Prevalence and risks of chronic internal diseases among workers of Uranium Processing Enterprise

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Abstract

Risks of somatic diseases among personnel of Uranium Processing Enterprise in Kazakhstan

The prevalence and relative risks of somatic pathology were studied in 912 workers of uranium processing plant. Excessive rough and standardized relative risks for arterial hypertension, chronic obstructive pulmonary disease were obtained.

The intensive development of the global economy does not allow for the foreseeable future to eliminate the use of atomic energy. The Republic of Kazakhstan takes one of the leading places in the world on reserves of uranium ore. In 2009, Kazakhstan moved into first place for the extraction of uranium in the world – the extraction of natural uranium was 13 500 tons [1]. Due to productive expansion, a large number of "professionals" and population are involved into impact area of radiation factor; therefore, the assessment of ionization radiation (IR) impact in low doses (LD) on the health of the nuclear fuel complex personnel becomes more acute [2]. Medical and biological effects of chronic exposure to low doses (LD) to the present time are not fully clear, although it is known that the extrapolation of data obtained for high doses of ionization radiation (IR) for the LD is not justified [3, 4]. At this stage, all effects of LD are considered as stochastic, realizing in the form of cancer or genetic disorders. However, as data of the literature give evidence, this is not all manifestations of the low level radiation exposure. These also include the effects of early aging, various metabolic disorders, respiratory diseases - plutonium pneumofibrosis, bronchitis, etc. [5, 6]. According to a number of authors, IR in LD can contribute to a number of somatic diseases. In this case the radiation factor may not play a decisive role, and act as an agent, potentiating impact of traditional risk factors for major somatic diseases [2, 7]. Existing in the available literature data on the prevalence of chronic noninfectious diseases among workers of the nuclear industry are small, fragmented and, in some cases, contradictory [2, 3, 8].

Aim of this study was to investigate the prevalence and relative rough and standardized risks of chronic somatic diseases among personnel of uranium processing enterprise who are exposed to the long-term radiation-toxic effects during their professional activity.

Materials and Methods. The prevalence and relative risks of somatic diseases were studied in 912 workers of primary production (personnel of group "A") of Hydrometallurgical Plant (HMP), which is one of the largest in Central Asia and Kazakhstan enterprise on production of commercial suboxide-oxide of uranium, molybdenum-acid ammonium and affined gold.

Men reached 809 persons (88.7%), women - 103 (11.3%) persons. The average age of personnel of HMP was 43,2 ± 10,3 years. Work experience in contact with sources of IR was 13,9 ± 12,7 years.

According to the service of radiation safety of HMP, the recorded radiation exposure to personnel in a number of years was uniform. Thus, the average individual radiation dose for 2010 was 6.76 mSv/y (maximum - 9.86 mSv/y, minimum - 0.064 mSv/y). Excess of MPL in concentration of natron, ammonia, sulfur dioxide, cinder dust, sulfuric acid vapor was not observed.

As a comparison group was studied the prevalence of somatic diseases among 788 (696 men and 92 women) workers of the production shop at the Stepnogorsk Bearing Plant (SBP), located at a distance of 10 km from HMP.

The one-stage continuous cross-sectional survey was conducted. The prevalence of somatic diseases was assessed according to results of in-depth medical examination, which covered 96.3% of HMP workers and 98.5% of SBP workers of main production plants.

As an integral indicator of health status, moment prevalence (Pr) was assessed, rough relative risks (RR) of somatic diseases were calculated. Stratification of studied groups was performed and standardized relative risks (SRR) corrected according to gender, age, duration of labor experience and significant risk factors for major somatic diseases were identified. To calculate corrected values, Mantel-Hanzela procedure was used, 95% confidence limit (CL) was calculated by the method of Woolf [9].

For comparison of independent samples on the binary feature (prevalence), an analysis of fourfold table of contingency using criterion χ^2 was carried out. When checking the statistical hypotheses, the critical level of significance was taken as 0.05. The achieved level of significance when checking the statistical hypotheses was designated as «p <...» in the text. Statistical analysis was performed using the software package «Statistica 6.0» and «SPSS 13.0».

Results and discussion. Analysis of the values of moment prevalence of somatic diseases (Table 1) revealed a high prevalence of endocrine diseases among workers of HMP and SBP.

Table 1. Prevalence (Pr., ‰) of somatic diseases

Diseases	HMP			SBP		
	N	Pr., ‰	95% CL	N	Pr., ‰	95% CL
Endocrine diseases, total	**318**	**348,7**	**317,8-379,6**	**251**	**318,5**	**288,0-351,1**
Among them						
Hyperplasia of the thyroid gland	176	193,0	167,4-218,6	150	194,0	162,9-217,8
Obesity	92	100,9	81,4-120,4	77	97,7	77,0-118,4
Chronic autoimmune thyroiditis	43	47,1	33,4-60,8	16	20,3	10,5-30,2
Nodular goiter	14	15,4	7,4-23,4	7	8,9	2,3-15,4
Diabetes mellitus, type 2	9	9,9	3,5-16,3	7	8,9	2,3-15,4
Diseases of the circulatory system, total	**306**	**335,5**	**304,9-366,1**	**163**	**206,9**	**178,6-235,1**
Among them						

Diseases	HMP			SBP		
	N	Pr., ‰	95% CL	N	Pr., ‰	95% CL
Arterial hypertension	225	246,7	218,7-274,7	81	102,8	81,6-124,0
Chronic forms of ischemic heart disease	52	57,0	42,0-72,0	45	57,1	40,9-73,3
Neurocirculatory dystonia	32	35,1	23,2-47,0	24	30,5	18,5-42,5
Symptomatic arterial hypertensions	26	28,5	17,7-39,3	23	29,2	17,4-40,9
Diseases of the digestive system, total	**291**	**319,1**	**288,8-349,4**	**144**	**182,7**	**155,8-209,7**
Among them						
Chronic gastritis	159	174,3	149,7-198,9	64	81,2	62,1-100,3
Chronic cholecystitis	36	39,5	26,9-52,1	32	40,6	26,8-54,4
Gastro-oesophageal reflux disease	43	47,1	33,4-60,8	31	39,3	25,8-52,9
Chronic pancreatitis	28	30,7	19,5-41,9	20	25,4	14,4-36,4
Peptic ulcer disease	33	36,2	24,1-48,3	18	22,8	12,4-33,3
Diseases of the respiratory system, total	**190**	**208,3**	**181,9-234,7**	**79**	**100,3**	**79,3-121,2**
Among them						
Chronic obstructive pulmonary disease	176	193	167,4-218,6	77	97,7	77,0-118,4
Bronchial asthma	14	15,4	7,4-23,4	2	2,5	1,0-6,1
Diseases of the urinary system, total	**66**	**72,4**	**55,6-89,2**	**68**	**86,3**	**66,7-105,9**
Among them						
Chronic pyelonephritis	49	53,7	39,1-68,3	44	55,8	39,8-71,9
Nephrolithiasis	20	21,9	12,4-31,4	18	22,8	12,4-33,3
Diseases of the osteoarticular system, total	**59**	**64,7**	**48,7-80,7**	**48**	**60,9**	**44,2-77,6**
Among them						
Osteoarthritis	52	57,0	42,0-72,0	40	50,8	35,4-66,1
Diseases of the blood system, total	**23**	**25,2**	**15,0-35,4**	**21**	**26,6**	**15,4-37,9**
Among them						
Iron deficiency anemia	20	21,9	12,4-31,4	21	26,6	15,4-37,9

With that as it can be seen from Table 2, only chronic autoimmune thyroiditis and nodular goiter had an excessive RR (more than 1). Not less high prevalence of cardiovascular diseases among workers of

HMP was caused by considerable damage of personnel by arterial hypertension (AH), relative risk of which in the exposed group was increased (RR = 2,4; 95% CL 1,9-3,0). Excessive prevalence among workers of HMP had been also when chronic gastritis (CG)-RR=2,1; 95% CL 1,6-2,7 and chronic obstructive pulmonary disease (COPD) - RR=2,0; 95% CL 1,6 -2.6.

Table 2. Rough relative risks of somatic diseases

Diseases	**RR**	**95% CL**	χ^2	**p**
Endocrine diseases, total	1,1	0,97-1,25	1,59	0,207
Among them				
Hyperplasia of the thyroid gland	1,0	0,82-1,21	0,01	0,939
Obesity	1,0	0,75-1,32	0,02	0,892
Chronic autoimmune thyroiditis	2,3	1,31-4,04	8,31	0,004
Nodular goiter	1,7	0,69-4,18	0,97	0,325
Diabetes mellitus, type 2	1,1	0,41-2,93	0,00003	0,967
Diseases of the circulatory system, total	1,6	1,36-1,87	34,4	<0,0001
Among them				
Arterial hypertension	2,4	1,91-3,01	58,35	<0,0001
Chronic forms of ischemic heart disease	1,0	0,68-1,46	0,01	0,923
Neurocirculatory dystonia	1,2	0,71-2,01	0,16	0,691
Symptomatic arterial hypertensions	1,0	0,57-1,73	0,01	0,934
Diseases of the digestive system, total	1,7	1,43-2,00	40,56	<0,0001
Among them				
Chronic gastritis	2,1	1,60-2,74	31,35	<0,0001
Chronic cholecystitis	1,0	0,62-1,58	0,01	0,912
Gastro-oesophageal reflux disease	1,2	0,76-1,87	0,45	0,504
Chronic pancreatitis	1,2	0,68-2,11	0,26	0,608
Peptic ulcer disease	1,6	0,91-2,81	2,15	0,143
Diseases of the respiratory system, total	2,1	1,65-2,66	36,27	<0,0001
Among them				
Chronic obstructive pulmonary disease	2,0	1,56-2,55	29,54	<0,0001
Bronchial asthma	6,2	1,41-27,16	6,13	0,013
Diseases of the urinary system, total	0,8	0,58-1,10	0,95	0,331

Diseases	RR	95% CL	χ^2	p
Among them				
Chronic pyelonephritis	1,0	0,67-1,48	0,01	0,933
Nephrolithiasis	1,0	0,53-1,87	0,02	0,899
Diseases of the osteoarticular system, total	1,1	0,76-1,58	0,05	0,826
Among them				
Osteoarthritis	1,1	0,73-1,63	0,21	0,645
Diseases of the blood system, total	0,9	0,50-1,61	0,03	0,853
Among them				
Iron deficiency anemia	0,8	0,43-1,46	0,4	0,527

Obtained excessive values of relative risks for major somatic diseases in personnel of HMP, were "crude" because they reflect only the quantitative characteristics, in our study - the prevalence of somatic diseases. "Crude" RRs do not give an answer on the causes of differences in the incidence of prevalence of a disease among the exposed on IR and non-exposed groups. Meanwhile, differences in prevalence between the compared enterprises may be not only in the impact of IR in the LD or lack of it, but also in the impact of other "disturbing" factors (confounding - factors). To eliminate the impact of confounding - factors, we performed a stratification of HMP personnel according to gender, age, duration of labor experience and the most significant risk factors (RF) for the progression of major somatic diseases.

To analyze the impact of AH predictors on prevalence of this disease, we has consistently studied the prevalence and relative risk of the following predictors of AH among the personnel of HMP and SBP: genetic heredity, obesity, metabolic syndrome, alcohol and table salt abuse, low physical activity, psychosocial stress. Results of the study revealed a significant prevalence of personal anxiety (PA) of high degree among workers of HMP (58.2% (95% CL: 54,8-61,6)), which exceeded the same prevalence among workers of SBP by 21.6 times ($p < 0, 0001$). It is known that work in hazardous conditions is accompanied by great emotional stress associated with the risk sensory uncertainty and prediction subjective uncertainty, meanwhile it was found that long-term chronic stress leads to the development of AH [10]. The prevalence of other predictors of AH at the compared enterprises was comparable.

As a result of conducted study we calculated SRR of AH, which was 2.91 (95% CL 2,1-3,8; χ^2=51,5; p<0,001).

To date no one has any doubts in the important role of Helicobacter pylori (HP) infection in the progression of CG, and it is confirmed by the results of controlled clinical and epidemiological studies [11]. In chronic atrophic (CAG) and non-atrophic gastritis (CNG) at the compared enterprises, the prevalence of HP colonization of gastric mucosa (GM) and its degree of severity were comparable. SRRs of CNG and CAG of HMP vs SBP were calculated. Stratification was carried out according to the degree of HP colonization of GM and age. SRR of HMP vs SBP for CNG was 2.1 (95% CL 1,4-2,7; χ^2=12,1; p=0.0007); for CAG - 3.9 (95% CL 1,9-7,0; χ^2=19,1; p<0.0001).

Smoking is a major proved predictor of CB. The prevalence of smoking at the compared

enterprises ranged from 67% to 72.3%, and the RR of smoking at HMP vs SBP=1.1 (was not excessive), what give evidence about the comparability of the prevalence of smoking in the enterprises. Stratification was carried out with regard to age, labor experience, pack-years index. SRR CB was 2,8 (RR = 2,4); SRR for chronic nonobstructive bronchitis (CNB) was 1,6 (RR=1,3); for COPD - 5,0 (RR=4,6).

As the impact of confounding factors in the process of stratification was excluded, the increase in SRR of major somatic diseases showed the influence of the aggressive factors of production, in particular the IR in LD, serving as an additional risk factor for the development and progression of primary somatic pathology in workers of uranium processing industry.

Conclusion

- Among personnel of uranium processing enterprise, the most common somatic diseases were arterial hypertension (Pr=247 ‰), CG (Pr=174 ‰) and COPD (Pr=193 ‰).
- Personnel undergoing long-term radiation-toxic effects had a greater risk for AH progression – by 2.4 times; CG – by 2.1 times and COPD - by 2.0 times in comparison with workers of non-exposed enterprise.
- Standardized (according to gender, age, labor experience, significant risk factors) relative risks of a major somatic diseases among personnel of uranium processing enterprise versus personnel of non-uranium hazardous production were higher than rough risk and were for AH - 2.91; CNG - 2.1; CAG - 3.9 and COPD- 5,0.

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