**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 137Cs and 90Sr, will remain radiologically significant for decades.

Radioecological monitoring regularly carried out in the Bryansk region shows that the density of soil contamination with 137Cs and 90Sr in the southwestern territories exceeds the established limits by tens of times (up to 2116 kBq/m2 for 137Cs and up to 60 kBq/m2 for90Sr) [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 (NOx), 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 137Cs and 90Sr radioactive contamination and the level of chemical contamination by leading gaseous pollutants vary widely. For 137Cs – from 4.1 to 427.1 kBq/m2, for 90Sr – from 0.4 to 15.0 kBq/m2. In terms of gross emissions of gaseous pollutants into the atmospheric air, the area of the district (g/m2) 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 (AAED90) 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/m2 | | Primary morbidity, ‰ | |
| Total | Ofthem: | | | |
| VOCs | NOx | SO2 | CO | 137Cs | 90Sr | Children | Adults |
| Gross emissions of gaseous pollutants per area of the district, g/m2 | | | | |
| **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 *(ρ)* and levels of their statistical significance *(p)* | | | | | | | | | |
| Children | ρ=0,33  р=0,07 | ρ=0,21  р=0,26 | ρ=0,32  р=0,08 | ρ=0,09  р=0,64 | **ρ=0,42**  **р=0,02** | **ρ=0,64**  **р=0,001** | **ρ=0,66**  **р=0,001** |  | |
| Adults | ρ=0,08  р=0,68 | ρ=-0,02  р=0,92 | ρ=0,17  р=0,37 | ρ=-0,14  р=0,46 | ρ=0,13  р=0,49 | **ρ=0,50**  **р=0,005** | **ρ=0,48**  **р=0,007** |

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 (ρ=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 (ρ=0.64, p=0.001 for 137Cs and ρ=0.66, p=0.001 for 90Sr) and in adults (ρ=0.50, p=0.005 for 137Cs and ρ=0.48, p=0.007 for 90Sr).

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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