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IODINE DEFICIENCY IN CHILDREN IN THE FAR EASTERN FEDERAL DISTRICT: PROBLEMS AND SOLUTIONS

An observational, analytical, cross-sectional study was conducted to assess the prevalence of iodine deficiency among children living in the Arctic and southern zones of the Far Eastern Federal District (FEFD). A total of 188 children aged 1 to 18 years, permanently residing in the Arctic zone of the FEFD - Chukotka Autonomous Okrug (ChAO), Anadyr (n = 120), and the southern zone - Khabarovsk Krai, Khabarovsk (n = 68), were included in the study by simple random sampling. Depending on their age, the study participants were divided into comparison groups: young children (1-3 years old, n = 38), preschoolers (4-6 years old, n = 46), primary school children (7-11 years old, n = 46), and adolescents (12-18 years old, n = 58). Iodine status was assessed by determining the concentration of ioduria using the arsenite-cerium method. The study revealed that only 26.1% of children living in the Far North had normal iodine levels in their bodies. Mild, moderate, and severe iodine deficiency was diagnosed in 34.0%, 30.3%, and 9.6% of those examined, respectively. The incidence of low iodine status in children in the Far North was 2.6 times higher than in the southern zone (80.9% and 61.8%, respectively, OR = 2.611, 95% CI 1.339-5.090), with a significant prevalence of moderate iodine deficiency (37.5% and 17.7%, respectively, p = 0.005). Interviews with parents of the examined children revealed that only 20.0% of Far East families use iodized salt daily, which is categorically insufficient to eliminate iodine deficiency.

Keywords: iodine, ioduria, iodine deficiency, iodized salt, children, Arctic zone, Far Eastern Federal District

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Introduction. Iodine is an essential microelement required for the synthesis of thyroid hormones and, as a result, plays a key role in maintaining adequate metabolism in the body [20]. Chronic insufficient iodine intake can lead to the development of iodine deficiency diseases (IDD), including endemic goiter, subclinical hypothyroidism, impaired fertility, as well as a decrease in cognitive reserve and the formation of growth and developmental abnormalities in children [6, 7].

According to the latest global estimates, the incidence of iodine deficiency is 108.3 per 100,000 population, with a higher prevalence among women – 139.8/100,000, for males this figure is 78.1/100,000. The prevalence of iodine deficiency varies depending on the socio-demographic indicator: low-income countries have the highest incidence of iodine deficiency - 205.0/100,000, and, conversely, regions with a high standard of living are characterized by the minimum prevalence of iodine deficiency - 20.5/100,000 [19].

In 2019, the highest iodine deficiency rates at the regional level were recorded in Central Africa (458.95 per 100,000 population), Southern Asia (211.47 per 100,000 population) and Eastern Africa (185.56 per 100,000 population), while the lowest iodine deficiency rate at the regional level was recorded in Oceania (4.31 per 100,000 population) [19].

It is interesting to note that in 1990, the number of people suffering from iodine deficiency worldwide was 146.4 million, in 2021 there was an increase in the global prevalence of iodine deficiency to 180.8 million (an increase of 23.5% compared to 1990) and is projected to reach 194.5 million by 2050 (an increase of 7.6% compared to 2021) [17].

The development of deficiency states in both adults and children may occur due to a number of reasons, namely: unbalanced nutrition, inadequate nutrient intake, food selectivity, unconventional diets [3, 8, 16], and elemental imbalances in the environment [11]. In nature, iodine is found in the form of chemical compounds, mainly in the form of iodides and iodates [10]. Iodide is mainly found in soil and sea water, and due to its volatility, iodine compounds enter the atmosphere, thus causing its natural biogenic migration with subsequent impact on the iodine content in food products [20]. Historically, high prevalence of iodine deficiency was observed in the population of inland regions (Central Asia and Africa, Central and Eastern Europe, central USA), mountainous areas (Alps, Andes, Atlas, Himalayas) and areas with frequent floods (Southeast Asia) [20]. However, given the current data on the prevalence of iodine deficiency, all population groups require increased attention due to the presence of not only biogeochemical provinces of territories, but also low iodine supply due to inadequate nutritional status.

Over the past decades, a high level of iodine deficiency has persisted among the child population of Russia, regardless of the climatic and geographical zone of residence [1]. Particular attention is required to the regions of the Russian Arctic due to the diversity of elemental status imbalances in children, leading to the development of microelementoses - environmentally dependent diseases of

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biogeochemical nature (IDD) [5], which negatively affects both the health of each individual and the well-being of the population as a whole.

The only territory of the Far Eastern Federal District that is fully related to the Arctic zones of the Russian Federation is the Chukotka Autonomous Okrug. The latest studies of mineral metabolism in the aboriginal inhabitants of the Chukotka Peninsula were conducted in the 1970-1980s [5]. However, it should be taken into account that over a long period of time, global ecological and climatic changes have occurred, as well as a transformation of the demographic structure of the population with a change in lifestyle, including those associated with nutrition [5], which necessitates a revision of the iodine status parameters.

Aim of the study – to assess the prevalence of iodine deficiency among children living in the Arctic and southern zones of the Far Eastern Federal District.

Materials and methods. *Study design:* observational, analytical, cross-sectional study.

Using a simple random sampling method, 188 children aged 1 to 18 years, permanently residing in the Chukotka Autonomous Okrug (ChAO, Anadyr, n=120), which is an Arctic territory, and in Khabarovsk Territory (Khabarovsk, n=68), which belongs to the southern zone of the Far Eastern Federal District, were included in the study. When analyzing the iodine status depending on the age of children living in the Far Eastern Federal District, study groups were formed according to the main principles of age periodization: young children (1-3 years, n=38), preschoolers (4-6 years, n=46), primary school children (7-11 years, n=46) and adolescents (12-18 years, n=58). An analysis of iodine status was also conducted in groups formed by gender, but without taking into account age: a group of boys (n=103) and girls (n=85).

Biological material was collected to determine iodine status in the period from July to August 2024 in the children's clinic of the State Healthcare Institution Chukotka District Hospital of the Department of Health of the Chukotka Autonomous Okrug, Anadyr, as well as city children's clinics in Khabarovsk. In addition, interviews were conducted with the parents of the examined children to determine the family's commitment to the use of iodized salt and foods with a high iodine content.

Inclusion criteria: children aged 1-18 years, permanently residing in the Chukotka Autonomous Okrug (Anadyr) and Khabarovsk Territory (Khabarovsk), conditionally healthy (health groups 1-2, established by a pediatrician during a routine preventive examination), who have not taken iodine-containing dietary supplements for at least 3 months prior to the start of the study, written voluntary informed consent to participate in the study from the children's legal representatives.

In 2007, leading international organizations (WHO, UNICEF, ICCIDD) proposed epidemiological criteria for monitoring iodine deficiency states based on ioduria indicators. In this regard, the level of iodine supply to children's bodies was assessed by determining the concentration of the trace element in a single portion of morning urine using the arsenite-cerium method, which is regulated by MU 2.3.7.1064-01. The concentration of iodine in urine of 100-200 μg/l was assessed as a normal level of supply, the range of 50-99 μg/l was defined as mild iodine deficiency, the interval of 20-49 μg/l corresponded to moderate iodine deficiency, and with ioduria less than 20 μg/l, severe iodine deficiency was diagnosed [18].

The study was approved by the local ethics committee at the Far Eastern State Medical University of the Ministry of Health of the Russian Federation (protocol No. 2 dated 16.05.2024).

Statistical analysis of the study results was performed using Statistica 12.0 (StatSoft Inc., USA) and IBM SPSS Statistics 20. The study results are presented as the median (Me), interquartile range (Q1; Q3), relative value and its error. Comparison of quantitative indicators in the study groups was performed using the Kruskal-Wallis test with subsequent post hoc analysis and pairwise comparison of groups using the Dunn test. When analyzing multifield tables, the statistical significance of differences in relative indicators was assessed using the Pearson $\chi 2$ test or Fisher's exact test in accordance with the restrictions on the number of observations. For a quantitative assessment of the relationship between a certain outcome and a risk factor when comparing two groups, the statistical indicator odds ratio (OR) was used. When calculating the OR, an estimate of 95% confidence intervals (CI) was used. Differences between groups were considered statistically significant at $p<0.05$.

Results and discussion. The study showed high prevalence of low iodine status among children in the Far Eastern Federal District, which was observed in 3 out of 4 children. Only 26.1±3.2% of study participants had normal iodine levels in their bodies. Every third child was diagnosed with mild iodine deficiency (34.0±3.5%), 30.3±3.4% and 9.6±2.2% of children suffered from moderate and severe iodine deficiency, respectively.

When analyzing the age characteristics of the distribution of the level of iodine supply in children, no statistically significant differences were obtained in the study groups (Table 1). The highest median value of iodine concentration in urine was recorded in younger schoolchildren - 70.0 μg/l, while it corresponded to a mild deficiency, and the upper quartile slightly exceeded the lower limit of the normal range of supply (104.0 μg/l). The medians of ioduria in the groups of early, preschool and adolescent children were lower, but were also within the limits of mild deficiency (59.0 μg/l, 54.0 μg/l and 63.0 μg/l, respectively).

Table 1. Comparative analysis of the level of iodine supply of children of different age groups living in the Far Eastern Federal District

Comparative analysis of the prevalence of different levels of supply did not reveal reliable differences in children of the comparison groups: in all age groups, mild and moderate iodine deficiency was predominant (Table 1). It should be noted that statistically significant differences in ioduria indicators depending on gender were also not recorded: the median value of iodine concentration in urine in boys was 62.0 μg/l, in girls – 65.0 μg/l ($p = 0.488$), the interquartile range was the same 41.0-103.0 μg/l.

A study of school-age children from La Pampa, Argentina, yielded results comparable to ours [13]: adequate iodine status was observed in 27.0% of study participants, iodine deficiency was diagnosed in 39.2% of cases. The median iodine value in the urine of the subjects was 145.5 μg/l, which is 2 times higher than the value in our study, however, despite its compliance with the optimal level of supply, 28.8% of children had iodine levels below 50 μg/l, a fact that the authors of the study attribute to the incomplete coverage of children's daily consumption of iodized salt (85.5%). Also, the concentration of ioduria in boys and girls did not differ statistically significantly and was equal to 139.7 μg/l (29.1–256.9) and 149.3 μg/l (61.5–209.5), respectively [13].

When assessing ioduria in children living in different climate-geographic zones of the Far Eastern Federal District, a statistically significant difference in iodine status was found in the study groups ($p < 0.001$) (Table 2): the median iodine

Table 1

Comparative analysis of the level of iodine supply of children of different age groups living in the Far Eastern Federal District

Age group	1-3 years (n=38)	4-6 years (n=46)	7-11 years (n=46)	12-18 years (n=58)	p
Me (Q1; Q3), µg/l	59.0 (41.0; 86.0)	54.0 (35.0; 104.0)	70.0 (41.0; 104.0)	63.0 (43.0; 103.0)	0.636
Severe iodine deficiency (abs., P±m)	2 (5.3±3.6)	7 (15.2±5.3)	5 (10.9±4.6)	4 (6.9±3.3)	0.397
Moderate iodine deficiency (abs., P±m)	13 (34.2±7.7)	15 (32.6±6.9)	12 (26.1±6.5)	17 (29.3±6.0)	0.844
Mild iodine deficiency (abs., P±m)	15 (39.5±7.9)	11 (23.9±6.3)	16 (34.7±7.0)	22 (37.9±6.4)	0.380
Normal iodine level (abs., P±m)	8 (21.0±6.6)	13 (28.3±6.6)	13 (28.3±6.6)	15 (25.9±5.8)	0.869

concentration in the urine of children in the Arctic territory was 50.5 µg/l, which is 1.5 times less than in the southern zone (74.5 µg/l).The incidence of low iodine status in children in the Far North was 2.6 times higher than in the southern zone (80.9±3.6% and 61.8±5.9%, respectively, OR = 2.611, 95% CI 1.339-5.090), with a significant predominance of moderate iodine deficiency (37.5±4.4% and 17.7±4.6%, respectively, p = 0.005). Optimal iodine status among northern children was twice as rare (19.1±5.9% and 38.2±5.9%, respectively, p = 0.005; OR = 0.383, 95% CI (0.196-1.747)), which raises concerns.

Table 2. Features of iodine status in children living in different climatic and geographical zones of the Far Eastern Federal District

An analysis of the iodine status of children aged 3-6 years living in different climatic and geographical regions of the Republic of Sakha (Yakutia) showed that the highest prevalence of iodine deficiency was characteristic of the southern territory: in the Central zone, 54.6% of children suffered from iodine deficiency, in the Arctic zone - 57.7%, in the Western zone - 68.5%, in the Eastern zone - 72.8% and in the Southern zone - 77.0% [9], which may be associated with the peculiarities of the nutritional component of iodine provision, but not the influence of the ecological and climatic component.

Due to the limited number of studies on the iodine status of children living in the Arctic, we decided to study the iodine status of northern children in more detail. In general, when analyzing the absolute values of iodine concentration in the urine, it was determined that in the groups of children of early and primary school age, the median value was in the range of mild deficiency (59.0 µg/l and 62.5 µg/l, respectively), while in preschoolers and adolescents the level of provision corresponded to moderate de-

Table 2

Features of iodine status in children living in different climatic and geographical zones of the Far Eastern Federal District

Territory	Arctic zone (n=120)	Southern zone (n=68)	p	OR (95% CI)
Me (Q1; Q3), µg/l	50.5 (34.0; 87.5)	74.5 (53.5; 114.0)	**< 0.001**	-
Severe iodine deficiency (abs., P±m)	14 (11.7±2.9)	4 (5.9±2.9)	0.302	2.113 (0.667-6.699)
Moderate iodine deficiency (abs., P±m)	45 (37.5±4.4)	12 (17.7±4.6)	**0.005**	**2.800 (1.356-5.780)**
Mild iodine deficiency (abs., P±m)	38 (31.7±4.3)	26 (38.2±5.9)	0.362	0.749 (0.402-1.395)
Normal iodine level (abs., P±m)	23 (19.1±5.9)	26 (38.2±5.9)	**0.005**	**0.383 (0.196-1.747)**

Table 3

Level of iodine supply of children living in the Arctic zone of the Far Eastern Federal Distric

Me (Q1; Q3), µg/l	1-3 years (n=30)	4-6 years (n=30)	7-11 years (n=30)	12-18 years (n=30)	p
Severe iodine deficiency (abs., P±m)	59.0 (41.0; 104.0)	38.5 (23.0; 62.0)	62.5 (32.0; 97.0)	49.0 (34.0; 89.0)	**0.045**
Moderate iodine deficiency (abs., P±m)	0 (0.0)	7 (23.4±7.7)	3 (10.0±5.5)	4 (13.3±6.2)	**0.029**
Mild iodine deficiency (abs., P±m)	11 (36.7±8.8)	13 (43.2±9.1)	10 (33.3±8.6)	11 (36.7±8.8)	0.879
Normal iodine level (abs., P±m)	11 (36.7±8.8)	7 (23.4±7.7)	10 (33.3±8.6)	10 (33.3±8.6)	0.720
Нормальный уровень йода (абс., P±m)	8 (26.6±8.1)	3 (10.0±5.5)	7 (23.4±7.7)	5 (16.7±6.8)	0.383

ficiency (38.5 μg/l and 49.0 μg/l, respectively) (p = 0.045) (Table 3).

Table 3. Level of iodine supply of children living in the Arctic zone of the Far Eastern Federal Distric

The highest prevalence of moderate iodine deficiency was recorded in preschool children (43.2±9.1%), slightly less in young children and adolescents (36.7±8.8%). Severe iodine deficiency was found in preschool children 2 times more often than in school-age children and was not diagnosed at all in children aged 1-3 years (p = 0.029). The normal level of provision in children of different ages did not have reliable differences and was found in 1-4 children out of 10 (p = 0.383) (Table 3).

Based on the results of interviewing the parents of the examined children, it was found that only 21.6±5.3% of families in the southern territory of the Far Eastern Federal District use iodized salt in food, while a similar trend is observed in the Arctic zone: 18.3±3.5% of families are committed to the daily use of iodized salt. Fish and fish products were included in the weekly diet of 26.7±4.0% of children in the Arctic, which is 2 times less than the consumption among children in the southern zone (47.1±6.1%, p = 0.005). However, the latter prefer river fish, which contains less iodine than sea fish.

Since 1995, China has implemented a policy of universal salt iodization to prevent and treat iodine deficiency diseases, which has gradually solved the problem of iodine deficiency. An analysis of iodine nutrition in Hainan Province found that the main source of iodine was iodized salt, with a coverage rate of 98.6%, while the contributions of kelp, milk, seaweed, fish and seafood were only 8.2%, 7.3%, 6.6% and 2.4%, respectively [15]. Interestingly, the average urinary iodine value of children in the central mountainous zone was 190.8 μg/l, which was significantly higher than that in the western and eastern coastal zones (149.4 μg/l and 161.0 μg/l, respectively) [15].

A similar study of 8- to 10-year-old children conducted in Chongqing Municipality, China, also found statistically significant differences in median urinary iodine concentrations in children from different climatic and geographical regions: the highest mean urinary iodine concentration was observed in children from Southeast Chongqing (252.6 μg/l), slightly lower in those examined in the central city zone (250.0 μg/l), and statistically significantly lower urinary iodine levels were recorded in children from West and Northeast Chongqing (221.0 μg/l and 200.6 μg/l, respectively) [14].

Differences in the level of iodine supply with universal consumption of iodized salt and products with a high iodine content are associated with the characteristics of the content, accumulation and biogenic migration of iodine compounds in soil, water and plant products, which also contribute to the iodine status of residents of these territories and vary depending on the terrain, agrophysical and agrochemical properties of soils, as well as the climate of the territory [10, 15].

Conclusion. The study revealed a high prevalence of low iodine status in children living in the Far Eastern Federal District, which was observed in 73.9% of cases with a higher prevalence of severe and moderate iodine deficiency in children living in the Arctic zone. Statistically significant differences in iodine content in the body of children of different age groups were determined only in northern children, in whom the highest prevalence of iodine deficiency was observed in preschool age, which is probably due to the formation of food selectivity, the lack of iodine supplements in the form of iodized salt, drugs or dietary supplements.

At the present stage, the paradigm of eliminating iodine deficiency with an emphasis on nutritional status comes to the fore, i.e. iodine status largely depends on the level of commitment to the use of iodized salt and iodine-rich foods, which requires health education work by pediatricians in order to increase parents' awareness of ways to eliminate iodine deficiency by correcting children's diets and supplementation to prevent thyroid diseases, physical and cognitive development disorders in the younger generation.

At the national level, it is necessary to develop the production of functional food products, expand the range of snack products and Health & Wellness products for healthy eating, enriched with iodine, which will have a health-saving effect. [2, 4, 12].

The authors declare no conflict of interest.

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HYGIENIC SITUATION AND OCCUPATIONAL MORBIDITY AT COPPER-ZINC ORE MINING ENTERPRISES

The article is devoted to the hygienic assessment of working conditions and their impact on the health of employees of a mining enterprise engaged in the extraction and processing of copper-zinc ore located in the Southern Urals. The relevance of the study is due to the need for a detailed study of the hygienic situation in all divisions of a mining enterprise in order to assess the levels of occupational risk of damage to the health of employees and timely preventive measures aimed at minimizing it. Priority harmful production factors have been identified in the workplaces of various departments: during underground ore mining, noise, vibration, lack of natural light, unfavorable microclimate, severity, and labor intensity; during transportation of extracted ore, vibro-acoustic factors, severity, and labor intensity; during ore processing, noise. The overall assessment of the workers' working conditions corresponded to harmful classes 3.1-3.3. Working environment factors contributed to the formation of chronic somatic diseases among workers engaged in mining and transporting ore, among which dorsopathies and arthropathies prevailed, which is confirmed by the high strength of the association of these diseases with working conditions. In the workers of the processing plant, dorsopathies with an average degree of association were attributed to diseases related to working conditions. The structure of occupational morbidity was dominated by diseases caused by exposure to vibration, aerosols, mainly fibrogenic effects, and physical overloads. Workers engaged in mining and transporting ore have the highest occupational morbidity index (0.32 - 0.50). The highest total assessment of occupational health risk, taking into account all the studied indicators, was established for workers engaged in underground mining. The materials of the conducted research served as the basis for the development of medical and preventive recommendations to minimize the occupational risk to the health of employees of the studied enterprise.

Keywords: mining enterprise, workers, harmful production factors, occupational diseases, diseases related to working conditions

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Introduction. Despite the implementation of national programs aimed at preserving the longevity and active life of the working population, a high proportion of workers employed in unfavorable working conditions remains at individual enterprises in various sectors of the economy, and occupational diseases are registered. Such industries include mining, in which more than half of employees work in conditions that negatively affect their health, and the level of occupational morbidity over the past five years, according to Rosstat, has varied from 15.2 to 21.2 cases per 10,000 employees.

There is a high risk of adverse effects of harmful production factors on the health of employees of enterprises in this industry, including companies engaged in the extraction and processing of metal ores [3-5, 7, 8, 10, 13, 15].

According to various authors, vibration sickness, sensorineural hearing loss, diseases of the peripheral nervous