ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Peculiarities of Chidren's Risk Assessment on Ingestion of Chemicals with Drinking Water.

Stepanova N.V*., Valeeva E.R., Ziyatdinova A.I., Fomina S.F.

Kazan (Volga Region) Federal University, Institute of Fundamental Medicine and Biology, Kazan, Russia (420008, Kazan, street K. Marx, 74).

ABSTRACT

Results of the noncarcinogenic health risk assessment for the child population living in different districts of the city of Kazan are given in the article. The risk assessment was carried out for the peroral route of ingestion with the account of standard and regional exposure factors. Risk level analysis with application of local factors (particularly at the level of 95% pers.) and age differences in exposure to the chemicals ingested with drinking water showed that application of standard values resulted in underestimation of the actual health risk for the child population.

Keywords: risk, children, drinking tap water

Corresponding author

ISSN: 0975-8585

INTRODUCTION

One of the most important ecological factors of the habitat that affect the health of the population in the investigated territory is the quality of drinking water from the sources of centralized water supply. Children are the group, which is the most sensitive to the effects of unfavorable environmental factors; therefore the health of the child population can be a reliable indicator of ecological well-being in the region [1]. Due to their physiological peculiarities, in comparison with adults, children are more exposed to the effect of toxic substances in drinking water, because they consume more water per unit of weight (mg/kg). The amount of water per unit of the child weight reaches maximum during the first month of life and decreases with age. Development and application of information for implementation of the children's health risk assessment is an urgent field of research.

This is due to the fact that many experts still use the default exposure values: for the screening level assessment (consumption for adults is 2 l/24 hrs per 70 kg of weight and consumption for a child is 1 l/24 hrs per 10 kg correspondingly) [2, 5].

The aim of the work is to assess the non-carcinogenic health risk for the child population in peroral route of chemical compounds with drinking tap water on the basis of standard and regional exposure factors.

MATERIALS AND METHODS

The assessment of non-carcinogenic risk when chemical substances get into the body with drinking water was carried out for children aged 3-6 living in 4 districts (areas) of the city of Kazan allowing to minimize the uncertainties associated with specific regional parameters in exposure assessment (preschool-age children are less susceptible to commuting, this fact allows to take into account all aspects of seasonal and daily activities). The research areas were allotted on the basis of arrangement of permanent stations for monitoring the atmospheric air pollution and the children's polyclinics (No. 4, 6, 10, 11) providing services to these districts with the purpose of subsequent complex assessment of the multi-environmental risk. The selected areas have significant differences in the present ecological and hygienic situation with heavy metals in soil and snow cover [3, 4]. The risk assessment was carried out according to the data of the Regional Information Fund (RIF) of social and hygienic monitoring and results of the research carried out on the basis of an accredited laboratory of the Federal State-Funded Healthcare Institution "The Center of Hygiene and Epidemiology in the Republic of Tatarstan" in keeping with Guidelines P 2.1.10.1920-04 [5, 6].

The values of HQ in the range from 0.11 to 1.0, and HI – from 1.1 to 3.0 were taken for the allowable level of non-carcinogenic effects. Information on local exposure factors was obtained in the cross-sectional study when questioning parents (babysitters, grandmothers) of 1250 children (from 3 to 6 years of age). A questionnaire developed by the researchers of the Institute of Fundamental Medicine and Biology of the Kazan (Volga Region) Federal University included the following information on the exposure factors: the child weight (kg), height (cm), the amount of drinking water taken (l/24hrs), the number of water procedures (hand washing) - (times/24hrs), taking a shower (a bath) – times /week, the duration of water procedures (min/24 hrs), exposure time (days /year), spending time outdoors (hrs/24hrs), spending time indoors (hrs/24hrs). Statistical analysis of the obtained data was implemented in operating system Windows 2007 with the use of standard application program packages Excel 2007 and "STATISTICA v.6.0".

RESULTS

The local exposure factors for the child population obtained in the cross-sectional study showed that children consume on the average, at the median level (Me), the same amount of water as in case of standard exposure – 1.0 l/24 hrs (Table.1). Whereas at the level of 95% CI (confidence interval) this index was 2.0 l/24 hrs, which corresponds to the value of standard factor for adults. The weight in child population was at the level of Me 10.3 kg, and at the level of upper 95% Pers. – 16.4 kg (standard value – 15 kg). The time spent indoors in the city children at the level of Me is 1 hour less (for recommended standard values of the exposure factor – 19 hrs/day) and 3 hours more at the value of 95% Pers. It is established that children spend less time outdoors in the course of the day (Me – 4 hrs/day and 8 hrs/day at the level of 95% Pers.). The duration of the water procedure effect (washing, taking a shower, a bath) for the city child population was lower than standard values and made 296 days (Me) and 364 days (95% Pers).

18 pollutants (aluminium, barium, iron, calcium, magnesium, nitrates (in NO3), nitrites (in NO2), cadmium, manganese, lead, strontium (stable), copper, zinc, fluorides, residual chlorine, petroleum products (in total), chloroform) make the list of priority substances getting into the body with drinking water. Basic criteria for selection of priority chemical compounds were a high proportion of unsatisfactory samples in hygienic studies, determination of reference doses (RfD), previous disclosure of critical target, availability of quotients and other reference values required for calculation.

The risk assessment resulted in establishing that hazard quotients (HQ) of the substances contained in drinking water from the utility and drinking water supply system in the city of Kazan, when using standard exposure factors for the child population, exceeded the allowable level (HQ =1.0) in the 2nd and 4th areas in petroleum products (HQ = 4.25 and 2.15), and in the 3rd and 4th areas – in nitrates (HQ = 1.04 and 2.35). Hazard quotients (HQ) for the child population calculated with application of local exposure factors (at the level of Me) were higher than the allowable level of risk in all areas in chloroform (HQ 1.03 – 1.43, in the 2nd ,3rd and 4th areas – in nitrates (HQ 1.51 – 3.57) and petroleum products (HQ 3.27 – 6.45). Calculation of hazard quotients for the child population with application of local exposure factors (at the level of 95 % Pers.) showed increase of the allowable level in petroleum products (HQ = 8.1 and 4.1) in the 2nd and 4th areas, in fluorides (HQ = 1.16) in the 3rd area, in nitrates (HQ 1.9 – 4.5) in the 2nd, 3rd and 4th areas, and in residual chlorine (HQ 1.1 – 1.26) in the 1st and 4th areas. Increased level of hazard quotients in chloroform (HQ 1.3 – 1.8) was obtained in all city areas (Table. 2, 3).

Results of the non-carcinogenic risk assessment in the peroral route of chemical substances getting into the body with drinking water showed that the magnitude of the total risk only in the 1st city area (in case of standard exposure factors) corresponded to the allowable level. In all the rest areas, irrespective of the exposure factor value (regional factor at the level of Me or 95% Pers.), the total hazard quotients speak of alert and unacceptable levels of risk. The total hazard index (HI) in combined peroral route of chemical compounds and elements with drinking water in allotted areas of the city of Kazan indicates a high risk level for the child population living in the 2nd and 4th areas (HI_{Me} = 11.8 and 10.9; $HI_{95\%pers}$ = 14.8 and 13.7) and an average risk level – for children from the 1st and 3rd areas, and jeopardizes the health (Tab.2). The main critical organs and systems were identified according to the analysis results in all areas. The basic risk systems in all areas are the blood system, kidneys and in the 4th area – the cardiovascular system. Differences between applied approaches expressed in the magnitude of risk (it is higher in case of regional exposure factors at the level of 95% pers). The highest levels of total risk (HI) and risk for the above stated critical systems were determined for the 4th area.

Table 1: Local and standard exposure factors in child population in the city of Kazan

Exposure factor	Children aged 3-6 years		Children aged 0 - 6 years
	Regional factors		Standard (recommended) factors
	Me	95% Pers	
Weight, kg	10,3	16,4	14,0 -15,0
Amount of consumed water, l/24 hrs	1,0	2,0	1,0
Duration of water procedures, min/24 hrs	30,0	90,0	20,0
Duration of the effect per annum, days	296,0	364,0	350,0
Spending time indoors, hrs/day	18,0	22,0	19 17 (weekends and holidays)
Spending time outdoors, hrs/day	4,0	8,0	5 7 (weekends and holidays)

ISSN: 0975-8585

Table 2: Hazard quotients (HQ) for substances with synergistic effects

Substances	HQ with application of standard exposure factors			
	1st area	2nd area	3rd area	4th area
Aluminum	0,02	0,03	0,03	0,04
Barium	0,02	0,03	0,04	0,02
Iron	0,17	0,36	0,40	0,15
Magnesium	0,14	0,37	0,49	0,28
Nitrates (in NO3)	0,39	1,00	1,04	2,35
Nitrites (in NO2)	0,03	0,13	0,26	0,13
Cadmium	0,09	0,08	0,08	0,00
Manganese	0,00	0,06	0,00	0,01
Lead	0,13	0,07	0,14	0,07
Strontium	0,11	0,07	0,10	0,07
Copper	0,07	0,06	0,05	0,09
Zinc	0,01	0,01	0,02	0,03
Fluorides	0,32	0,50	0,61	0,41
Residual chlorine	0,58	0,00	0,00	0,66
Oil products (in total)	0,04	4,25	0,21	2,15
Chloroform	0,68	0,76	0,94	0,74
HI	2,79	7,76	4,40	7,19

Table 3: Hazard quotients (HQ) for chemical substances in drinking water

Substances	HQ with application of regional exposure factors (Me)				HQ with application of regional exposure factors (95% Pers)			
	1st area	2nd area	3rd area	4th area	1st area	2nd area	3rd area	4th area
Aluminum	0,04	0,04	0,04	0,06	0,05	0,05	0,05	0,07
Barium	0,03	0,05	0,06	0,03	0,04	0,06	0,08	0,04
Iron	0,26	0,55	0,61	0,23	0,33	0,70	0,77	0,28
Magnesium	0,21	0,56	0,75	0,42	0,27	0,70	0,94	0,53
Nitrates (in NO3)	0,59	1,51	1,58	3,57	0,75	1,90	1,98	4,48
Nitrites (in NO2)	0,05	0,19	0,39	0,19	0,06	0,24	0,49	0,24
Cadmium	0,14	0,12	0,12	0,00	0,17	0,15	0,15	0,00
Manganese	0,00	0,09	0,00	0,01	0,00	0,11	0,00	0,02
Lead	0,19	0,10	0,21	0,11	0,24	0,13	0,26	0,14
Strontium	0,16	0,10	0,15	0,11	0,21	0,13	0,19	0,14
Copper	0,11	0,09	0,08	0,14	0,13	0,11	0,10	0,18
Zinc	0,01	0,02	0,03	0,05	0,01	0,03	0,04	0,06
Fluorides	0,48	0,76	0,92	0,62	0,60	0,96	1,16	0,78
Residual chlorine	0,88	0,00	0,00	1,00	1,11	0,00	0,00	1,26
Oil products (in total)	0,06	6,45	0,32	3,27	0,07	8,10	0,41	4,11
Chloroform	1,03	1,16	1,43	1,12	1,29	1,45	1,79	1,40
HI	4,24	11,79	6,69	10,93	5,33	14,8	8,4	13,7

CONCLUSION

Significant differences in regional and standard values of exposure factors were revealed based on the results of the screening assessment of the non-carcinogenic risk on the peroral route of chemical substances with drinking water. It shows influence both on the amount of a chronic mean daily dosage of chemical contaminants in the drinking water, and on the risk level when taking drinking water. Priority contaminants of the drinking water forming the increased non-carcinogenic health risk to the child population in all areas in the city of Kazan are chloroform, oil products and nitrates. Thus, analysis of the risk levels with application of local factors (at the level of 95% Pers. in particular) and age differences in exposure of chemical substances getting into the body with drinking water showed that application of standard values resulted in an underestimation of the actual health risk to the child population.

The research was supported by the state program of competitiveness of Kazan (Volga region) Federal University among the World's leading research and education centers within the aid-grant of Kazan (Volga region) Federal University to perform the scientific research.

REFERENCES

[1] Stepanova N.V., Valeeva E.R. Basic health trends of the child population in the Republic of Tatarstan // Hygiene and sanitation. 2015. No. 1. P. 92-97.

[2] Margot T. B., Foos B.P. Assessing children's exposures and risks to drinking water contaminants: a manganese case study // Human and Ecological Risk Assessment. 2009. Vol. 15. No.5. P. 923-947.

[3] Stepanova N.V., Valeeva E.R., Fomina S.F. Approaches to city territory ranking in heavy metal pollution level // Hygiene and sanitation. 2015. No.5. P. 56-61.

[4] Stepanova N.V., Fomina S.F., Valeeva E.R. Biological monitoring as an indicator of ecological well-being of the territory on pollution by heavy metals // Scientific Almon. 2015. No 7(9). P. 904-912. doi: 10.17117/na.2015.07.904

[5] Rakhmanin J.A., Onitshenko G.G., Kiselev A.V. et al. Guidelines for health risk assessment for the population on exposure to chemical substances polluting the environment (P 2.1.10.1920-04). Moscow: Federal Center of the State Committee for Sanitary and Epidemiological Control. 2004. 143 p.

[6] USEPA. 2008. Child-Specific Exposure Factors Handbook . Available at: http: //cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=199243