

# INVESTIGATION OF CHILD AND ADULT PRIMARY MORBIDITY DEPENDING ON ENVIRONMENTAL CONDITIONS OF RESIDENCE

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Based on official statistics for 2008-2017, we carried out an ecological and hygienic assessment of the state of the environment and the level of primary morbidity in the child and adult population for all classes of diseases in all cities and districts of the Bryansk region according to radiation (due to the Chernobyl accident), chemical (due air pollution by pollutants from stationary sources) and combined radiation-chemical contamination of the environment. The level of primary morbidity of the child population in the territories of combined contamination exceeds the indicators of the territories of chemical pollution and radioactive contamination by 34 and 11% (1660 versus 1235 and 1501 per 1000 population), which suggests that living in these conditions is a significant risk factor for the health of children and, possibly indicates the synergistic nature of the action of radiation and chemical factors. Correlation analysis of the relationship between the level of primary morbidity in the child population and the level of radiation and chemical contamination revealed an average statistically significant correlation with atmospheric air pollution with carbon monoxide and higher and more significant relationships with the density of radioactive contamination by Cesium-137 and Strontium-90 in both children and adults.

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## Introduction

At present, the number of territories in which the dose rates from the radiation of the new spectrum of technogenic radionuclides are tens of times higher than the background that existed in the pre-atomic period is steadily growing [1-3].

About 5 million people live in the radioactively contaminated territories of Ukraine, Belarus and Russia [3], and the density of radioactive contamination, determined mainly by long-lived <sup>137</sup>Cs and <sup>90</sup>Sr, will remain radiologically significant for decades.

Radioecological monitoring regularly carried out in the Bryansk region shows that the density of soil contamination with <sup>137</sup>Cs and <sup>90</sup>Sr in the southwestern territories exceeds the established limits by tens of times (up to 2116 kBq/m<sup>2</sup> for <sup>137</sup>Cs and up to 60 kBq/m<sup>2</sup> for <sup>90</sup>Sr) [4].

According to official data (*On the state and environmental protection of the Russian Federation in 2019*), in recent years in the Bryansk region there has been an increase in the emission of air pollutants, mostly volatile organic compounds (VOCs) and nitrogen oxides (NO<sub>x</sub>), as well as solid household and industrial waste [5].

At the same time, despite the well-known geography of the distribution of radiation pollution in the Bryansk region, the study of the consequences of the Chernobyl accident is considered without taking into account the accompanying chemical pollution [6, 7].

The grouping of territories and, accordingly, population groups of the population, taking into account the geography of distribution of contamination by the main pollutants and radionuclides due to the Chernobyl accident, was carried out in single works [6-11].

The constant aggravation of the ecological situation leads to an increase in the incidence of the population, as well as to an increase in the number of mutagenic factors, creating a real basis for an increase in the genetic load, changes in the rate of the mutation process [12].

In this regard, the study of the health status of the population living in such ecologically unfavorable conditions is extremely important.

### Methods

A comprehensive ecological and hygienic assessment of the state of the environment and the level of primary morbidity in the child and adult population for all classes of diseases in all cities and districts of the Bryansk region for radiation, chemical and combined radiation and chemical pollution over a ten-year period (2008-2017) was carried out.

We have isolated the main pollutants that pollute the atmospheric air: carbon monoxide, sulfur dioxide, nitrogen oxides and volatile organic compounds – VOCs (including benz (a) pyrene, benzene, styrene, pyridine, vinyl chloride, formaldehyde, acrolein, and phenol).

The primary morbidity in the child and adult population for all classes of diseases in the Bryansk region was analyzed according to [13].

### Results

The study of the influence of pollutants on the incidence of primary morbidity in children and adults over 10 years (2008-2017) revealed that the impact of environmental factors is determined by the combined effect of nitrogen oxides, carbon monoxide, sulfur dioxide and volatile organic compounds in combination with the contamination of territories with long-lived radionuclides (Cesium-137 and Strontium-90) with their isolated and combined influence.

We have identified 4 groups of territories of the Bryansk region according to the degree of ecological disadvantage of the environment (Table 1): 1) ecologically safe territories; 2) territories of chemical pollution; 3) territories of radioactive contamination; 4) territories of combined radiation and chemical contamination.

As the Table 1 indicate data on the density of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  radioactive contamination and the level of chemical contamination by leading gaseous pollutants vary widely. For  $^{137}\text{Cs}$  – from 4.1 to 427.1 kBq/m<sup>2</sup>, for  $^{90}\text{Sr}$  – from 0.4 to 15.0 kBq/m<sup>2</sup>. In terms of gross emissions of gaseous pollutants into the atmospheric air, the area of the district (g/m<sup>2</sup>) is from 9 to 28047, of which: for carbon monoxide – from 6 to 11934, nitrogen oxides – from 0 to 8434, sulfur dioxide – from 0 to 1924 and VOC – from 0 to 5755. Average annual accumulated effective doses (AAED<sub>90</sub>) population exposure from the Chernobyl component in the group of ecologically safe areas and areas of chemical pollution does not exceed 0.3 mSv per year, while in the group of radioactive and combined contamination the maximum values reach 5.5 mSv per year [14].

The data presented in Table 1 indicate that the level of primary morbidity in ecologically safe areas ranges from 663 to 1301 for children and from 362 to 647 for adults. The average values are 927 and 458, respectively. In areas of chemical pollution, the values range from 694 to 1754 for children and from 335 to 659 for adults. In conditions of radioactive and combined contamination, the values range from 1370 to 1885 and from 1162 to 2046 for the child population; from 539 to 1189 and from 428 to 688 for an adult. The average values of the frequency of primary morbidity in children and adults in ecologically safe areas are less than in areas of chemical, radioactive and combined contamination by 33, 62 and 79% for children and less pronounced (by 2, 28 and 9%) for adults, which confirms ecological safety of this group of

districts. In addition, the data obtained confirm that children are much more susceptible to environmental factors than the adult population.

Table 1.

Correlation analysis of primary morbidity in children and adults in cities and districts of the Bryansk region with the level of radiation and chemical contamination of the environment (2000-2019)

Cities and districts of the Bryansk region	Maingaseousairpollutants					Contamination density, kBq/m <sup>2</sup>		Primary morbidity, %	
	Total	Ofthem:				<sup>137</sup> Cs	<sup>90</sup> Sr	Children	Adults
		VOCs	NO <sub>x</sub>	SO <sub>2</sub>	CO				
		Gross emissions of gaseous pollutants per area of the district, g/m <sup>2</sup>							
Ecologically safe areas (control)									
Rognedinsky	9	0	3	0	6	20,2	0,7	929	370
Suzemsky	20	7	4	0	9	17,2	2,3	865	545
Brasovsky	35	8	7	0	20	23,4	0,4	1000	647
Dubrovsky	35,3	10	6	0,3	19	6,7	0,4	1142	398
Mglinsky	38	9	4	2	23	6,1	0,5	663	362
Sevsky	42	28	3	0	11	17,5	1,3	734	473
Navlinsky	55	15	8	2	30	17,5	0,8	1278	604
Kletnyansky	68	50	4	3	11	5,0	0,4	716	37
Komarichsky	99	33	10	9	47	25,1	0,9	807	453
Karachevsky	107	37	22	1	47	12,9	0,8	1301	571
Surazhsky	147	33	33	5	76	7,6	0,4	762	581
	Areas of chemical pollution								
Pogarsky	162	112	14	3	33	27,8	1,0	1279	659
Zhiryatinsky	211	151	14	0	46	5,0	0,7	694	483
Zhukovsky	244	67	46	43	88	6,1	0,8	995	335
Trubchevsky	307	135	25	1	146	21,9	0,7	1435	523
Pochepsky	489	275	37	5	172	5,0	0,5	1044	414
Unechsky	549	285	48	25	191	6,7	0,7	1222	372
Bryansky	1161	1035	30	2	94	5,2	0,4	1179	361
Vygonichsky	1191	1057	38	2	94	5,2	0,4	1049	515
TownSeltso	3804	1091	1474	3	1236	4,1	0,8	1339	600
Dyatkovsky	6545	370	3551	414	2210	35,6	1,0	1754	657
CityBryansk	28047	5755	8434	1924	11934	8,2	5,5	1594	586
	Areas of radioactive contamination								
Gordeevsky	13,5	1	3	0,5	9	304,7	4,6	1370	539
Krasnogorsky	15	2	4	0	9	281,4	8,6	1411	597
Zlynkovsky	18	5	3	0	10	382,4	15,0	1885	559
Novozybkovsky	71	3	0	0	68	427,1	7,7	2046	688
Klimovsky	84	29	6	12	37	129,4	5,9	1379	575
	Areas of combined radiation-chemical contamination								
Klintsovsky	175	15	79	2	79	180,3	4,3	1433	1189
City Novozybkov	6632	2600	1095	0	2937	423,3	9,0	2046	688
CityKlintsy	6591	2755	1844	114	1878	181,4	2,7	1772	428
Starodubsky	447	357	20	15	55	42,1	1,3	1162	490
Correlation coefficients ( <i>ρ</i> ) and levels of their statistical significance ( <i>p</i> )									
Children	<i>ρ</i> =0,33 <i>p</i> =0,07	<i>ρ</i> =0,21 <i>p</i> =0,26	<i>ρ</i> =0,32 <i>p</i> =0,08	<i>ρ</i> =0,09 <i>p</i> =0,64	<b><i>ρ</i>=0,42</b> <b><i>p</i>=0,02</b>	<b><i>ρ</i>=0,64</b> <b><i>p</i>=0,001</b>	<b><i>ρ</i>=0,66</b> <b><i>p</i>=0,001</b>		
Adults	<i>ρ</i> =0,08 <i>p</i> =0,68	<i>ρ</i> =-0,02 <i>p</i> =0,92	<i>ρ</i> =0,17 <i>p</i> =0,37	<i>ρ</i> =-0,14 <i>p</i> =0,46	<i>ρ</i> =0,13 <i>p</i> =0,49	<b><i>ρ</i>=0,50</b> <b><i>p</i>=0,005</b>	<b><i>ρ</i>=0,48</b> <b><i>p</i>=0,007</b>		

The level of primary morbidity of the child population in the territories of combined contamination exceeds the indicators of the territories of chemical pollution and radioactive contamination by 34 and 11% (1660 versus 1235 and 1501 per 1000 population), which suggests that living in these conditions is a significant risk factor for the health of children and, possibly indicates the synergistic nature of the action of radiation and chemical factors.

Statistically significant differences in primary morbidity are recorded in the child population in ecologically safe territories in comparison with territories of radioactive ( $p=0.001$ ), chemical ( $p=0.02$ ) and combined ( $p=0.02$ ) contamination. The same pattern was revealed between the territories of chemical and radioactive contamination ( $p=0.03$ ) and, to a lesser extent (due to the small sample size in conditions of combined pollution), chemical and combined ( $p=0.14$ ) and areas of combined contamination also did not reveal significant differences. In the adult population, significant differences in morbidity between groups of districts were not revealed, reaching maximum values between ecologically safe areas and areas of radioactive contamination ( $p=0.06$ ), areas of chemical and radioactive contamination ( $p=0.07$ ).

Correlation analysis of the relationship between the level of primary morbidity in the child population and the level of radiation and chemical contamination revealed an average statistically significant correlation with atmospheric air pollution with carbon monoxide ( $p=0.42$ ,  $p=0.02$ ) and higher and more significant relationships with the density of radioactive contamination with Cesium-137 and Strontium-90 both in children ( $p=0.64$ ,  $p=0.001$  for  $^{137}\text{Cs}$  and  $p=0.66$ ,  $p=0.001$  for  $^{90}\text{Sr}$ ) and in adults ( $p=0.50$ ,  $p=0.005$  for  $^{137}\text{Cs}$  and  $p=0.48$ ,  $p=0.007$  for  $^{90}\text{Sr}$ ).

Further studies of the health status of the population living in such ecologically unfavorable conditions are extremely necessary and may reflect some general trends similar to those that cause a global increase in cancer incidence [15, 16] (for example [12], an increase in the genetic load in human populations due to with the growth of chemical and radiation pollution of the biosphere by "global" and "eternal" pollutants).

### Conclusions

1. The incidence of primary morbidity in the child population living in ecologically safe areas is statistically significantly lower ( $p=0.001-0.02$ ) than in areas of chemical, radioactive and combined pollution (by 33, 62 and 79%).

2. The frequency of primary morbidity in the adult population in ecologically safe areas is 2, 28 and 9% less than in areas of chemical, radioactive and combined contamination, while the differences are not statistically significant.

3. The level of primary morbidity of the child population in the areas of combined contamination exceeds the indicators of the territories of chemical and radioactive contamination by 34 and 11%, which suggests that living in these conditions is a significant risk factor for the health of children and, possibly, indicates the synergistic nature of the action of radiation and chemical factors.

3. Correlation analysis of the relationship between the level of primary morbidity in the child population and the level of radiation and chemical contamination revealed an average statistically significant correlation with atmospheric air pollution with carbon monoxide and higher and more significant relationships with the density of radioactive contamination by Cesium-137 and Strontium-90 in both children and adults, which indicates the leading role of the radiation factor in the incidence of primary morbidity in the population (especially children).

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## **ИССЛЕДОВАНИЕ ПЕРВИЧНОЙ ЗАБОЛЕВАЕМОСТИ ДЕТСКОГО И ВЗРОСЛОГО НАСЕЛЕНИЯ В ЗАВИСИМОСТИ ОТ ЭКОЛОГИЧЕСКИХ УСЛОВИЙ ПРОЖИВАНИЯ**

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На основании официальных статистических данных за 2008-2017 гг. проведена эколого-гигиеническая оценка состояния окружающей среды и уровня первичной заболеваемости детского и взрослого населения по всем классам болезней во всех городах и районах Брянской области, по радиационному (вследствие аварии на ЧАЭС), химическому (вследствие загрязнения атмосферного воздуха поллютантами от стационарных источников) и сочетанному радиационно-химическому загрязнению. Уровень первичной заболеваемости детского населения на территориях сочетанного загрязнения превышает показатели территорий химического и радиоактивного загрязнения на 34 и 11% (1660 против 1235 и 1501 на 1000 населения), что позволяет предполагать, что проживание в этих условиях является значимым фактором риска для здоровья детей и, возможно, указывает на синергетический характер действия радиационного и химического факторов. Корреляционный анализ связи уровня первичной заболеваемости детского населения с уровнем радиационного и химического загрязнения выявил среднюю статистически значимую корреляционную связь с загрязнением атмосферного воздуха оксидом углерода и более высокие и значимые связи с плотностью радиоактивного загрязнения цезием-137 и стронцием-90 как у детей, так и у взрослых.

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