

RANKING OF TERRITORIES IN THE VORONEZH REGION BY THE INCIDENCE RATES RESULTING FROM CHEMICAL LOAD

Mehantsev I¹, Enin AV²✉

¹ Office of Rospotrebnadzor in the Voronezh Region, Voronezh, Russia

² Burdenko Voronezh State Medical University, Voronezh, Russia

Numerous studies conducted by domestic and foreign researchers report the influence of environmental pollution on shaping morbidity of a population. The study was aimed to rank the territories of the Voronezh Region by the incidence rates probably resulting from chemical pollution of atmospheric air, drinking water, soils in residential areas recorded in 2018–2022. The districts were divided into three groups based on the long-time annual average incidence rates. The degree of correlation between the disease entities and the chemical environmental factors was determined through correlation analysis. The findings have shown that the city of Voronezh and Pavlovsky District are the territories at risk of the disorders with the etiology that is likely to be associated with chemical air pollution. The territories at risk of the disorders that are likely to be associated with chemical pollution of drinking water include Kashirsky, Kantemirovsky, Olkhovatsky, Ternovskiy, Khokholskiy districts, while the territories at risk of the disorders that are likely to be associated with chemical pollution of soils in residential areas include the city of Voronezh, Borisoglebskiy city district, Liskinskiy and Rossoshanskiy districts. The situation observed in the above administrative territories requires in-depth study of the degree of the impact of chemical factors on public health and identification of the sources of these factors. The findings can be used to develop the guidelines on minimization of the adverse effects of chemical environmental factors on public health in the region.

Keywords: hygiene, chemical load, public health, ranking of territories

Author contribution: Mehantsev I — study concept and design, data acquisition; Enin AV — analysis and interpretation of the results, literature review, manuscript draft preparation. Both authors reviewed the results and approved the final version of the manuscript.

✉ **Correspondence should be addressed:** Andrey V. Enin
Studencheskaya, 10, Voronezh, 394036, Russia; en111a@mail.ru

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РАНЖИРОВАНИЕ ТЕРРИТОРИИ ВОРОНЕЖСКОЙ ОБЛАСТИ ПО ЗАБОЛЕВАЕМОСТИ НАСЕЛЕНИЯ, ОБУСЛОВЛЕННОЙ ХИМИЧЕСКОЙ НАГРУЗКОЙ

И. И. Механтсев¹, А. В. Енин²✉

¹ Управление Роспотребнадзора по Воронежской области, Воронеж, Россия

² Воронежский государственный медицинский университет имени Н. Н. Бурденко, Воронеж, Россия

В многочисленных исследованиях отечественных и зарубежных ученых отмечено влияние загрязнения окружающей среды на формирование заболеваемости населения. Целью работы было ранжировать территории Воронежской области по показателям уровня заболеваемости, вероятно обусловленной влиянием химического загрязнения атмосферного воздуха, питьевой воды, почвы селитебных территорий, за 2018–2022 гг. Районы разделили на три группы по среднепогодному уровню заболеваемости. Степень взаимосвязи нозологических форм с химическими факторами окружающей среды установили с помощью корреляционного анализа. По результатам проведенного исследования установлено, что в Воронежской области «территориями риска» по заболеваниям, этиологически вероятно связанным с химическим загрязнением атмосферного воздуха, являются г. Воронеж и Павловский район. К «территориям риска» по нозологиям, вероятно обусловленным химическим загрязнением питьевой воды, отнесены Каширский, Кантемировский, Ольховатский, Терновский, Хохольский районы, а к «территориям риска» по заболеваемости, вероятно обусловленной химическим загрязнением почвы селитебных территорий, — г. Воронеж, Борисоглебский городской округ, Лискинский и Россосанский районы. Ситуация на указанных административных территориях требует углубленного изучения степени влияния химических факторов на здоровье населения и выявления их источников. Результаты исследования могут быть использованы для разработки рекомендаций по минимизации вредного влияния химических факторов окружающей среды на состояние здоровья населения региона.

Ключевые слова: гигиена, химическая нагрузка, здоровье населения, ранжирование территорий

Вклад авторов: И. И. Механтсев — концепция и дизайн исследования, сбор данных; А. В. Енин — анализ и интерпретация результатов, обзор литературы, подготовка проекта рукописи. Оба автора рассмотрели результаты и одобрили окончательный вариант рукописи.

✉ **Для корреспонденции:** Андрей Владимирович Енин
ул. Студенческая, д. 10, г. Воронеж, 394036, Россия; en111a@mail.ru

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Health preservation and improvement provide the basis for the development of the state [1]. In numerous studies, domestic and foreign researchers report the influence of environmental pollution on shaping morbidity of a population [2–9]. Thus, the papers by a number of researchers report the development of cardiovascular, endocrine, digestive system, respiratory tract, skin disorders, malformations and cancer resulting from atmospheric air pollution [10–12]. In particular, the situation in the Voronezh Region is discussed, where predominance of the contribution of chemical atmospheric air pollution by motor vehicles over the contribution of industrial enterprises

is observed, as in many other regions [13, 14]. The papers by many researchers report the impact of drinking water contamination with arsenic, manganese and other substances on public health in Dagestan, Far East and other regions of our country [15–18]. Some papers are focused on the Voronezh Region, where natural factors of drinking water pollution prevail (iron, total hardness, manganese, boron, fluorine), but anthropogenic influence, associated mainly with contamination of drinking water with nitrates, is also possible [19, 20]. The paper [21] discusses the issues of direct (oral) intake of hazardous substances from soils of residential areas by children and its impact

Table. Assessment scale for overall incidence among individuals aged 18 and older (number of cases per 1000 population)

Incidence	18 years of age and older
Low	1323.59 and below
Medium	1323.59–1559.35
High	1559.35 and above

on pediatric morbidity. Thus, the relevance of the issue of the chemical environmental pollution impact on morbidity of a population grows with the development of industry, transport, and agriculture.

The study was aimed to rank the territories of the Voronezh Region by the incidence rates probably resulting from chemical pollution of atmospheric air, drinking water, soils in residential areas.

METHODS

The study involved the data provided by the Center for Hygiene and Epidemiology in the Voronezh Region on the morbidity of a population and the results of laboratory testing of atmospheric air, drinking water, soils in residential areas of the Voronezh Region for the years 2018–2022.

The ranking method represented the procedure involving determination of the long-time annual average incidence per 1000 pediatric (under the age of 14 years) and adult (18 years and older) population; calculation of standard deviations (σ) from median values; dividing the values obtained into three groups (low, medium, high incidence rate). To determine the degree of the association between the disease development and the chemical factors of atmospheric air, drinking water, and soils of residential areas, the paired correlation coefficients were calculated. We assessed statistical significance with the likelihood of statistical error below 5% ($p < 0.05$). Calculations were performed using the MyOffice software package (New Cloud Technologies; Russia).

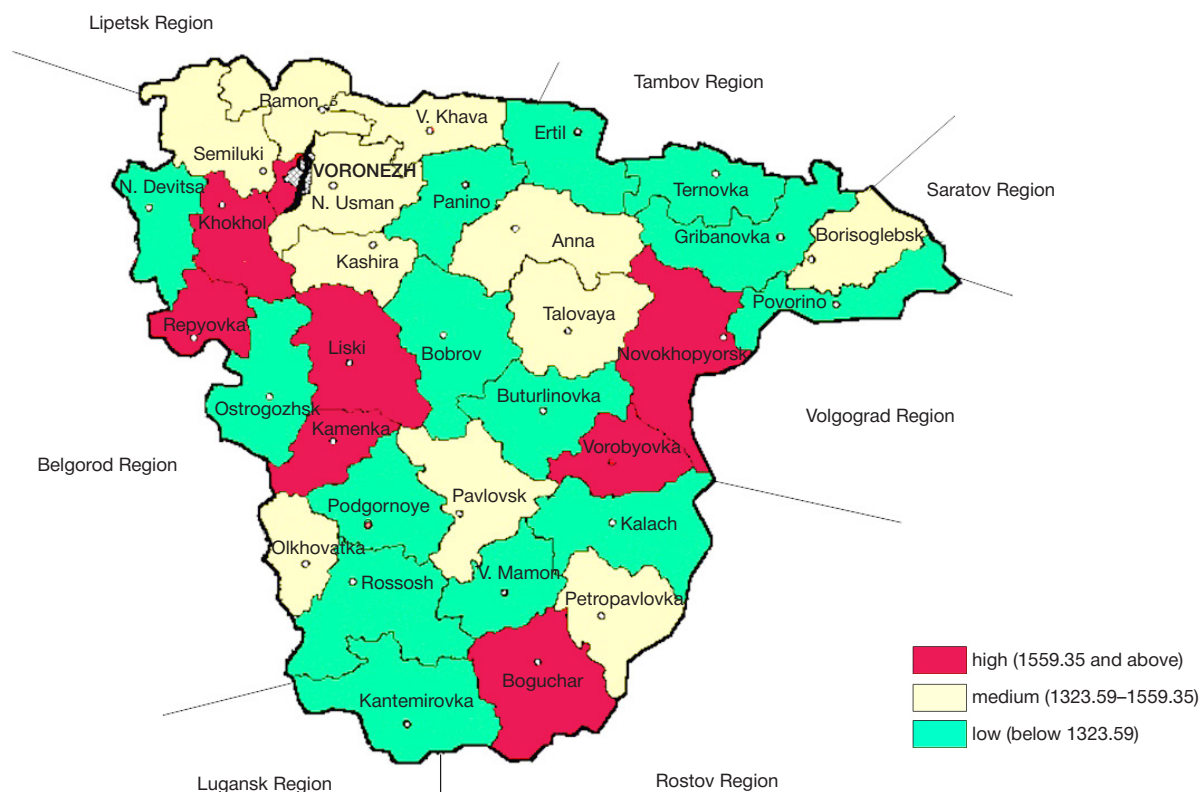
RESULTS

The ones related to environmental factors were selected in the general list of the disease classes and distinct disease entities considered based on the literature data. The list consisted of 13 parameters: overall incidence; diseases of blood and blood-forming organs and certain disorders involving the immune mechanisms; ischaemic heart diseases; asthma, status asthmaticus; pneumonia; diabetes mellitus; diseases of the nervous system; cerebrovascular diseases; allergic rhinitis (pollinosis); contact dermatitis; urolithiasis; congenital malformations, deformations and chromosomal abnormalities; malignant neoplasms.

We plotted assessment scales for the pediatric and adult incidence rates, based on which the territories showing consistently high incidence rate, i.e. territories at risk, were identified. The assessment scale for overall incidence of individuals over the age of 18 is provided in the Table, while ranking of territories by these indicators is presented on the map (Fig. 1).

Thus, high overall incidence among adults was reported in eight studied administrative territories out of 33, specifically in Bogucharsky, Vorobyovsky, Kamensky, Liskinsky, Novokhoporsky, Repyovsky, Khokholsky districts and the city of Voronezh. Overall incidence among children was high in the Borisoglebsky city district, Petropavlovsky, Repyovsky, Semiluksky districts and the city of Voronezh, i.e. in five territories of the region out of 33.

It should be noted that high incidence of several diseases was reported for the majority of studied districts of the Voronezh

**Fig. 1.** Overall incidence among adults (number of cases per 1000 population)

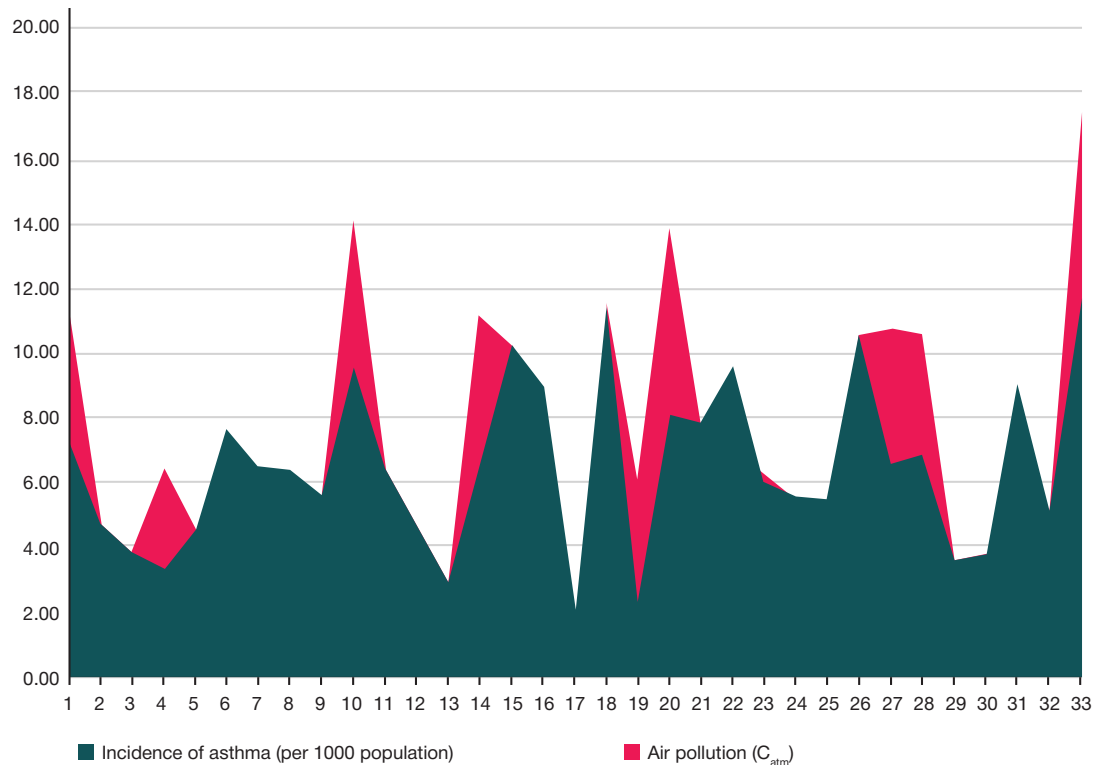


Fig. 2. Correlation between pediatric incidence of asthma and atmospheric air pollution

Region. Thus, high pediatric incidence of six disorders is reported for the city of Voronezh, Semiluksky, and Kalacheyevsky districts, while that of five disorders is reported for Bobrovsky, Petropavlovsky, Rossoshansky, and Ternovsky districts. High incidence of three disorders among adults is registered in the city of Voronezh. High adult incidence of five disease entities is reported for Verkhnemamonsky, Repyovsky, Novokhopyorsky, and Ertilsky districts.

Analysis of the correlation with the atmospheric component of chemical load revealed a strong significant correlation of the pediatric (children under the age of 14) incidence of asthma (correlation coefficient $r = 0.76$, $t_{est} = 6.5 > t_{crit} = 1.96$, $p < 0.05$) (Fig. 2) and a moderate significant correlation of the adult incidence of nervous system diseases (correlation coefficient $r = 0.38$, $t_{est} = 2.25 > t_{crit} = 1.96$, $p < 0.05$). Moderate significant correlations of the pediatric and adult incidence of contact dermatitis with the water component of the load are reported ($r = 0.41$, $t_{est} = 2.52 > t_{crit} = 1.96$ and $r = 0.34$, $t_{est} = 2.03 > t_{crit} = 1.96$, respectively, $p < 0.05$). Moderate significant correlations of the component of industrial pollution of soils with the pediatric incidence of cerebrovascular diseases ($r = 0.4$, $t_{est} = 2.48 > t_{crit} = 1.96$, $p < 0.05$) and nervous system diseases ($r = 0.34$, $t_{est} = 2.01 > t_{crit} = 1.96$, $p < 0.05$) are revealed.

Based on the earlier conducted ranking of the territories of the Voronezh Region, the city of Voronezh and Pavlovsky District were considered to be the territories at risk based on the chemical atmospheric air pollution; the city of Voronezh, Bobrovsky, Kantemirovsky, Kashirsky, Olkhovatsky, Ternovsky, Khokholsky districts were the territories at risk based on the drinking water pollution; the city of Voronezh, Borisoglebsky city district, Liskinsky, Podgorensky, Rossoshansky districts were considered to be the territories at risk based on chemical pollution of soils in residential areas.

Our study has shown that the territories at risk based on the atmospheric component of chemical load, specifically the city of Voronezh and Pavlovsky District, are also the territories with high pediatric incidence of asthma and high adult incidence

of nervous system disorders in the studied period. Among territories with high chemical load based on the drinking water components, the territories with high pediatric incidence of contact dermatitis are represented by Kashirsky, Olkhovatsky, and Ternovsky districts, while the territories with high incidence of contact dermatitis among adults are represented by Kantemirovsky, Kashirsky, Khokholsky districts. Among territories with high levels of chemical contamination of soils in residential areas, in the studied period the territories with high pediatric incidence of nervous system disorders included the city of Voronezh, Borisoglebsky city district, and Rossoshansky District, while the territories, for which pediatric incidence of cerebrovascular diseases was reported, included the city of Voronezh, Liskinsky and Rossoshansky districts. Thus, it is likely that the emergence of the above disease entities in the discussed territories is associated with the effects of chemical contamination of atmospheric air, drinking water, and soils in residential areas.

DISCUSSION

The Voronezh Region is a territory showing high levels of industrialization and agricultural development. In the city of Voronezh there are numerous enterprises, among which the largest are JSC II – VASO, JSC Voronezhsintezkauchuk, etc.; there is a highly developed network of roads. In the studied period, excesses of the annual average and maximum single maximum permissible concentrations of hazardous substances in the atmospheric air were identified in the city (2 MPC_{am} for formaldehyde; more than 1 MPC_{am} for ozone; more than 1 MPC_{am}, up to 3 MPC_{ms} for phenol; more than 1 MPC_{am} for soot).

In Pavlovsky District, there is one of Europe's largest granite mining and processing enterprises, JSC Pavlovsk Nerud. The federal highway M4-Don passes through the territory of the region. In the studied period, excesses of the annual average and maximum single maximum permissible concentrations of hazardous substances in the atmospheric air were identified

in the district (more than 3 MPCam for formaldehyde; more than 3 MPCtwa, up to MPCms for sulfur dioxide; more than 1 MPCam for phenol). Thus, high morbidity rate resulting from chemical atmospheric air pollution is quite natural for these territories.

The earlier studies of the impact of the drinking water chemical contamination on the morbidity of a population in the region revealed moderate significant correlations between the adult incidence of urolithiasis and the total hardness of water (correlation coefficient $r = 0.42$); between the adult incidence of the diseases of the skin and subcutaneous tissue and the levels of iron in drinking water (correlation coefficient $r = 0.35$); the issue of the nitrate pollution of water sources in rural areas (both centralized and decentralized) was addressed, several cases of methemoglobinemia in children under one year of age were identified [22]. Our study has not confirmed the relationship between urolithiasis and the impact of drinking water. However, the incidence of skin disorders and the issue of nitrate pollution in certain rural areas are still relevant. Thus, in the Kashirsky District, for which high incidence of contact dermatitis among both children and adults has been reported, excesses of the annual average and maximum single maximum permissible concentrations of nitrates in the drinking water (up to 2 MPCam, more than 4 MPCms) have been simultaneously revealed in the studied period. The condition of soils to the great extent reflects the condition of other media, such as atmospheric air [23]. In the Voronezh Region, excesses of maximum single maximum permissible concentrations of benzo[a]pyrene in the soils

of residential areas were reported for the city of Voronezh (more than 3 MPCms) and Rossoshansky District (1.5 MPCms) in the studied period, the main sources of which could be vehicle emissions and asphalt road pavement. It is noteworthy that 80% of territories of the region with high levels of chemical soil pollution are urban areas. In the only district considered to be the territory at risk based on chemical contamination of soils, where there are no urban areas (Podgorensky District), there is no benzo[a]pyrene among the priority components of chemical soil pollution.

CONCLUSIONS

The analysis of data for the years 2018–2022 has shown that the city of Voronezh and Pavlovsky District are the territories at risk of the disorders with the etiology that is probably associated with chemical air pollution. The territories at risk of the disorders probably associated with chemical contamination of drinking water include Kashirsky, Kantemirovsky, Olkhovatsky, Ternovsky, Khokholsky districts. The territories at risk of diseases probably associated with chemical contamination of soils in residential areas include the city of Voronezh, Borisoglebsky city district, Liskinsky and Rossoshansky districts. The situation observed in these administrative territories requires in-depth study of the degree of the impact of chemical factors on public health and identification of the sources of these factors aimed at making managerial decisions on minimization of the adverse effects of chemical environmental factors on public health in the region.

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