

## ОКРУЖАЮЩАЯ СРЕДА И ГИГИЕНА ТРУДА

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Original article

ASSESSING INFLUENCE EXERTED  
BY AMBIENT AIR POLLUTION ON PUBLIC  
HEALTH IN THE RUSSIAN FEDERATION*S.V. Kleyn, N.V. Nikiforova, S.A. Vekovshinina*

**Background.** One of the factors influencing the health of the population, which is the object of one of the federal projects, is atmospheric air. Many studies have established that atmospheric air pollution with chemical impurities can cause the onset of a new or exacerbation of an existing pathology in humans.

**Purpose.** Assess the impact of atmospheric air pollution on the health indicators of the population of the Russian Federation.

**Materials and methods.** The hygienic assessment of atmospheric air quality was carried out using the data from Rospotrebnadzor form 18 for 2012-2021, data from the federal information fund for social and hygienic monitoring. The analysis of the primary morbidity of the population was carried out using statistical collections "The incidence of the entire population of Russia with a diagnosis established for the first time in life" for 2012-2021. The calculation of additional cases of population diseases associated with atmospheric air quality was performed in accordance with Methodological recommendations 5.1.0095-14.

**Results.** For the period 2012-2021 on the territory of the Russian Federation, the share of atmospheric air samples that do not meet hygienic requirements decreased by 1.69 times. Priority substances for which excesses of standards are registered are: benz(a)pyrene, xylene, hydrogen chloride, nickel oxide, ozone, ethenylbenzene, hydrochloride, methanethiol, particulate matter, formaldehyde, etc. Improvement in atmospheric air quality has reduced the number of additional cases

*of disease from all causes associated with air pollution. The structure of additional morbidity associated with atmospheric air quality is dominated by diseases of the respiratory, digestive, circulatory, and nervous systems. Additional cases of diseases of the population associated with air quality are registered, depending on the class of diseases, in the territories of 22-42 subjects of the Russian Federation.*

**Conclusion.** *The results obtained can be used in the formation of monitoring programs aimed at reducing priority chemical impurities in the atmospheric air and developing programs for the primary prevention of the population from diseases associated with atmospheric air quality.*

**Keywords:** *atmospheric air; associated morbidity; impact of atmospheric air on health*

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Научная статья

## ОЦЕНКА ВЛИЯНИЯ ЗАГРЯЗНЕНИЯ АТМОСФЕРНОГО ВОЗДУХА НА ЗДОРОВЬЕ НАСЕЛЕНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ

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**Обоснование.** *Одним из факторов, оказывающих влияние на здоровье населения, и являющегося объектом одного из федеральных проектов, является атмосферный воздух. Многими исследованиями установлено, что загрязнение атмосферного воздуха химическими примесями может обуславливать начало новой или обострение уже существующей патологии у человека.*

**Цель.** *Оценить влияние загрязнения атмосферного воздуха на показатели здоровья населения Российской Федерации.*

**Материалы и методы.** *Гигиеническая оценка качества атмосферного воздуха проведена с использованием данных формы 18 Роспотребнадзора за 2012-2021 гг., данных федерального информационного фонда социально-гигиенического мониторинга. Анализ первичной заболеваемости населения проводили с использованием статистических сборников «Заболеваемость всего населения России с диагнозом, установленным впервые в жизни» за*

2012-2021 гг. Расчет дополнительных случаев заболеваний населения, ассоциированных с качеством атмосферного воздуха, выполнен в соответствии с Методическими рекомендациями 5.1.0095-14.

**Результаты.** За период 2012-2021 гг. на территории Российской Федерации удельный вес проб атмосферного воздуха, не соответствующих гигиеническим требованиям, снизился в 1.69 раза. Приоритетными веществами, по которым регистрируются превышения нормативов, являются: бенз(а)пирен, ксилол, хлористый водород, никель оксид, озон, этилбензол, гидрохлорид, метантиол, взвешенные вещества, формальдегид и пр. Улучшение качества атмосферного воздуха позволило снизить в 2.8 раза число дополнительных случаев заболеваний от всех причин, связанных с загрязнением атмосферного воздуха. В структуре дополнительной заболеваемости, ассоциированной с качеством атмосферного воздуха, преобладают болезни органов дыхания, органов пищеварения, системы кровообращения, нервной системы. Дополнительные случаи заболеваний населения, ассоциированные с качеством воздуха, регистрируются, в зависимости от класса болезней, на территориях 22-42 субъектов РФ.

**Заключение.** Полученные результаты могут быть использованы при формировании программ наблюдения, направленных на снижение в атмосферном воздухе приоритетных химических примесей и разработки программ первичной профилактики населения по заболеваниям, ассоциированным с качеством атмосферного воздуха.

**Ключевые слова:** атмосферный воздух; ассоциированная заболеваемость; влияние атмосферного воздуха на здоровье

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## Introduction

Public health is a vital criterion that determines a state as a developed and socially oriented one. It is important to examine and understand factors influencing public health since this gives an opportunity to make public healthcare more effective and to adapt it to constantly changing conditions in the contemporary world [2]. Over the last decade, several federal projects have been actively developed and approved in the Russian Federation. Their primary goal is to improve the environmental situation in the country as well as public health [1]. Ambient air is among factors producing effects on public health and it is the primary object within one of these federal projects [5, 6, 11, 13].

Multiple studies have established that chemical pollution in ambient air can induce a new pathology in a person or exacerbate an already existing one. Ambient air pollution with chemicals is known to make a certain contribution to development of such diseases as respiratory ones (pneumonia, chronic obstructive pulmonary disease, flu, cerebrovascular diseases, asthma), malignant neoplasms, circulatory diseases including hypertension, diseases of the endocrine system (diabetes mellitus), kidney diseases, congenital malformations, etc. [3, 4, 7–10, 12].

Given that, it is vital to establish priority health disorders associated with ambient air quality as well as priority chemicals that probabilistically cause these disorders.

### **Materials and methods**

Our hygienic assessment on ambient air quality relied on data taken from the statistical reports issued by Rospotrebnadzor (Form No. 18 “Data on the sanitary situation in a given RF region) in 2012-2021 as well as data provided by the federal information fund of social and hygienic monitoring (SHM).

Data on incidence among the country population were taken from the statistical collections “Incidence among the whole RF population with diagnoses put for the first time” in 2012-2021. Therefore, we analyzed primary incidence.

A number of additional disease cases among population associated with ambient air quality was calculated in accordance with the Methodical Guidelines 5.1.0095-14 “Calculation of actual economic losses caused by population incidence, mortality and disability and associated with negative effects produced by the environmental factors and similar losses prevented due to control and surveillance activities”. We applied models built with the use of dynamic data on RF regions (2012-2021) to calculate a number of associated disease cases in RF regions.

### **Results**

#### *Assessment of the existing inhalation exposure*

According to data obtained by instrumental research on ambient air quality in the Russian Federation, over a period from 2012 to 2021 a share of ambient air samples that did not conform to hygienic standards went down by 1.69 times. This indicator was equal to 0.79% in 2021. This favorable descending trend in a number of samples deviating from the hygienic standards was typical for both urban settlements where it decreased from 1.37% to 0.82% (by 1.67 times) and rural ones, from 1.08% to 0.54% (by 2 times).

In 2021, the hygienic standards existing in the RF were violated as per contents of such chemicals in ambient air as benz(a)pyrene (5.98% of samples with its concentration exceeding MPC), xylene (2.85% of samples), and hydrogen chloride (1.2% of samples). A share of ambient air samples that contained the same chemicals in concentrations higher than MPC also grew; this growth amounted to 3.15 times for benz(a)pyrene, 2.85 times for xylene and 1.67 times for hydrogen chloride. Besides, a growing share of samples with chemical concentrations exceeding MPC was detected for toluene (by 1.61 times) and chlorine and its compounds (by 1.6 times).

Some chemicals were detected in concentrations up to five MPC; the list includes nitrogen oxide, ammonia, benzene, particulate matter PM<sub>10</sub>, PM<sub>2.5</sub>, dihydrosulfide, xylene, sulfur dioxide, styrene, toluene, heavy metals, carbon (soot), carbon oxide, phenol, formaldehyde, hydrogen fluoride, and ethylbenzene. When these chemicals occur in ambient air in concentrations being higher than the hygienic standards, this may cause elevated incidence regarding diseases of the respiratory organs, immune system, central nervous system, liver and others among exposed population.

In 2021, priority territories with high shares of ambient air samples with chemicals contents exceeding MPC included Yakutia, Transbaikalia, Buryatia, Vladimir region, Chelyabinsk region, and Krasnoyarsk region (Table 1).

Table 1.

**Priority RF regions as per a share (%) of ambient air samples with elevated chemical contents in urban and rural settlements<sup>1</sup>, 2021**

RF region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	A growth against 2012, %
Yakutia	1.13	0.90	3.48	0.77	0.56	1.40	0.38	0.51	0.48	6.28	+454.2
Transbaikalia	14.26	21.04	16.73	7.50	2.36	0.77	0.00	2.40	6.38	5.93	-58.4
Buryatia	10.67	4.80	6.25	6.55	2.25	3.52	3.26	3.02	7.86	4.89	-54.1
Vladimir region	1.99	0.27	8.38	0.56	0.42	0.53	0.78	0.53	0.63	4.56	+129.4
Chelyabinsk region	1.57	1.71	4.62	1.07	1.21	2.17	1.89	0.80	2.13	3.25	+107.1
Krasnoyarsk region	4.50	4.31	3.92	3.61	2.29	2.31	1.71	1.99	3.39	2.35	-47.8

High concentrations (higher than five MPC) of chemicals in ambient air were detected in the following regions:

<sup>1</sup> The table provides data only on those RF regions where in 2021 more than 800 single concentrations were detected by measurements accomplished within the complete control program performed during 200 and more days a year (State Standard GOST R59059-2020 “Environmental protection. Control of ambient air pollution. Terms and definitions”)

- benz(a)pyrene and ethylbenzene in Transbaikalia;
- benz(a)pyrene, xylene, particulate matter, including PM<sub>10</sub>, PM<sub>2.5</sub>, dihydro-sulfide, sulfur dioxide, and toluene in Krasnoyarsk region;
- benz(a)pyrene and xylene in Buryatia;
- particulate matter, including PM<sub>10</sub>, PM<sub>2.5</sub>, in Yakutia;
- particulate matter PM<sub>2.5</sub> and benz(a)pyrene in Chelyabinsk region.

Apart from these regions, chemicals pollutants were detected in ambient air in concentrations exceeding five MPC in other 15 RF regions including Irkutsk region, Kirov region, Krasnodar region, Murmansk region, Bashkortostan, Ryazan region, Kemerovo region, Kaluga region, Kostroma region, Sverdlovsk region, Primorye, Omsk region, Karelia, Khabarovsk region, and Chukotka.

We analyzed data provided by the federal information fund of social and hygienic monitoring and revealed that in 2021 99.34% of ambient air samples conformed to the hygienic standards as per average daily MPC and this was by 0.92% higher than in 2012 (98.42% samples). Overall, in 2012-2021 a share of ambient air samples with chemicals contents that were higher than average daily MPC went down by 2.5 times in the country. Concentrations higher than average daily MPC were detected only in 0.66% of ambient air samples.

In 2021, chemical pollutants in concentrations higher than their average daily MPC were detected in ambient air samples in 61 RF regions. Out of them, these violations were detected in more than 5% of samples in 7 RF regions including the Khanty-Mansi Autonomous Area (16.05% of samples), Mari El Republic (8.9% of samples), Tyva (6.07% of samples), Omsk region (5.42% of samples), Dagestan (5.2% of samples), Vologda region (5.19% of samples), and Buryatia (5.1% of samples).

According to social and hygienic monitoring data, priority chemical pollutants in ambient air include benz(a)pyrene (a share of samples with its concentration exceeding average daily MPC is 17.77%), nickel oxide (recalculated as per nickel) (4.92% of samples), ozone (3.24% of samples), gaseous fluoride compounds (recalculated as per fluoride) (2.16% of samples), styrene (2.07% of samples), hydrochloride (1.45% of samples), methanethiol (1.44% of samples), particulate matter (1.32% of samples), and formaldehyde (1.24% of samples).

Therefore, we have established an overall descending trend in the RF for the number of ambient air samples deviating from the hygienic standards during the period from 2012 to 2021. Priority chemicals that still occur in ambient air in concentrations deviating from the hygienic standards include benz(a)pyrene, xylene, hydrogen chloride, nickel oxide, ozone, gaseous fluoride compounds, styrene, hydrochloride, methanethiol, particulate matter and formaldehyde.

*Assessment of additional incidence among population associated with ambient air quality*

We assessed additional incidence among the RF population that was associated with ambient air quality. The assessment revealed that a number of additional disease cases due to all causes associated with ambient air pollution went down by 2.8 times in 2021 against 2012 and was equal to 520.44 cases per 100 thousand people. Additional disease cases among the RF population occurred due to ambient air being polluted with nitrogen oxide, ammonia, particulate matter, hydroxybenzene and its derivatives, dihydrosulfide, aromatic hydrocarbons, manganese, lead, sulfur dioxide, carbon oxide, formaldehyde, fluoride and its compounds (recalculated as per fluoride), hydrogen fluoride, chlorine and its compounds and some other chemicals.

Diseases of the respiratory organs prevailed in the structure of additional incidence among the RF population associated with ambient air pollution. They accounted for 69.7%. The second place belonged to diseases of the digestive organs (13.5%); the third place, circulatory diseases (7.1%); the fourth place, diseases of the nervous system (3.4%). All other groupings of diseases accounted for less than 2% in the structure of additional incidence associated with ambient air pollution.

In 2021, a number of additional respiratory diseases among population that were probabilistically associated with ambient air quality went down by 3 times against in 2021. In 2021, this indicator was equal to  $520.44_{0/0000}$  or 1.4% of the actual incidence due to this cause. Priority risk factors that caused additional incidence with respiratory diseases included elevated concentrations (exceeding the hygienic standards) of the following chemicals in ambient air: hydroxybenzene and its derivative, dihydrosulfide, fluoride and its compounds, ammonia, particulate matter, aromatic hydrocarbons, formaldehyde and others.

Chemicals occurring in ambient air probabilistically caused additional cases of respiratory diseases in 42 RF regions, within the range from 2.9 (Kirov region) to 11,479.5 (Chukotka) additional cases per 100 thousand people. This indicator was higher than on average in the country in 14 regions and this deviation varied from 1.8 to 21.4 times. Several regions were considered priority ones as per the number of additional respiratory diseases cases including Chukotka where this indicator was by 22 times higher than in the RF on average; Transbaikalia, by 9.3 times; Chelyabinsk region, by 7.9 times; Lipetsk region, by 5.8 times; and Udmurtia, by 5.3 times.

The number of additional digestive diseases that are probabilistically associated with ambient air quality also decreases. In 2021, this indicator was equal

to 101.9<sub>0/0000</sub> (3.9% of the actual incidence due to this cause) and this was by 1.2 times lower than in 2012. Additional cases of digestive diseases predominantly occurred due to elevated concentrations (higher than the hygienic standards) of aromatic hydrocarbons, including xylene, and some other chemicals in ambient air. Additional cases of digestive diseases associated with ambient air pollution were registered in 22 RF regions within the range from 3.4 to 2380.43<sub>0/0000</sub>. This indicator was higher than on average in the country in nine regions and this deviation varied from 1.2 to 23.5 times. Several regions were considered priority ones as per the number of additional digestive diseases cases including Vladimir region where this indicator was by 23.5 times higher than on average in the RF; Chelyabinsk region, by 13.6 times; Bryansk region, by 10 times; Sverdlovsk region, by 6 times; Primorye, by 4.2 times; and Krasnoyarsk region, by 2.3 times.

Additional cases of **circulatory diseases** among the RF population were mostly caused by exposure to carbon oxide and other chemicals in concentrations exceeding the hygienic standards. Additional incidence of such diseases amounted to 52.9<sub>0/0000</sub> (1.8% of the actual incidence due to this cause) in 2021 and went down by 2.2 times against its level in 2012. Additional cases of circulatory diseases were registered in 40 RF regions within the range from 0.99<sub>0/0000</sub> (Moscow) to 584.5<sub>0/0000</sub> (Tomsk region). This indicator was higher than on average in the country in 13 regions and this deviation varied from 2.0 to 11.0 times with its maximum values detected in Tomsk region, Altai region, Saratov region, Omsk region and Kursk region.

Additional incidence of diseases of the nervous system associated with ambient air quality went down by 3.4 times from 2012 to 2021 when it was equal to 25.3<sub>0/0000</sub> (2.0% of the actual incidence due to this cause). Priority chemicals that made the greatest contribution to the associated incidence of nervous diseases included dihydrosulfide, aromatic hydrocarbons, lead, carbon oxide and some others.

Incidence among population was probabilistically associated with ambient air quality in 54 RF regions. This indicator was higher than its average country level in 17 regions and this deviation varied from 1.5 to 9.6 times. The highest deviation levels were detected in Tomsk region where the indicator was by 9.6 times higher than on average in the country; Yakutia, by 7.4 times; Altai region, by 6.4 times; Omsk region, by 6.2 times, and Saratov region, by 5.7 times.

Therefore, we established priority health disorders associated with ambient air quality. They include diseases of the respiratory system, diseases of the digestive organs, diseases of the circulatory system and diseases of the nervous system. We also established priority chemicals that probabilistically caused additional incidence among population. These chemicals were nitrogen oxide,



ammonia, particulate matter, hydroxybenzene and its derivatives, dihydrosulfide, aromatic hydrocarbons, manganese, lead, sulfur dioxide, carbon oxide, formaldehyde, fluoride and its compounds (recalculated as per fluoride), hydrogen fluoride, chlorine and its compounds and others.

The results obtained during the study confirm and supplement the data of previously published studies [15-20].

### **Conclusion**

The research results revealed the following.

1. We established a positive trend in the RF regarding a share of ambient air samples that did not conform to hygienic standards. This share went down by 1.69 times over the period from 2012 to 2021. The descending trend was typical for both urban settlements where this share decreased by 1.67 times and rural ones where it dropped by 2.0 times.
2. Priority chemicals that are detected in concentrations exceeding the hygienic standards include benz(a)pyrene, xylene, hydrogen chloride, nickel oxide, ozone, gaseous fluoride compounds, styrene, hydrochloride, methanethiol, particulate matter and formaldehyde.
3. Priority territories where a share of samples with chemical contents exceeding MPC was the highest in 2021 include Yakutia, Transbaikalia, Buryatia, Vladimir region, Chelyabinsk region, and Krasnoyarsk region.
4. Ambient air quality improved in the country and this resulted in by 2.8 times lower numbers of additional diseases due to all causes associated with ambient air pollution. In 2021, incidence associated with ambient air pollution amounted to 520.44 cases per 100 thousand people.
5. Additional cases of diseases among the RF population are caused by exposure to nitrogen oxide, ammonia, particulate matter, hydroxybenzene and its derivatives, dihydrosulfide, aromatic hydrocarbons, manganese, lead, sulfur dioxide, carbon oxide, formaldehyde, fluoride and its compounds (recalculated as per fluoride), hydrogen chloride, chlorine and its compounds and other chemicals in ambient air.
6. Diseases of the respiratory organs prevail in the structure of additional incidence associated with ambient air quality (69.7%). They are followed by diseases of the digestive system, 13.5 %; diseases of the circulatory system, 7.1%; and diseases of the nervous system, 3.4%.
7. Incidence of respiratory diseases associated with ambient air quality was detected in 42 RF regions; digestive diseases, 22 RF regions; circulatory diseases, 40 regions; diseases of the nervous system, 54 RF regions.

8. In several RF regions, a share of ambient air samples that contained chemicals in concentrations higher than MPC was very high and this resulted in higher incidence. Thus, in Yakutia additional incidence of nervous diseases was by 7.4 times higher than on average in the country; in Transbaikalia, additional incidence of respiratory diseases was by 9.3 times higher than on average in the country; in Chelyabinsk region, additional incidence of respiratory diseases was by 7.9 times higher and of digestive diseases by 13.6 times higher than on average in the country.
9. Our results can be used to develop regional programs aimed at reducing concentrations of priority chemicals in ambient air. They are also relevant for use in developing primary prevention programs regarding diseases associated with ambient air quality.

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