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NON-CARCINOGENIC RISK FOR CHILDREN POPULATION HEALTH IN KAZAN CAUSED BY FOOD PRODUCTS AND FOOD RAW MATERIALS CONTAMINATION*

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The paper dwells on results of assessing non-carcinogenic risk for children health in Kazan caused by consumption of food products contaminated with chemicals. Research was performed in two stages (2007–2010 and 2011–2014) on children aged 3–6. Actual nutrition of children was examined via questioning and timing-weighing techniques. Daily doses were calculated allowing for regional exposure parameters at median (Me) and 95-th percentile level. We detected high non-carcinogenic risk at 95-th percentile level for methyl-mercury (3.89 and 3.33 in both periods correspondingly); high and intolerable for As (10.67 in the first period). We determined organs and systems in a body which were under greatest toxic effects. Alerting level of non-carcinogenic risk for central nervous system (HI = 3.03) was detected in the first period at median level. In 2007–2010 we detected the following high non-carcinogenic risks at the 95-th percentile level of a danger coefficient for children: non-carcinogenic risk for central nervous system (HI = 12.20), hormonal system (HI=12.87), immune system (HI=11.72), and alerting risk for development (HI=4.03). In 2011–2014 the following systems were most prone to overall toxic impacts: central nervous system and development (HI = 4.02 and 3.98 correspondingly). Non-carcinogenic effects risk over 2007–2011 for hormonal system (64 %), central nervous system (79 %), and immune system (91 %) was caused mostly by food products contamination with As. As for 2011–2014, the greatest risk factor was Pb introduction, (46 %) for hormonal system, and (57 %) for central nervous system.

Key words: *chemical contaminants, regional exposure factors, children, share contribution, non-carcinogenic risk, critical organs, critical systems in a body.*

Food products safety is becoming more and more vital each year as provision of proper food raw materials and food products quality is one of the basic factors which determine absence of human health risks when food is consumed. Nowadays food products contain various quantities of contaminants, in some cases, in doses mostly lower than the fixed hygienic standards [3, 7]. Long-term chemical loads with low intensity are one of the most significant health risk factors which make for decrease in a body resistance to impacts exerted by other unfavorable ecological and socially determined environmental factors [1, 16]. Therefore, it is necessary to provide surveillance over food products safety, to examine possible negative influence exerted by low doses of foreign substances on children's health; these theoretical and practical hygienic tasks are seen as truly vital. Children are a contingent most

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sensitive to unfavorable impacts exerted by environmental factors, so children's health can be a reliable indicator showing whether ecological situation in a region is safe or not.

Our review of publications on risk assessment in Russia has revealed that most issues these paper dwell on are related to exposure assessment uncertainties and absence of regional, national, and age discrepancies in exposure factors and sensitivity to carcinogens [4, 13]. Children under 6, due to their functional characteristics peculiarities are known to be most vulnerable in terms of exposure to chemicals [8].

Our research goal was to assess non-carcinogenic risk for 3-6 year old children's health depending on food products loads with contaminants in the region..

Our research was performed in two periods: 2007-2010 and 2011-2014. We examined actual nutrition of children aged 3-6 years incorporating the following: examination of individual and family nutrition (questioning); examination of nutrition in pre-school children facilities where a child received full or partial ration (timing-weighing technique). Actual nutrition which children received in a municipal pre-school children facility "Children's kindergarten No. 146" in Kazan was analyzed monthly via reports on food products consumption (cumulative lists analysis), as well as selectively via menu sheets analysis. Children's nutrition assessment was appended with the results obtained via parents' questioning on family nutrition at weekends and in the evening on workdays. To calculate exposure, we applied data on the examined chemicals content in food products and data on food products consumption by children on the basis of the median and 95% percentile in conformity with Methodical Guidelines 2.3.7.2519-09 "Determination of exposure on population and risk assessment for chemical contaminants in food products" [2]. Non-carcinogenic risk was assessed as per results of our research on analyzing Pb, Cd, As, and Hg contents in various food products. The analysis was performed in a certified laboratory at Tatarstan Republic Center for Hygiene and Epidemiology in accordance with the 2.1.10.1920-04 "Guide to health risk assessment when exposed to chemicals polluting the environment" and the US Environmental Protection Agency. General toxic effects were characterized on the basis of hazard quantifications (HQ) for specific chemicals and aggregate hazardous indexes (HI) for chemicals with similar impacts [5, 17]. HI values ranging from 1.1 to 3.0 were taken as permissible non-carcinogenic impacts; HI values ranging from 3 to 6 were considered to be alerting risk level; HI values higher than 6 were considered to be high risks [6].

Assessment results showed that Pb made the greatest contribution into the aggregate exposure in both examined periods (2007-2010 and 2011-2014); it was introduced with food products (69.34 % and 85.91 % at the median level and 50.93 % and 87.77 % at 95%-percentile level). As (arsenic) aggregate exposure took the second place in 2007-2010 (14.13% at the median level and 34.28 % at 95%-percentile level) (Table 1).

In 2011–2014 exposure share of Pb which penetrated children's bodies with food products was 1.7 times higher than in 2007-2010 at the median level and 95% percentile level.

Grain, cereals and bakery were products with the highest Pb content and they made the greatest contribution into the aggregate exposure in both periods (31.08% and

31.63% at the median level, 44.24 % and 35.02 % at 95%-percentile level); meat and meat products, poultry, and eggs also contributed (28.85% and 30.22 % at the median level, 18.03% and 22.58 % at 95%-percentile level); milk and dairy products took the third place (16.66% and 18.94% at the median level, 14.31% and 20.42 % at 95%-percentile level).

Table 1

Assessment results for exposure to chemical contaminants introduced with food products

Contaminants	2007–2010				2011–2014			
	Exposure mg/kg*day		Contribution into aggregate exposure, %		Exposure mg/kg*day		Contribution into aggregate exposure, %	
	median	95% percentile	median	95% percentile	median	95% percentile	median	95% percentile
Pb	0,00952	0,03329	69,34	50,93	0,01694	0,05072	85,91	87,77
Cd	0,00154	0,00710	11,22	10,86	0,00246	0,00580	12,47	10,04
As	0,00194	0,02241	14,13	34,28	0,00006	0,00008	0,3	0,01
Hg [1]	0,00055	0,00218	4,00	3,33	0,00016	0,00093	0,81	1,61
Methyl Hg [2]	0,00018	0,00039	1,31	0,6	0,00010	0,00033	0,51	0,57
Sum	0,01373	0,06537	100,0	100,0	0,01972	0,05778	100,0	100,0

Note (here and further on):
[1] Exposure dose for Hg is calculated for food products groups without fish and non-fishery trade objects.
[2] Exposure dose for methyl Hg is calculated for fish and non-fishery trade objects.

The greatest contribution into exposure to Cd in 2007-2010 was made by the following groups of products: grain, cereals, and bakery (42.63 % at the median level and 39.81%, at 95%-percentile level); fish and non-fishery trade objects (18.47% and 21.51%, correspondingly); fruit and vegetables (15.19% and 14.11 %, correspondingly). In 2011–2014 the greatest contribution into exposure to Cd was made by milk and dairy products (64.57% at the median level and 27.35%, at 95%-percentile level), as well as grain, cereals, and bakery (17.82% at the median level and 40.17%, at 95%-percentile level). The greatest contribution into exposure to Hg in both periods was made by meat and meat products, poultry, and eggs (28.78% and 36.86% at the median level and 20.73% and 28.84%, at 95%-percentile level); grain, cereals, and bakery (28.52 % and 18.45% at the median level and 40.49% and 42.74%, at 95%-percentile level); fish and non-fishery trade objects (18.55% and 28.79% at the median level and 10.94% and 19.80% at 95%-percentile level). In 2007-2010 milk and dairy products also contributed into exposure to Hg (20.04 % at the median level, 21.48% at 95%-percentile level).In 2007–2010 substantial contributions into overall exposure to As were detected for fish and non-fishery trade objects (83.13% at the median level, 77.44% at 95%-percentile level); and in 2011–2014, for milk and dairy products (57.78% at the median level, 64.37 % at 95%-percentile level), as well as for sugar and confectionary (42.22% at the median level, 35.63% at 95%-percentile level). It can be explained by the fact that in 2011-2014 we didn't detect any As content in other groups of food products.

As most Hg in fish is actually methyl Hg, so, as per recommendations given by United Nations Environment Programme (UNEP) and WHO, in 2008 Hg content in fish and non-fishery trade objects was recalculated in to methyl Hg. Methyl Hg is easily absorbed into a body via the gastrointestinal tract and has higher exposure levels. Pregnant women and children are more susceptible to it even when exposure is rather low. We should also note that non-organic Hg is a food contaminant but exposure to it is considered to be less significant in comparison with exposure to methyl Hg [11, 15, 17, 18].

We applied officially recommended data on reference (safe) doses (RfD) under chronic exposure on critical body organs and systems as criteria for assessing non-carcinogenic risks for children's health caused by the examined chemicals introduced with food products (Table 2).

Risk characteristics revealed that values obtained for methyl Hg at the median level, Cd and Hg, at 95%-percentile level in the first period, were higher than the reference value being equal to 1.0. Hazard quantification for methyl Hg at 95%-percentile level was higher than 3.0 which meant average risk. Risk as per As turned out to be extremely high (hazard quantification was higher than 10.0). In the second period hazard quantification for methyl Hg at 95%-percentile level was also higher than 3.0. Non-carcinogenic risks caused by exposure to Pb in the first period, and to Pb, Cd, and Hg, in the second period didn't exceed permissible levels (Table 3).

The examined chemical contaminants (Pb, Cd, As, Hg, and methyl Hg), detected in the analyzed food products in 2007–2010 and 2011–2014, can possibly cause various adverse effects in a body [10, 12].

Hazard indexes (HI) calculated on the basis of the median hazard quantification values were equal to 3.0 in the first period which meant risk was average, and they were lower than 3.0 in the second period which meant risk was permissible.

Table 2

Non-carcinogenic hazard parameters for the examined chemicals at oral introduction

CAS*	Chemical	Non-carcinogenic effects		Data source
		RfD, mg/kg	Critical organs and systems	
7439-92-1	Pb	0,035	Nervous system, blood making organs, cardiovascular system, reproductive system, urogenital system	P.2.1.10.1920-04 [5]
7440-43-9	Cd	0,001	Urogenital system, kidneys	IRIS [14]
7440-38-2	As	0,0003	Central nervous system, nervous system, cardiovascular system, immune system, hormonal system, gastrointestinal tract	IRIS [14]
7439-97-6	Hg	0,0003	Immune system, kidneys, central nervous system, reproductive system, hormonal system	P.2.1.10.1920-04 [5]; WHO/UNEP, 2008 [18]
	Methyl Hg	0,0001	Central nervous system, kidneys, nervous system	WHO/UNEP, 2008 [18]

Note: * – unique numerical identifier for chemical substances

Table 3

Non-carcinogenic risks of functional disorders in nervous system for children in Kazan at oral contaminants introduction with food products

Contaminants	2007–2010				2011–2014			
	Hazard quantifications (HQ)		Contribution into HI, %		Hazard quantifications (HQ)		Contribution into HI, %	
	Median	95% percentile	Median	95% percentile	Median	95% percentile	Median	95% percentile
Pb	0,039	0,136	1,28	1,11	0,069	0,207	6,058	20,254
As	0,925	10,670	30,53	87,24	0,029	0,039	2,546	3,816
Hg	0,260	1,036	8,57	8,47	0,078	0,442	6,848	43,249
Methyl Hg	1,806	0,389	59,63	3,18	0,963	0,334	84,548	32,681
Total (HI)	3,029	12,231	100,00	100,00	1,139	1,022	100,00	100,00

In the first period children ran alerting non-carcinogenic risk for the central nervous system at the median level (HI was equal to 3.03), and high risk at 95% percentile level (HI was equal to 12.2). We also detected high non-carcinogenic risk for the hormonal system at the 95%-percentile level (HI=12.87), immune system (HI=11.72), and alerting risk for the overall development (HI=4.03). In 2011–2014 the central nervous system and the overall development were most exposed to overall toxic effects (HI = 4.02 and 3.98 correspondingly). In 2007-2010 non-carcinogenic risks for the hormonal system (64%), central nervous system (79%), and immune system (91%) were mostly determined by food products contamination with As; and in 2011-2014, with Pb, the hormonal system (46%), central nervous system (57%).

Given high non-carcinogenic risk at 95%-percentile level caused by As and methyl Hg, as well as a child's body peculiarities (greater quantities of products and chemicals being introduced as per 1 kg of body weight than in adults), it is necessary to enhance surveillance over the examined contaminants contents in food products. It is necessary to assess exposure for specific age groups of children allowing for their behavior at a different age, and peculiarities of a region they live in [9]. Some facts are being discovered that allow to suggest that increased risks of certain diseases evolvement in adults, notably, cancer and heart diseases, can be partly caused by early exposure to certain chemicals from the environment in childhood [13].

Risk analysis allowing for local factors and age differences in exposure to chemicals introduced orally with food products revealed that standards values application in risk assessment methodology causes underestimation of actual children health risks.

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