” was issued on September 26, 2002.

In order to optimize these measures and increase their effectiveness, regional programmes were adopted in all regions of Ukraine, guidelines, departmental instructions on the elimination of iodine deficiency and monitoring of iodine prevention programmes for different populations both within the country and in individual regions were developed, monographs were published [51-53, 55, 56].

Extensive awareness rising activities were held among health professionals, educators and the public to highlight the damage of lack of iodine to the human body and importance of prevention. A series of lectures on the necessity of iodine prophylaxis was given in all regions of Ukraine. 4 educational films about iodine deficiency related harm to health were released, three monographs and a handbook for medical students were published, medical scientists have repeatedly appeared on radio, television and in newspapers. All this helped to significantly improve the awareness of the population of the problem of iodine deficiency and, as a result, to increase the consumption of iodized salt by the population in recent years (from 5 to 50%), as well as the consumption of products and preparations containing iodine. The result of this consistent and persistent work is as follows: the prevalence of diffuse goitre of the 1st degree among children at the end of 2015, compared to 2002, decreased by 285 thousand cases, and diffuse goitre of the 2nd degree – by 66 thousand. Number of cases of these forms of goitre among children, has decreased respectively by 27 and 44% [17].

Technical and economic indicators and their comparison with the best domestic and foreign counterparts.

With the support of the United Nations Children’s Fund (UNICEF) at the Consulting Research and Production Enterprise “IOD” and the state enterprise “Ukrsil” it became possible to develop and produce iodized table salt with iodine content ( $30 \pm 15$ ) mg/kg and  $KIO_3$ , namely:

- table salt Extra with iodine,
- salt “Cozachenky” (obtained by evaporation),
- table salt Extra with iodine and fluorine (obtained by evaporation),
- table salt Extra with fluorine (obtained by evaporation),

- rock table kitchen salt of the 1st sort of the 1st grind with iodine,
- rock table kitchen salt of the 1st sort of the 1st grind with iodine and fluorine,
- table salt Extra with iodine,
- table salt Extra with fluorine,
- rock table kitchen salt of the 1st sort of the 1st grind with iodine,
- table salt Extra with iodine (obtained by evaporation),
- rock table kitchen salt of the 1st sort of the 1st grind with iodine and fluorine,
- table salt Extra with iodine (obtained by evaporation)
- iodized salt with low sodium chloride content.

It is known that iodine deficiency in women during pregnancy affects foetal development, leads to cretinism and other forms of mental and physical retardation in the unborn child. Studies conducted in several countries, showed that about 3.4% of all babies born to mothers with iodine deficiency suffer from cretinism, and 10.2% are mentally retarded.

Performed meta-analysis showed that in the population with iodine deficiency IQ decreases by an average of 13.5%. Assuming that this figure is the average for the entire population, and it is equal to almost complete standard deviation in the normal distribution of IQ, applying these figures only to children born to mothers with goitre, we can conclude that the overall decline in productivity of the generation of children in iodine deficiency populations is 5%.

According to the State Statistics Committee, 400,000 children are born in Ukraine every year, 8.054% of whom are born to iodine-deficient mothers. Thus, 32,275 children with low intelligence are born in the country every year. The total loss of IQ is 462,700 units. The number of infants with symptoms of cretinism born to mothers with goitre is 0.034, the proportion of infants with severe and moderate mental retardation is 0.103 and 0.864, respectively.

As a result of iodine deficiency, the country loses \$ 36,586,000 annually due to decrease in work capacity. That's 5.7 million business days a year.

For further calculations of the benefit/cost correlation the cost of production of iodized salt (equipment costs, amortization, staff training, the cost of iodising compound, and recurrent costs), expected result, spending on advocacy, awareness raising activities, control and moni-

toring, projected cost of implementation and ensuring of mass salt iodizing, estimated at \$ 5,663,405, were taken into account.

Projected benefits from the introduction of mass salt iodizing are as follows: each hryvnia invested into elimination of the problem of iodine deficiency in Ukraine will give from 19 to 63 hryvnias in profits.

Clinical effects of the implementation of the programme of mass iodization of salt will be no less significant. After the 2002 national study of iodine status of the population of Ukraine and identification of iodine deficiency the State Programme for Elimination of Iodine Deficiency in 2002-2005 was adopted, under which local, regional programmes to combat iodine deficiency have been developed, particularly in the west, the saturation of the market with iodine-containing products has significantly increased, which, in turn, has a significant economic effect in the form of reduction of the cost on diagnosis, treatment and observation of persons with thyroid pathology.

When comparing the frequency of thyroid pathology in the population of Ukraine, according to official data, there have been significant positive developments over the past 11 years. Thus, in 2002, the prevalence of diffuse non-toxic goitre of the 1st degree in the adult population was 1,153,398 people, and in 11 years the incidence of goitre of the first degree – 740,633 (decreased by 40%). Among children, the same trend is observed: in 2002, the prevalence of diffuse goitre of the 1st degree was 482,182 thousand, 2<sup>nd</sup> - 3<sup>rd</sup> degree – 37,441 thousand, and in 2015 the incidence of goitre of the 1st degree decreased by 55% (198 324 thousand), 2<sup>nd</sup> - 3<sup>rd</sup> degree – by 60% (143 91). The incidence of diffuse goitre has decreased over the past 15 years: from 216,875 of adults with grade 1 goitre to 85,105 (by 61%), from 34,894 people with grade 2 to 3 goitre to 14,391 (by 59%). Among children, the decrease in the number of patients is also noticeable – from 98,847 children with initial manifestations of goitre to 32,562 (by 67.4%) and from 8,460 children with grade 2 - 3 goitre to 1,914 (by 76%). Relevant data on preventive work per 100 thousand children in recent years, compared to 2002 are given in table. 2.

Taking into consideration the above data, it can be stated that for 6 months at an average cost of drugs for prevention and treatment at 50 UAH per month for 270 thousand children, cost savings is 81 million 45 thousand UAH.



Table 2

## Prevalence and incidence of diffuse and nodular goitre in children aged 0 to 14 years

Number of cases per 100 thousand children						
1 <sup>st</sup> degree goitre			2 <sup>nd</sup> degree goitre		nodular goitre	
year	prevalence	morbidity	prevalence	morbidity	prevalence	morbidity
2002	6065.2 ± 75.5	1243.3 ± 35	432.6 ± 20.8	106.4 ± 10.3	19.0 ± 4.4	5.8 ± 2.4
2007	5316.9 ± 71.0*	906.9 ± 30.0 *	314.9 ± 17.7 *	51.3 ± 7.2 *	12.2 ± 3.5	4.1 ± 2.0
2008	5002.9 ± 68.9*	856.0 ± 29.1 *	295.6 ± 17.2 *	54.7 ± 7.4 *	10.3 ± 3.2	3.3 ± 1.8
2009	4725.0 ± 67.1*	846.0 ± 29.0 *	259.5 ± 16.1 *	44.7 ± 6.7 *	11.2 ± 3.3	4.1 ± 2.0
2010	4485.2 ± 65.5*	769.5 ± 27.6 *	239.0 ± 15.4 *	43.7 ± 6.6 *	11.3 ± 3.4	3.6 ± 1.9
2011	4193.7 ± 63.4*	709.5 ± 26.5 *	212.0 ± 14.5 *	38.8 ± 6.2 *	11.8 ± 3.4	4.1 ± 2.0
2012	3935.0 ± 61.5*	658.7 ± 25.6 *	200.0 ± 14.1 *	36.8 ± 6.1 *	12.3 ± 3.5	4.1 ± 2.0
2013	3636.0 ± 59.2*	595.9 ± 24.3 *	180.2 ± 13.4 *	34.5 ± 5.9 *	12.3 ± 3.5	4.1 ± 2.0
2014	3319.7 ± 56.7*	539.3 ± 23.2 *	169.5 ± 13.0 *	32.8 ± 5.7 *	12.6 ± 3.5	4.1 ± 2.0
2015	3075.0 ± 54.6*	504.9 ± 22.4 *	160.2 ± 12.6 *	29.7 ± 5.4 *	12.7 ± 3.6	3.24 ± 1.8
2016	2895.1 ± 53.0*	479.2 ± 21.8 *	148.4 ± 12.2 *	26.4 ± 5.1 *	14.0 ± 3.7	4.9 ± 2.2
2017 - 2019 **						

Notes: \* -  $p \leq 0.05$  compared to 2002;

\*\* - because of the termination of record-keeping by the Ministry of Healthcare of Ukraine data is not available.

The economic effect of iodine prophylaxis is undeniable. This is evidenced by numerous calculations. Here is an eloquent figure: in just 2 years, the economic effect would be approximately 920 million hryvnias.

Following the calculations given above and used in other countries, it can also be stated that these initial measures were sufficient to reduce the loss of intellectual potential of the population. If the incidence of thyroid pathology decreased by approximately 25% in 5 years, it can be assumed that children with reduced intelligence were born by 42,840 people less, while the loss of IQ decreased by 577,540 units. This is a significant social and economic result, which indicates the high effectiveness of preventive measures and the possibility of raising the quality and quantity of living standards in Ukraine from 0.5 to 30%. The development and implementation of new samples of table salt is adequate to the needs of the population.

Awareness of the population and state assistance in the development of prevention programmes have reduced the number of cases of

thyroid pathology, which in turn has a significant economic effect in the form of reduction of the cost of diagnosis, treatment and follow-up of persons with thyroid disorder.

**Conclusions.** A detailed study of iodine supply of various segments of the population of Ukraine has proved the negative effects of iodine deficiency on health; in particular, it was found that the overall decline in productivity of the generation of children in iodine deficiency populations is 5%.

Measures to eliminate iodine-dependent disorders among the population of Ukraine have been developed and implemented.

The development and production of iodized table salt, adequate to the needs of the population, has been carried out.

The result of devised and implemented measures to eliminate iodine-dependent disorders and improve the nation's intelligence is the improvement of iodine supply of the population, according to official data, a significant reduction in thyroid disorder cases, especially among those affected by <sup>131</sup>I, which has an important socio-economic effect, even for this indicator only.

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### **СОЦІАЛЬНО-ЕКОЛОГІЧНА ТА МЕДИЧНА ПРОБЛЕМИ НЕСТАЧІ ЙОДУ СЕРЕД НАСЕЛЕННЯ УКРАЇНИ**

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**РЕЗЮМЕ. Мета.** Вивчення йодного забезпечення різних верств населення на всій території України, встановлення рівня захворюваності, зумовленого нестачею йоду, стан профілактичних заходів, їх ефективність та розробка адекватних шляхів масової, групової та індивідуальної профілактики йододефіциту в організмі, що сприятиме зниженню рівня захворюваності населення ендемічних на йод регіонів. У статті розглянуто найважливіші результати багаторічних епідеміологічних досліджень вивчення йодного забезпечення різних категорій населення практично всіх регіонів України. Значний об'єм цієї роботи виконано за підтримки МОЗ України, представництва Дитячого фонду ЮНІСЕФ в Україні, а також центру CDC в Атланті (США), який впродовж понад 19 років здійснював зовнішній контроль за якістю вивчення йодного статусу населення України. Наведено дані щодо вмісту йоду в харчуванні та біологічних рідинах населення регіонів, постраждалих внаслідок Чорнобильської катастрофи та показано залежність дози опромінення щитоподібної залози від забезпечення організму стабільним йодом і оптимізації вмісту останнього в організмі людей після прийняття Державної програми профілактики йодної недостатності населення на 2002–2005 роки. Підкреслено ефективність масової йодної профілактики шляхом вживання універсально йодованої харчової солі. У статті представлені дані про запропоновані та впроваджені шляхи масової, групової та індивідуальної йодопрфілактики, вивчена їх ефективність і показана позитивна динаміка змін при забезпеченні населення аліментарним йодом, а також доведено необхідність постійного вживання продуктів із достатнім вмістом аліментарного йоду, зокрема йодованої кухонної солі. Описано суттєві зміни щодо поширеності та захворюваності населення на тиреоїдну патологію, соціально-екологічні та медичні переваги профілактики йодозалежних захворювань. Стаття підготовлена як науковий інформаційний матеріал для сімейних лікарів, ендокринологів, акушер-гінекологів, гігієністів, громадськості, МОЗ України у зв'язку з необхідністю законодавчого вирішення проблеми профілактики йодозалежних захворювань в Україні.

**Матеріали та методи.** Для вивчення проблеми та оцінки стану нестачі йоду на території України вперше застосовано критерії, рекомендовані ВООЗ та дитячого фонду ООН (ЮНІСЕФ), розроблено та впроваджено методику визначення вмісту йоду в організмі, що дозволило приєднатися до міжнародної системи "Equip" контролю за станом йодного забезпечення у світі та в Україні. Це надало можливість перейти від опосередкованих до прямих методів визначення надходження йоду в організм.

**Висновки.** Детальне вивчення йодного забезпечення різних верств населення України довело, що дефіцит йоду має негативні наслідки для здоров'я, зокрема встановлено, що загальне зниження продуктивності покоління дітей у йододефіцитних популяціях становить 5%.

Розроблено та запроваджено заходи щодо ліквідації йодозалежних захворювань серед населення України.

Здійснено розробку та започатковано випуск харчової йодованої солі, адекватної потребам населення. Наслідком розроблених та впроваджених заходів щодо ліквідації йодозалежних захворювань стане поліпшення інтелекту нації. Покращення йодної забезпеченості населення, за офіційними даними,

суттєво знизить кількість захворювань щитоподібної залози, особливо серед осіб, які зазнали впливу дії  $^{131}\text{I}$ , що має значний соціально-економічний ефект.

**Ключові слова:** аварія на ЧАЕС, дефіцит йоду, йодована сіль, населення, профілактика, регіони.

### СОЦИАЛЬНО-ЭКОЛОГИЧЕСКАЯ И МЕДИЦИНСКАЯ ПРОБЛЕМЫ НЕДОСТАТОЧНОСТИ ЙОДА СРЕДИ НАСЕЛЕНИЯ УКРАИНЫ

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**РЕЗЮМЕ. Цель.** Изучение йодного обеспечения различных слоев населения на всей территории Украины, установление уровня заболеваемости, обусловленного нехваткой йода, состояние профилактических мероприятий, их эффективность и разработка адекватных путей массовой, групповой и индивидуальной профилактики йододефицита в организме приведет к снижению уровня заболеваемости населения эндемичных йодом регионов.

В статье рассмотрены важнейшие результаты многолетних эпидемиологических исследований, направленных на изучение йодного обеспечения различных категорий населения практически всех регионов Украины. Значительный объем этой работы выполнен при поддержке МЗ Украины, представительства Детского фонда ЮНИСЕФ в Украине, а также центра CDC в Атланте (США), который на протяжении более 19 лет осуществлял внешний контроль за качеством изучения йодного статуса населения Украины. Приведены данные по содержанию йода в питании и биологических жидкостях населения регионов, пострадавших вследствие Чернобыльской катастрофы и показано зависимость дозы облучения щитовидной железы от обеспечения организма стабильным йодом и оптимизации содержания последнего в организме людей после принятия Государственной программы профилактики йодной недостаточности населения на 2002-2005 годы. Подчеркнуто эффективность массовой йодной профилактики путем применения универсально йодированной пищевой соли. В статье представлены данные о предлагаемых и внедренных путях массовой, групповой и индивидуальной йодопрфилактики, изучена их эффективность и показана положительная динамика изменений при обеспечении населения алиментарным йодом, а также доказана необходимость постоянного употребления продуктов с достаточным содержанием алиментарного йода, в частности йодированной поваренной соли. Описаны существенные изменения в распространенности и заболеваемости населения тиреоидной патологией, социально-экологические и медицинские преимущества профилактики йодозависимых заболеваний. Статья подготовлена как научный информационный материал для семейных врачей, эндокринологов, акушеров-гинекологов, гигиенистов, общественности, МЗ Украины в связи с необходимостью законодательного решения проблемы профилактики йодозависимых заболеваний в Украине.

**Материалы и методы.** Для изучения проблемы и оценки состояния недостатка йода на территории Украины впервые применены критерии, рекомендованные ВОЗ и детским фондом ООН (ЮНИСЕФ), разработана и внедрена методика определения содержания йода в организме, что позволило присоединиться к международной системе "Equip" контроля за состоянием йодного обеспечения в мире и в Украине. Это позволило перейти от опосредованных к прямым методам определения поступления йода в организм.

**Выводы.** Детальное изучение йодного обеспечения различных слоев населения Украины доказало негативные последствия дефицита йода для здоровья, в частности установлено, что общее снижение производительности поколения детей в йододефицитных популяциях составляет 5 %.

Разработаны и внедрены меры по ликвидации йодозависимых заболеваний среди населения Украины. Осуществлена разработка и начат выпуск пищевой йодированной соли, адекватной потребностям населения.

Следствием разработанных и внедренных мероприятий по ликвидации йодозависимых заболеваний является улучшение интеллекта нации, йодной обеспеченности населения и, по официальным данным, существенное снижение количества заболеваний щитовидной железы, особенно среди лиц, подвергшихся воздействию  $^{131}\text{I}$ , что имеет значительный социально-экономический эффект.

**Ключевые слова:** авария на ЧАЭС, дефицит йода, йодированная соль, население, профилактика, регионы.

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