

Short communication

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Mercury and hazard to health of the population of the Yamalo-Nenets Autonomous Okrug

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ABSTRACT. The aim of this study was to assess the mercury hazard to the health of the population in the Arctic zone on the example of the Yamalo-Nenets Autonomous Okrug (YaNAO). The study included two stages. At the first stage, we assessed the potential risk associated with the mercury intake in the body with local food products and water based on the hazard quotient (HQ). At the second stage, we examined the selected groups of the adult population living over 20 years in the Arctic and analysed the mercury concentrations in biological substrates to identify the dependence of the somatic and neuropsychic disorders on the mercury concentrations. The mean values of mercury intake in the body with food products were 0.001 mg/kg for adults per week, and 0.0015 mg/kg – for children. HQ was acceptable and correlated with the mercury concentrations in biological substrates. We identified the risk of low stress resistance (OR = 2.4 [1.3-6.2]) in people who had elevated mercury concentrations in their hair. In the risk group, the proportion of the examined people with elevated mercury concentrations in their hair was 46.0%, while in the comparison group it was 38.8%, and the mean concentrations of this toxicant were also higher, 2.51 µg/g and 1.69 µg/g, respectively. The risks of low self-assessment of health (OR = 5.7 [2.1-15.2]) and low stress resistance (OR = 3.3 [1.3-8.3]) were typical of people with low neuropsychic adaptation. Therefore, despite the absence of somatic health hazard for the newly arrived population of YaNAO, the people with elevated mercury accumulation showed a decrease in the neuropsychic adaptation, which determines the need to introduce biomonitoring in the medical examination system for the population of the Arctic.

Keywords: mercury, the Arctic, biological matrices, health hazard

1. Introduction

The global Convention on Mercury indicates that ecosystems and indigenous communities in the Arctic are especially vulnerable to toxicants, including through biomagnification and mercury pollution of traditional foods. It was shown that in the Arctic zone, between the polar sunrise and the end of snowmelt, the influx of Hg from the atmosphere to the terrestrial and aquatic ecosystems increases dramatically, leading to its accumulation in the food chains (Lindberg et al., 2002; Dudarev and Odland, 2017). This can explain the elevated concentrations of Hg in the tissues of Arctic fish and animals (Córdoba-Tovar et al., 2022). Selenium, zinc and other elements are mercury antagonists (Rahman et al., 2018; Castriotta et al., 2020). In this regard, of special importance is the expansion of knowledge about the Hg accumulation in the bodies of the Arctic residents with a deficiency of essential elements and an excess of toxic ones. To prevent

chronic non-communicable diseases and maintain health, it is necessary to preserve the specifics of the Arctic diet that should contain such products as fish and reindeer meat. The results of biological monitoring conducted previously by researchers from Arctic Research Center revealed that the Hg concentrations in biological matrices of the population of the Yamalo-Nenets Autonomous Okrug (YaNAO) varied greatly depending on gender, age and ethnicity (Agbalyan and Shinkaruk, 2018; Agbalyan et al., 2018).

The aim of the study was to assess the mercury hazard to the health of the Arctic population on the example of YaNAO.

2. Materials and methods

Hg quantification was carried out by inductively coupled plasma mass spectrometry (ICP-MS) and a sample preparation system based on microwave-assisted decomposition. A value of <0.01 µg/mL was the upper

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limit of the permissible Hg concentration in the blood (Skalny et al., 2004). The value of 0.01 $\mu\text{g}/\text{mL}$ was the maximum safe mercury level for an adult. In addition to Hg, nutrients (Zn and Se) were determined in hair and blood. A risk for humans was assessed based on the maximum and mean exposition, taking into account an oral route as the most likely.

Clinical and psychological examinations, as well as a sociological survey, included 120 permanent representatives of the newly arrived population living over 20 years in the Arctic (in the cities of Labytnangi and Salekhard, and the Kharp settlement), among which 30% were men. Studies at the individual level included such blocks as general characteristics, chronic morbidity, psycho-emotional state, and concentrations of trace elements in the body. For statistical processing, methods of parametric and nonparametric analyses were used based on the approaches recommended for biomedical research (Medik and Tokmachev, 2007; Grzhibovsky, 2008). In comparing the frequency indicators in the cities studied, the significance criterion was adopted, taking into account the Bonferroni correction ($p < 0.017$). The closeness of the relationship was assessed by the Pearson and Spearman correlation coefficients. To identify factors that characterised the relationship between groups of parameters, factor analysis with varimax rotation was used. To determine the dependence of health disorders on the effect of some factors, the odds ratio was calculated with a 95 percent confidence interval (OR (CI)).

3. Results and discussion

Table 1 shows the distribution of the respondents by the frequency of consumption of certain food types in the Labytnangi and Salekhard cities as well as in the Kharp settlement. We found that only 7.5% of respondents from the Kharp settlement daily consumed fish from local water bodies. 73.33% respondents from Salekhard and 52.2% respondents from the Kharp settlement indicated that they consumed the local fish "several times a month".

Among the respondents, 8.57% of Labytnangi residents and 4.44% of Salekhard residents daily consumed venison, and 8.57 and 13.33%, respectively, consumed it several times a week. The proportion of respondents consuming venison several times a month was close in Salekhard and Kharp (37.78 and 30.3%).

Concerning the consumption of offal (primarily liver), the differences were revealed in comparing the Labytnangi and Kharp groups ($p = 0.023$). The average daily consumption of offal was 0.005 kg/day.

Taking into account the intake of Hg from foods and drinking water, we determined that the mean weekly Hg dose for the population based on its maximum concentration in food was 0.003 mg/kg in adults. Calculating the average values indicated that the weekly Hg intake was 0.001 mg/kg, which reflects an acceptable risk and corresponds to the Hg concentrations in biological substrates. The hazard quotients for the consumption of food products (offal) of the local supply ranged from 0.19 to 0.9.

The Hg concentration in the blood of men varied greatly (Table 2). The mean concentration for the group was $0.0024 \pm 0.0009 \mu\text{g}/\text{mL}$. In groups of women, there were no differences in the concentrations, and the mean value was slightly lower than in men ($0.0019 \pm 0.0004 \mu\text{g}/\text{mL}$). These values testified to a low health hazard to the population, which was caused by the presence of Hg in the blood. Previous studies indicated that the mercury concentration in the blood of indigenous residents of YaNAO was much higher. For example, it was $0.0131 \pm 0.0096 \mu\text{g}/\text{mL}$ in residents of the Kharsaim settlement and $0.0142 \pm 0.0085 \mu\text{g}/\text{mL}$ in residents of the Kutopiyugan settlement (Agbalyan et al., 2018).

The concentration of toxicants in hair better reflected long-term intake of toxicants (Tatsiy, 2013; Human biomonitoring..., 2015). In Salekhard, the mean group concentration of Hg in hair was two times higher than in Labytnangi and Kharp, and among women – 3.4 and 1.3 times, respectively. The mean value of Hg concentration in hair was $1.38 \pm 0.47 \mu\text{g}/\text{g}$ among men, and $1.17 \pm 0.30 \mu\text{g}/\text{g}$ among women (no significant differences were detected). The mercury concentration above 1 $\mu\text{g}/\text{g}$ was identified in 20.0% of the examined Labytnangi residents, 60.0% of the Salekhard residents and 47.5% of the Kharp residents ($r^2 = 13.0$; $p = 0.002$). There were no cases of concentrations at the level of clinically significant values.

We determined that health had moderate feedback with the level of neuropsychic adaptation ($r = -0.35$; $r = -0.33$) and place of residence ($r = -0.32$; $r = -0.48$). Furthermore, the Labytnangi residents rated their health as good more often than the Kharp residents, which generally coincided with the health

Table 1. Distribution of the examined people by the consumption frequency of the main types of food in the studied groups (% of respondents).

Food type	Consumption frequency	1-Labytnangi (n = 35)	2-Salekhard (n = 45)	3-Kharp (n = 40)	Significance of differences
Fish from local water bodies	daily	0.00 (0)	0.00 (0)	7.50 (3)	p1/2 = 0.000 p2/3 = 0.077 p1/3 = 0.0002
	several times a week	28.57 (10)	8.89 (4)	2.50 (1)	
	several times a month	0,00 (0)	73.33 (33)	52.50 (21)	
	rarely/ never	71.43 (25)	17.78 (8)	37.50 (15)	

Table 2 . Mercury concentrations in biological matrices of the adult newly arrived population of YaNAO

Indicators	YaNAO settlements					
	Labytnangi		Salekhard		Kharp	
	women	men	women	men	women	men
n	24	11	30	15	30	10
blood, µg/mL						
*Geometric mean	0.0001	0	0.0001	0	0.0002	0.0001
Standard error	0.0002	0.0004	0.0002	0.0001	0.0005	0.0003
hair, µg/g						
*Geometric mean	0.4351	0.661	1.1476	1.1445	1.2022	0.5112
Standard error	0.0704	0.1601	0.2409	0.2994	0.1881	0.6138

Note: * the concentrations are presented as Log because the distribution is log-normal.

assessments of the respondents, which were carried out by specialists. There was a direct dependence of the stress level in men on the zinc to mercury ratio ($r=0.47$) as well as an indirect dependence in terms of Se/As ($r=-0.37$). The correlation of the Se/Hg ratio in hair and stress assessment had the same direction both in men, $r=0.38$ ($p<0.017$), and in women, $r=0.13$ ($p>0.017$). Moreover, men showed a statistically significant dependence of neuropsychic adaptation on the balance of Zn/Hg ($r=0.46$) and Zn/Pb ($r=0.35$). All the variety of factors obtained during factor analysis revealed that the component-1 that determined 12% of the total dispersion was based on the circulation of toxic and assumed toxic elements in blood and hair. The concentrations of toxicants in hair had the greatest factor loading that was 0.97 for lead, 0.96 for mercury and 0.92 for manganese. The indicated elements had a negative effect on the nervous system, which led to certain limitations in our results and determined the future direction of research.

The calculation of the odds ratio for priority factors revealed the risk of low stress resistance ($OR=2.4$ [1.3-6.2]) and a trend in the proportion of people under regular medical check-up ($OR=1.2$ [0.4-3.5]) and having chronic diseases ($OR=1.1$ [0.5-2.3]).

4. Conclusions

Therefore, the Hg concentrations in the hair and blood of the adult population living over 20 years in YaNAO confirm the long-term intake of this toxicant in the bodies of 20 to 60% of the examined people in an amount below a clinically significant level. There were no relationships between disorders of somatic health and circulation of Hg in the body (in existing concentrations), but there was a risk of a decrease in stress resistance and neuropsychic adaptation. Study of dependency of health characteristics and balances of nutrients and mercury in blood and hair revealed that the higher the selenium to zinc ratio in the blood, the lower the stress level and the higher the neuropsychic adaptation in men.

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Conflict of interest

The authors declare no conflict of interest.

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