Regional aspects of assessing dietary effect of mercury on vulnerable populations

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Abstract. Analysis of mercury (Hg) and methyl mercury (MeHg) intake with the diet of children aged 3-6 years old from the city of Kazan was carried out. Meat and meat products, poultry, eggs (36.86 % and 28.84 % correspondingly), cereals and bakery goods (18.45 % and 42.74 % correspondingly), fish, non-finfish (28.79 % and 19.80 %) contributed most to Hg exposure at the median and the 95th perc levels. The value of exposure to MeHg in children at the median (0.1 μg / kg of body weight per week) and the 95th perc (0.33 μg / kg of body weight per week) levels did not exceed the recommendations of USEPA and the Joint FAO/WHO Expert Committee on Food Additives (JECFA). Non-carcinogenic risk from exposure to Hg with the main food groups at the median and the 95th perc levels was acceptable (HQ<1). Non-carcinogenic risk in children on MeHg intake at the level of the 95th perc made 2.29, that fact being unacceptable (HQ >1) and indicating the risk of neuropsychological disorders for younger children from the city of Kazan due to fish and seafood consumption.

Keywords: mercury, methylmercury, food products, non-carcinogenic risk assessment, the child population

1. Introduction. Modern scientific data show that exposure to toxic metals remains a serious problem for public health. In the countries with high level of fish intake, exposure to neurotoxic methylmercury (MtHg) in the prenatal period exceeded often the levels considered to be safe [1]. The implementation of the global legal instrument– the Minamata Convention on Mercury (2013) – can reduce economic losses associated with neurological disorders caused by exposure to mercury (Hg). The article 19 of this Convention requires agreed methodologies for monitoring of mercury levels in population [2].

The determination of regional (local) levels with the account of a complex of such ecologo-hygienic factors in the territory under study as the population morbidity, the environmental status and assessment of the health risk from exposure to environmental hazards remains an important aspect [3, 4, 5]. Mercury is a heavy metal, which is naturally present in the environment, but the human activity increased its concentration in the environment about three times for the past century [6]. In aquatic ecosystems, Hg transforms into its organic form, MeHg, which is more bioavailable and bioaccumulates in water food chains to reach the highest concentrations at the upper trophic levels. The assessment of exposure to MeHg can be carried out on the basis of Hg measurement in foods (fish and fish products). Methylmercury is the dominant form of mercury found in fish and other seafoods, and it is particularly toxic for the developing nervous system including the brain. The exposure of methylmercury with foods seldom exceeds TWI, but the probability of reaching such level increases with dietary intake in frequent fish consumers [7]. Although inorganic Hg is a food pollutant, its impact is considered to be less important because of low toxicity compared with MeHg [8].

Neurotoxicity of MeHg in humans is well studied and is shown in several large-scale epidemiological [9, 10]. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) considers that negative effects of pollutants can be balanced by positive effects of healthy nutrients in fish and sea foods [11]. New studies showed that positive effects associated with long-chain omega 3 fatty acids, present in fish, probably, resulted previously in underestimation of potential side effects of MeHg in fish. Therefore a scientific group of EFSA on food chain pollutants (the group CONTAM) studied new scientific information on toxicity of these mercury forms and assessed the preliminary TWI (tolerable weekly intake) [7].

2. Materials and methods. Analysis of actual nutrition of the 3-6- year old children in two basic fields of investigation: the study of individual and family nutrition (questionnaire method) and the study of nutrition in communities, where a child receives full or partial diet (time-weight method) was carried out. The pattern of actual nutrition of children in the Municipal Preschool Educational Institution No. 146 in the city of Kazan was identified by analysis of the monthly reports on food expenditure (according to cumulative records), as well as selectively according to menu production records. The assessment of children nutrition was supplemented by the results of the parents' questionnaire survey including food intake on weekends and in the evening on weekdays. The assessment of exposure to Hg coming with foods was carried out for the period from 2011 to 2014 on the basis of the median and the 95-th perc, in accordance with Guidelines 2.3.7.2519-09 "Exposure determination and risk assessment of the impact of chemical contaminants in foods on the population". The non-carcinogenic risk was assessed based on the research findings of Hg in food groups carried out on the basis of an accredited laboratory of the FSFHI "The Center of Hygiene and Epidemiology in the Republic of Tatarstan" in keeping with Guidelines P 2.1.10.1920-04 [12]. Characteristics of the total toxic effects were made based on hazard quotients (HQ) of certain substances and total hazard indices (HI) for the substances with synergistic effects [13]. According to EFSA the acceptable intake of TWI for MeHg should not exceed 1.3 μg / kg of body weight per week [7].

3. Results and discussion. The assessment results showed that the major contribution to Hg exposure at the median level and that of the 95th perc was made by meat and meat products, poultry, eggs (36.86 % and 28.84 % correspondingly), cereals and bakery goods (18.45 % and 42.74 % correspondingly), fish, non-finfish (28.79 % and 19.80%). The value of exposure to MeHg in children at the median level (0.1 μg / kg of body weight per week) and the level of the 95-th perc (0.33 μg / kg of body weight per week) did not exceed the recommendations of USEPA and the Joint FAO/WHO Expert Committee on Food Additives (JECFA) [14]. (Tables 1, 2).

Table 1. Results of exposure assessment (intake) of chemical contaminants with foods, μg (kg / 24hrs) (- 1) day

Contaminants	The years 2011-2014

	Exposure		%	
	Median	95th perc	Median	95th perc
Hg [1]	0.00016	0.00093	61.54	73.81
MeHg [2]	0.00010	0.00033	38.46	26.19
Total	0.00026	0.00126	100	100

[1] Exposure dose in Hg is calculated for food groups not including fish and non-finfish.
[2] Exposure dose in Hg is calculated for fish and non-finfish.

Table 2. Ranging of foods according to contribution to total exposure value of mercury for the period of 2011-2014

Food groups	Mercury	
	Median, %	95th perc, %
Meat and meat products; poultry, eggs	36.861	28.843
Milk and dairy products	7.609	1.058
Fish, non-finfish	28.791	19.796
Cereals and bakery goods	18.445	42.743
Sugar and confectionery goods	0.505	0.080
Fruits and vegetables	1.710	5.095
Vegetable oil and other fats	6.079	2.385

The assessment of dietary impact of MeHg with fish was carried out by means of recalculation based on the fact that almost 90% of the total amount of Hg, present in fish flesh, fish and seafoods exist in the form of MeHg. MeHg is easily absorbed into the body through the gastrointestinal tract and has higher impact levels [8]. The level of non-carcinogenic risk from exposure to Hg with main food groups at the median level and that of the 95-th perc is acceptable (<1), HQ=0.078 and 0.442. [15]. The risk for children on intake of MeHg with fish at the median level made 0.661 (<1), at the level of the 95-th perc, it made 2.29, which which exceeded the allowable level (HQ >1) (Table.3).

Table 3. Non-carcinogenic risk for the child population health in the city of Kazan on intake of contaminants with foods

Contaminants	2011-2014			
	Hazard quotients , (HQ)		%	
	Median	95th perc	Median	95th perc
Hg [1]	0.078	0.442	10.55	16.18
MeHg [2]	0.661	2.29	89.45	83.82
Total HI	0.739	2.732	100	100

Taking into account the peculiarities of the child body (the amount of chemicals ingested per kilogram of body weight is higher in children, than in adults), the potential risk of developing harmful effects from intake of MeHg at the level of the 95-th percentile was determined. The dose-effect and the dose-response relationships in children under 6 years old due to differences in structural and functional characteristics of older children and the adults are responsible for their high vulnerability on exposure to chemicals [16, 17, 18, 19]. Pollution with MeHg in fish is a world problem for the environment, because fish contains high quality protein and other necessary nutrients required for the growth and development of children. Fish is an excellent source of omega 3 fatty acids, and the balance of risks and advantages becomes the increasingly important aim of recommendations on fish intake [20, 21, 22]. Taking into account the physiologicoanatomical peculiarities of the child body and behavioral responses, one should take into consideration the potential benefits for health from fish intake, which can make not more than 1-2 times a week in our region and will not exceed the level of TWI. However the obtained risk levels at the level of the 95-th perc indicate the risk of neuropsychological disorders for younger children in the city of Kazan due to intake of fish and sea foods.

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