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HYGIENIC ASSESSMENT OF PRIORITY ENVIRONMENT HEALTH RISK FACTORS AND HEALTH STATE OF MOSCOW POPULATION

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The article outlines the results of adjoint hygienic assessment devoted to priority environmental health risk factors and health state of population in Moscow. We have shown that some conditions under which negative health risk factors can exert hazardous influence on population health still exist on the megacity territory. Such trends are confirmed by air pollutants content exceeding hygienic standards (up to 6.6 daily average maximum permissible concentrations); a substantial growth of centralized water supply sources (up to 65.87%) with water quality in them not conforming to hygienic standards; high quantity of soil samples also not conforming to hygienic standards (more than 50% as per a number of sanitary-chemical and microbiological parameters in some administrative districts). At the same time we have noticed a trend showing reduction in number of drinking water samples not conforming to the standards (from 4.36% to 2.45%) which were taken from distribution network of centralized household water supply. We have determined that primary morbidity parameters are also characterized with positive trends as they tend to decrease; still we have seen some separate morbidity categories and nosologies to exceed average country levels (from 4.1% up to 68.3%). Such morbidity categories include "Respiratory organs diseases", "Skin and subcutaneous tissue diseases", "Neoplasms" etc. We have received about 50 valid and biologically well-grounded mathematic models which helped us to accomplish cause-and-effect relations analysis in the system "human environment quality (danger factor) – population health (morbidity, mortality). The analysis has shown that negative environmental factors exert their influence on population mortality and morbidity causing up to 29.2% additional morbid cases and up to 0.056% additional deaths per year. Air and soil quality which does not conform to hygienic standards makes the greatest contribution into probable occurrence of additional morbid cases; as for mortality, the main probable reason for additional deaths is air quality not conforming to hygienic standards. Risk factors are phenol, benzpyrene, nitrogen dioxide, suspended substances, ammonia, chlorine and its compounds, sulfur dioxide etc., contained in air, as well as cadmium, microbiological agents, and radioactive substances which can be found in soil.

Key words: *human environment factors, spatial-dynamic analysis, population health, primary morbidity, mortality, mathematic modeling, cause-and-effect relations, additional morbid cases.*

State and society development nowadays overcomes significant changes and faces a lot of new risks and dangers including those of sanitary and epidemiologic character. Providing sanitary and epidemiologic well-being, especially on the territories with high population density and size, is a very important activity aimed at preventing population health losses related to human environment quality. Moscow is the greatest megacity in the RF and one of the biggest cities in the world

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as per population size [9]; according to the data provided by The Economist Intelligence Unit, in 2015 Moscow took the 13th place as per expected life span among 20 megacities with population exceeding 10 million (the top positions were occupied by Tokyo, Osaka, New-York and London). As per total population safety index Moscow took the 43th place among cities with population equal to 5-10 million and more [4].

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According to the data taken from the State reports on sanitary and epidemiologic well-being in the RF and in Moscow, in 2012-2014 environmental quality in the megacity was in general characterized with positive trends showing improvement, including air quality parameters, quality of water from centralized household supply, and soil quality. There were also some positive trends in medical and demographical parameters (birth rate, mortality, and expected life span). At the same time there are still some risks in Moscow which can cause additional death and morbid events; they are related to environment factor influence, primarily air and drinking water [6, 7, 8].

Therefore, hygienic assessment of population health, human environment, determination of factors causing health risk occurrence, and, consequently, additional deaths and morbid events, is a vital task in goal-setting and working out appropriate measures aimed at securing sanitary and epidemiologic welfare of the population [1, 2].

Research goal: adjoint hygienic assessment of priority environmental health risk factors and health state of population in Moscow

Data and methods. Within the frameworks of this research we have accomplished comparative spatial-dynamic analysis of morbidity and total and standardized mortality on the whole and in the context of administrative districts over 2012-2014 as per 20 categories of primary morbidity and 20 mortality categories. Mortality was assessed with the use of official statistic data in the context of death causes categories ("Medical and demographical parameters in the RF" reference books issued by the RF Public Health Ministry in 2013-2015). Primary morbidity was assessed in the context of categories and separate nosologic forms in various sex and age groups ("Population morbidity in the RF" reference books issued by the RF Public Health Ministry in 2013/2014/2015). Primary morbidity and mortality dynamics in the context of administrative districts over 2012-2014 was assessed with the use of spatial-dynamic analysis. Growth rate for mortality and primary morbidity parameters in 2014 was calculated as compared to 2012.

Air quality was assessed for the period of 2012-2014 as per social and hygienic monitoring data including those provided by "Mosecomonitoring" and "Moskovsliy ZGMS-3" for 201-2014. Air quality was compared with average Russian parameters and it was also assessed in the context of administrative districts; the main assessment parameter was maximum permissible concentrations exceeding safety standards at stationary sampling points, highways located in residential zones, in zones of industrial enterprises' influence (129 288 samples per 25 parameters). To obtain necessary data concerning annual average concentrations we plotted a considering points system on a city electronic map; the system was in the form of regular grid with total area equal to 3240 km^2, dimensions 54×60 km and mesh point pitch 200×200 m. We made the approximation as per "back distances" technique [3]. All our calculations were based on the data obtained over 2012-2014. We carried out comparative analysis of chemicals' concentrations in air in Moscow taking 2.1.6.1032-01 Sanitary and epidemiologic requirements, 2.1.6.1338-03 Hygienic standards and 2.1.6.2309-07 Hygienic standards into account.

We accomplished water quality assessment for household water supply systems according to the data of social and hygienic monitoring over 2012-2014 concerning centralized city water supply from Moskvoretskaya and Volzhskaya water systems (6 water intakes, 34,803 water samples from distribution network per 18 parameters). Water quality comparative assessment in all administrative districts was carried out with the use of linear approximation technique (interpolation and extrapolation) and Delaunay triangulation technique for the data obtained over the whole examined period as per annual average parameters [10]. Parameters' comparative analysis was made taking 2.1.4.1074-01 Sanitary and epidemiologic requirements and 2.2.5.1315-03 Hygienic standards into account.

We accomplished assessment of Moscow soils quality basing on the soil control data obtained for housing development territories, areas of children educational establishments, areas of medical and preventive facilities and in recreation zones (26,087 samples per 28 parameters). Parameters' comparative analysis was made taking 2.1.7.1287-03 Sanitary and epidemiologic requirements, 2.1.7.2511-09 Hygienic standards, and 2.1.7.2041-06 Hygienic standards into account.

Correlation modeling in the system "danger factor – morbid event" was carried out with the use of regression analysis technique. We assessed models validity basing on single-factor variance analysis per Fischer criterion. When doing mathematic modeling we applied determining 95-% confidence limit and scope for obtained models. We calculated additional morbid events as per modeling results [13].

Results and discussion. Air quality analysis in Moscow carried out by Federal service for surveillance over consumer rights protection and human well-being [8] showed that air quality in the city in 2014 improved in comparison to 2012. Specific weight of samples with pollutants concentrations exceeding single maximum permissible concentrations amounted to 0.22% in 2014 that was almost two times lower than in 2012 (0.43% samples with pollutants concentrations exceeding single maximum permissible concentrations).

Among most significant air pollutants in Moscow in 2014 (as per share of samples with parameters exceeding single maximum permissible concentrations) there was hydrogen sulfide (0.6±0.45%), nitrogen dioxide (0.59±0.19%), ammonia (0.3±0.29%) and aliphatic saturated hydrocarbons (0.25±0.13%), which corresponded to the data of previous research [11, 12].

As per FSBE "Zentralnoye UGMS" [5] on the whole in Moscow average daily concentrations of nitrogen dioxide, formaldehyde and nitrogen oxide were higher than average daily maximum permissible concentrations over a year period in 2014 (1.5 a.d. MPC, 1.4 a.d. MPC and 1.1 a.d. MPC correspondingly). Average daily concentrations of nitrogen dioxide, formaldehyde, benzpyrene, carbon oxide, ammonia, phenol, and suspended substances, measured over a month, exceeded hygienic standards 1.3-6.6 times in 2014. Formaldehyde concentrations exceeding hygienic standards were most frequently registered in Moscow air.

The highest air pollution levels were detected near highways and Moscow industrial zones. Here air pollution index was estimated as "high" in 2014. Air pollution equal to 1.4-6.4 maximum permissible concentrations near highways was caused by high concentrations of formaldehyde, nitrogen dioxide and benzpyrene. Maximum air pollution was detected in Zapadniy administrative district of Moscow where Mozhaiskoye highway is located.

Air quality assessment in various administrative districts of Moscow showed that the highest pollution levels were detected in Zapadniy district, Zelenogradskiy district, Zentral district and Yugo-Vostochniy district (average hygienic standards exceeding over 2012-2014 was determined for three substances; nitrogen dioxide concentrations were up to 1.51 times higher than a.d. MPC; ammonia concentrations, 1.25 times higher; formaldehyde concentrations, 1.34 times higher). Nitrogen dioxide and ammonia concentrations exceeded hygienic standards in Vostochniy district, Severniy district, Severo-Zapadniy district and Yuzhniy district (up to 1.34 a.d. MPC and 1.21 a.d. MPC correspondingly). Formaldehyde concentrations amounted to up to 1.05 a.d. MPC in Severo-Vostochniy district, and nitrogen dioxide concentrations were up to 1.11 a.d. MPC in Yugo-Zapadniy district.

Water to Moscow population in 2014 was supplied from Moskvoretskaya and Volzhskaya surface water systems, as well as from underground drinking water sources [6]. A share of centralized water supply sources which didn't conform to sanitary and epidemiologic requirements increased in the city in 2014 (by 43.83% as compared to 2012) and amounted to 65.81±10.38%; it was 4.2 times higher than in the RF on average. In spite of low quality of water taken from Moscow centralized water supply, 99.6% of Moscow population was provided with qualitative water in 2014.

Over 2012-2014 there was a trend in Moscow showing reduction in a number of water samples (taken from distribution network of centralized household water supply) not conforming to standards. Specific weight of samples not conforming to sanitary requirements as per sanitary-chemical parameters went down by 1.78 times in 2014 in Moscow (as compared to 2012) and amounted to 2.45±0.37%; as per microbiological parameters, 0.30±0.11% (picture 1).

Quality of drinking water taken from Moscow centralized household water supply systems didn't conform to sanitary requirements per sanitary-chemical parameters due to iron contents

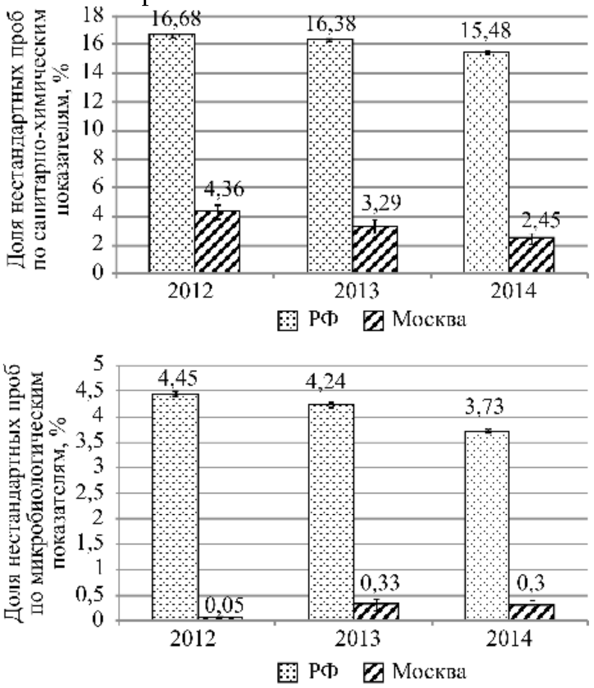


Figure 1. Comparative characteristics of water samples share (taken from distribution network of centralized household water supply) not conforming to sanitary requirements, the RF and Moscow, %
(first bar graph: % of samples not conforming to standards per sanitary-chemical parameters; second bar graph: % of samples not conforming to standards per microbiological parameters)

(1.53±1.13% non-conforming samples in 2012, 1.94±1.2% in 2013 and 2.21±1.44% in 2014), and tetrachlormethane as well (0.25±0.17% in 2014).

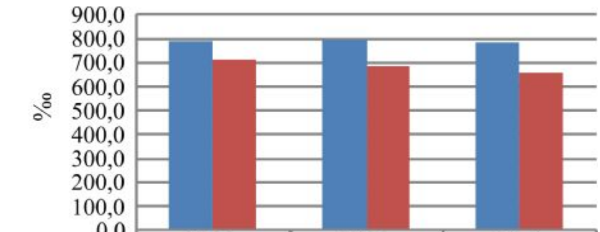
Chemicals concentrations amounted to 0.5 to 1 MPC in water supplied in Severo-Vostochniy district and Vostochniy district most frequently; they were less frequently higher than permitted in Zelenogradskiy and Severo-zapadniy district.

Assessment of soil quality and soil sanitary condition in Moscow showed that s share of soil samples in the city which didn't conform to hygienic standards per sanitary-chemical, microbiological and parasitological parameters tended to reduce. However, the level of soil chemical pollution in Moscow in 2012-2014 exceeded average level in the country 2.7 times. Microbiological pollution level was also rather high exceeding average country level 2.2 times.

The highest soil pollution level was detected in industrial enterprises zones, around highways (17.65% non-conforming samples) and in housing development zones (17.63% non-conforming samples). Such heavy metals as mercury, lead, and cadmium, were the main pollutants as share of non-conforming samples for them on the whole was more than 20% in 2012-2014. And also there were other pollutants detected in various administrative districts; among them there was copper, zinc, manganese, nickel, arsenic, mercury, cobalt, nitrates, petroleum products, formaldehyde (including significant concentrations). Microbiological and parasitological parameters (colibacillus group bacteria and enterococcus index, pathogenic germs, roundworms, Echinococcus hexacanthes, toxocar, whipworms) also didn't conform to hygienic standards in some administrative districts.

More than 50% of soil samples taken in Zentral district, Zapadniy District, Severniy district and Yuzhniy district of Moscow in 2014 didn't conform to hygienic standards as per sanitary-chemical parameters. A share of unsatisfactory soil samples as per bacteriological parameters was also higher than 50% in two administrative districts (Yugo-Vostochniy and Vostochniy districts).

Primary morbidity analysis of Moscow population showed that over 2012-2014 morbidity tended to decrease in all main age groups, Decrease rate for primary morbidity of population in total amounted to 8%; it was 8.9% for adults and 11.5% for children (Figure 2).



	2012 г.	2013 г.	2014 г.
Российская Федерация	794,7	800,3	786,2
г. Москва	717,0	687,9	659,9

Figure 2. Primary morbidity dynamics for the whole population in Moscow and in the RF, 2012-2014.

Morbidity structure for the whole population and main age groups didn't change over the examined period. Respiratory organs diseases had the 1st rank among all categories in the megacity and amounted to 46.8-47.5%: the second place belonged to injuries, intoxications and some other external causes (13.3-13.7%); skin diseases and subcutaneous tissue diseases followed with 6.1-6.2%; then there were urogenital system diseases (5.5-5.6%), and musculoskeletal apparatus and connective tissue diseases (4.1-4.4%). Over 2012-2014 primary morbidity levels for Moscow city population were lower than average corresponding country level by 9.78-16.06% (figure 3).

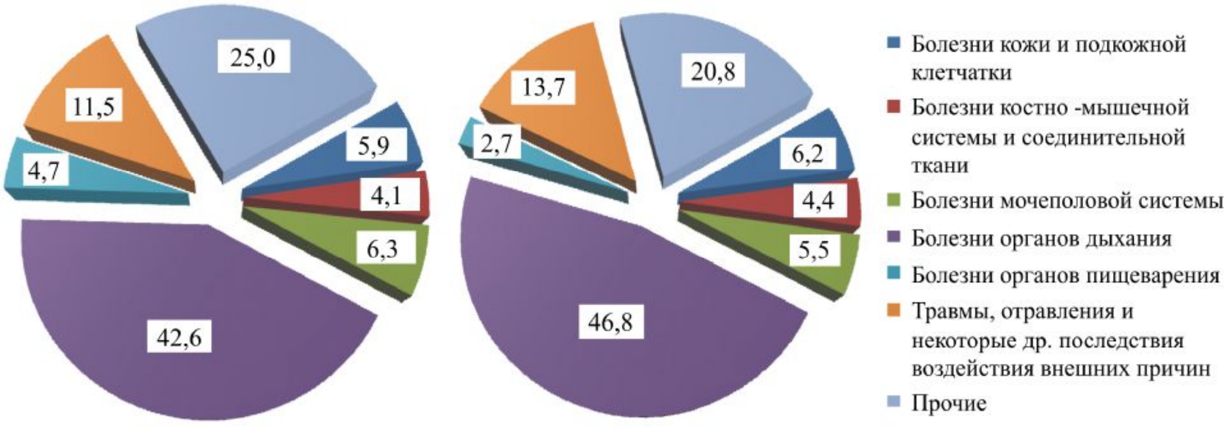


Figure 3 – Primary morbidity structure for whole Russian population and Moscow city population, 2014 (%)
To the right: skin diseases and subcutaneous tissue diseases; musculoskeletal apparatus diseases and connective tissue diseases; urogenital system diseases; respiratory organs diseases; digestive organs diseases; injuries, intoxications and some other external causes

Primary morbidity for adult Moscow city population in general was also lower than average country level by 13.1-20% in 2012-2014. The greatest contribution into primary morbidity level of this age group was made by respiratory organs diseases (34.2-35.6%); injuries, intoxications and some other external causes (16.6-16.8%); urogenital system diseases (8.1-8.3%); skin diseases and subcutaneous tissue diseases (7.0-7.3%); and musculoskeletal apparatus diseases and connective tissue diseases (5.1-5.6%).

Primary morbidity for children in Moscow taken in dynamics was higher than average country level by 7.7-15% in 2012-2014 and amounted to 2203–1950‰. Respiratory organs diseases made the greatest contribution into the morbidity level having 70.8-71.1%; the second were skin diseases and subcutaneous tissue diseases (4.8-5.3%); eyes and their accessory apparatus diseases were the next with 4.1-4.4%; some infectious and parasitic diseases followed with 3.3-3.55%; ear and mastoid diseases had 3.2-3.5%.

Primary morbidity parameters in the priority class of respiratory organs diseases among adults in Moscow were higher than average country levels in 2012-2013 by 5.2-11%; in 2014 primary morbidity level for adults amounted to 150.5‰, which corresponded to average country level (151.3‰). Taken in dynamics over the examined period, primary morbidity for adults as per this morbidity class tended to decrease; decrease rate amounted to 11.6%. Primary morbidity levels for children in Moscow were constantly higher than average country level by 9.5-19.6% over 2012-2014; but taken in dynamics, they tended to decrease; decrease rate amounted to 11.6% over 2012-2014. Still, children primary morbidity was constantly 8.0-8.4 times higher than adult primary morbidity (figure 4).

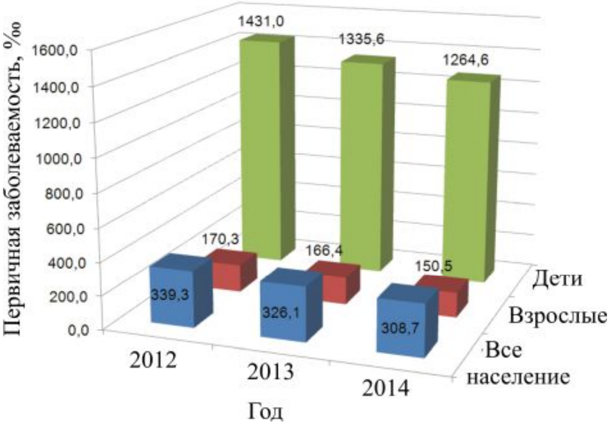


Figure 4 – Dynamics of respiratory organs primary morbidity for main age groups in Moscow in 2012-2014
To the left: primary morbidity; to the right: the whole population, adults, children

According to the data provided by WHO and National Institute for Environmental Hygiene (the USA) [14], ecologically determined respiratory organs diseases include chronic diseases of tonsils and adenoids, allergic rhinitis, and asthmatic state. These diseases contribute significantly to overall and chronic population morbidity; thus, in 2014 total morbidity for these nosologic forms was equal to 8.79‰ for all Moscow population, 6.01‰ for adults and 23.60‰ for children. This parameter in dynamics tended to decrease slightly by 0.8-8.2% (decrease rate) in all age groups over 2012-2014. Taken in dynamics over 2012-2014, primary morbidity for above stated nosologic forms in children age group went down (decrease rate was equal to 14.5%, morbidity level in 2014 was 8.73‰), but it grew in adults age group (increase rate was 5.1%, morbidity level in 2014 was 0.46‰). At the same time children's primary morbidity for such nosologic forms as tonsils and adenoids diseases, allergic rhinitis, asthma, and asthmatic state, was constantly 1.5-1.7 times higher than average country level (in 2012-2014 6.16–5.56‰).

Primary morbidity levels for children in Moscow in the category "Congenital abnormalities (malformations), deformations and chromosomal disorders" which are also included in the list of ecologically determined disorders [14], were equal to average country levels in 2012-2013, but in 2014 they were 1.2 times lower than average country level. Taken in dynamics over the analyzed period, primary morbidity tended to decrease; decrease rate was 42.9% for adults and 19.6% for children (figure 5).

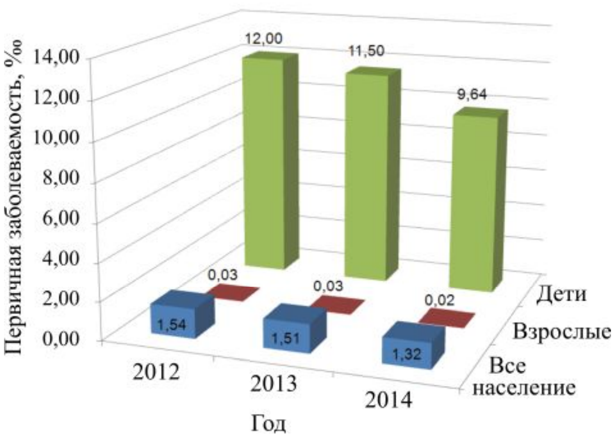


Figure 5 – Primary morbidity dynamics in the category "Congenital abnormalities (malformations), deformations and chromosomal disorders" for main age groups in Moscow in 2012-2014
To the left: primary morbidity; to the right: the whole population, adults, children.

Primary morbidity levels for adults in the category "Neoplasms" which, according to a number of scientists, are caused by several reasons and environment factors influence being one of them, in 2012 in Moscow were equal to average country level (13.1‰); in 2012-2013 they were 1.4 times lower than comparative parameter (average country level was 9.30–9.32‰). Primary morbidity levels for children were constantly 1.2-1.4 times higher than average country level (5.82–6.97‰ in 2012-2014). Decrease rate of primary morbidity for this nosologic form was equal to 33.0% for adults and 16.5% for children.

Comprehensive analysis of primary morbidity for Moscow city population comprising 2012-2014 showed that morbidity levels tended to decrease in all age groups (decrease rate was 8.0-11.5%). Primary morbidity structure in all main age groups didn't change in the examined period. On the whole, primary morbidity for adults exceeded average country levels only in the category "Respiratory organs diseases" by 5.2-11% in the examined period. As for children, their primary morbidity exceeded average country levels by 4.1-68.3% in such categories as "Respiratory organs diseases", "Skin diseases and subcutaneous tissue diseases", "Urogenital system diseases", "Eyes and their accessory apparatus diseases", "Ear and mastoid diseases", "Musculoskeletal apparatus and connective tissue diseases", "Neoplasms", "Injuries, intoxications, and some other external causes".

In 2012-2014 primary morbidity levels for the whole population tended to decrease on the territory of 80% administrative districts in Moscow (increase rate was from (-8.39%) to (-23.85%)). Nevertheless, there were negative trends detected for children's primary morbidity in the category "Respiratory organs diseases" on the territory of 60% administrative districts; "Eyes and the accessory apparatus" category showed some growth in several districts (increase rate was more than 20%); there was also an increase detected for such nosologic forms as "Ear and mastoid diseases" (increase rate equal to 20-56%), and "Digestive organs diseases" (increase rate was 14.95-42.84%). Primary morbidity level for adult population tended to decrease on the territory of all administrative districts in Moscow; decrease rate ranged from 3.42% (Zapadniy distruct) to 27.25% (Zentralniy district). The most adverse territories as per primary morbidity level for the whole population were: Zapadniy district, Severo-Vostochniy district, Yugo-Zapadniy district: for children, Severo-Vostochniy district, Zapadniy district, Zelenogradskiy district; for adults, Zentralniy district, Vostochniy district, Severo-Vostochniy district.

The results of total mortality levels for the whole population in Moscow taken in dynamics over 2012-2014 revealed that this parameter tended to decrease by 2.13% (total mortality level was 987.6 per 100 thousand people in 2012, 962.9 per 100 thousand people in 2013, 966.6 per 100 thousand people in 2014). But the total mortality level in Russia was 1.35 times higher (1331.2 per 100 thousand people in 2012, 1304.3 per 100 thousand people in 2013, 1305.8 per 100 thousand people in 2014).

Analysis of standardized mortality indexes in 2012-2014 for Moscow population showed that, taken in dynamics, there was a trend proving certain decrease in them in the examined period (decrease rate was 4.2%). Standardized mortality levels in Moscow in the examined period didn't exceed corresponding average country levels (figure 6).

Comparative analysis of standardized mortality indexes in the RF and Moscow over 2012-2014 didn't reveal any significant discrepancies in their structure. Thus, over the 3 years the following diseases made the greatest contribution into mortality structure: circulatory system diseases (from 48.13% to 53.96% in the RF, from 49.91% to 53.25% in Moscow); malignant neoplasms (15.64-15.83% in the RF, 21.24-21.74% in Moscow); external causes for mortality (11.1-11.2% in the RF, 6.2-6.66% in Moscow). Digestive organs diseases accounted for 4.98-5.45% in mortality structure in the RF and 4.3-4.92% in Moscow; respiratory organs diseases accounted for 3.85-4.22% in the RF and 2.42-2.57% in Moscow (figure 7).

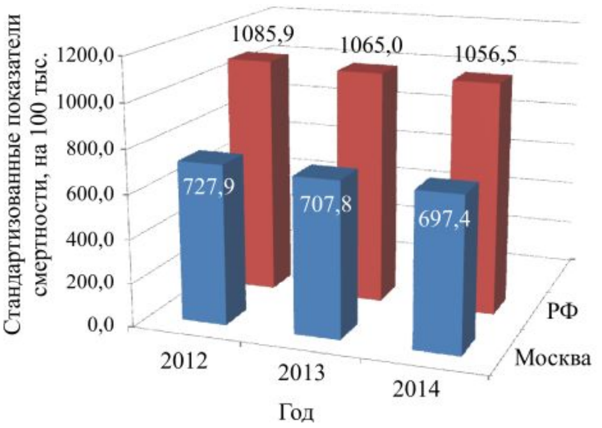


Figure 6. Standardized mortality indexes, Moscow and RF, 2012-2014 per 100 thousand people
X-axis: years; Y-axis: standardized mortality index, per 100 thousand people

Number of cases for all priority mortality causes of the whole population tended to decrease (decrease rate was from 1.75% to 17.97%), except female population mortality caused by certain infectious and parasitic diseases where mortality level remained steady (6.2 cases per 100 thousand people). Standardized mortality indexes for the whole population, including male and female, in Moscow were up to 2.6 times lower than average country ones. The only exception was female mortality caused by malignant neoplasms where mortality levels in Moscow were slightly higher or at the same level as average country ones (1.03-1.05 times).

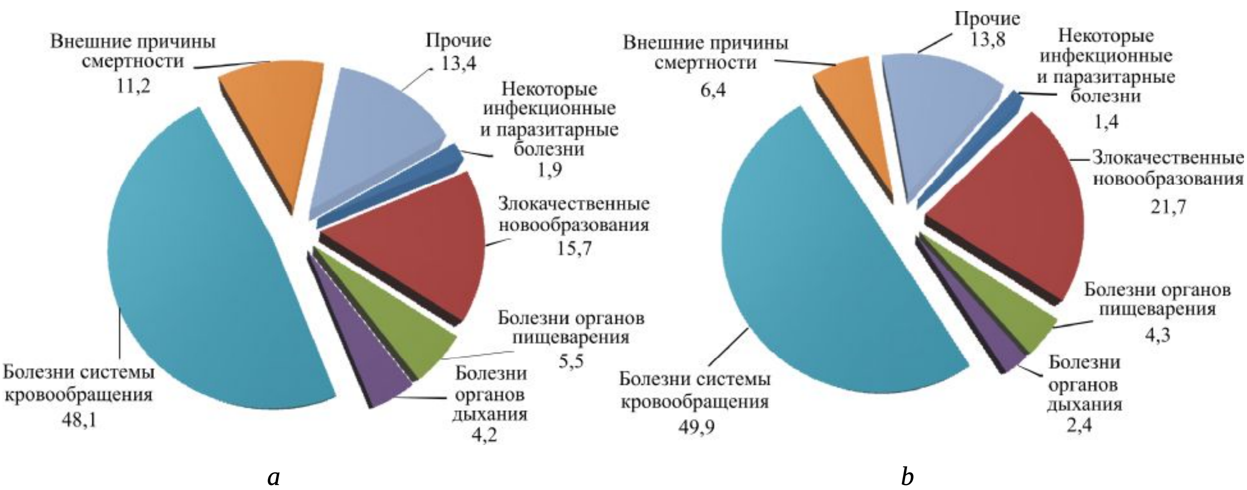


Figure 7. Standardized mortality structure in the RF (a) and in Moscow (b) in 2014, %
Legend: circulatory system diseases – external causes for mortality – other causes – certain infectious and parasitic diseases – malignant neoplasms – digestive organs diseases – respiratory organs diseases

Dimensional analysis of total mortality indexes taken in dynamics over 2012-2014 showed that total mortality level for the whole population tended to decrease on 80-100% territories in Moscow; reduction varied from 1.64% (Yuzhniy district) to 4.82% (Yugo-Vostochniy district); children mortality level decrease within the range from 1.55% (Zapadniy district) to 42.82% (Yugo-Zapadniy district); working population mortality also went down ranging from 3.25% (Severniy district) to 15.82% (Vostochniy district); mortality level for population older than working age also decreased in all administrative district (decrease rate varied from 2.25% in Zelenogradskiy district to 6.76 in Yugo-Vostochniy district).

Cause-and effect-relations between mortality and morbidity levels in Moscow and drinking water quality were statistically analyzed; the results revealed quite low level of negative responses from population health caused by unsatisfactory quality of drinking water taken from distribution network (share of samples not conforming to hygienic standards per sanitary-chemical parameters didn't exceed 2.45%, 2014). Thus, population mortality in Moscow caused by malignant neoplasms is associated with unsatisfactory quality of drinking water per sanitary-chemical parameters (α=0.013±0.002; F=45.2; p=0.001; R^2=0.21), and it may probably cause about 0.005‰ additional mortality cases for the whole Moscow population in this nosologic category. Additional mortality cases for adult population in Moscow due to this cause will amount to 0.006‰.

We detected the relation between quality of drinking water taken from distribution network (this quality was assessed in the context of the share of samples not conforming to hygienic standards per sanitary and chemical parameters) and Moscow population morbidity in the category of skin diseases and subcutaneous tissue diseases (α=21.3±4.7; F=39.9; p=0.002; R^2=0.21), urogenital system (α=15.9±4.9; F=32.9; p=0.002; R^2=0.18), digestive organs diseases (α=34.7±11.1; F=28.6; p=0.003; R^2=0.16), neoplasms (α=4.8±1.0; F=61.3; p=0.001; R^2=0.3). We calculated additional morbid cases as per obtained models; calculation results prove relatively low levels of negative responses from population health. Thus, drinking water quality not conforming to hygienic standards per sanitary-chemical parameters may probably cause about 0.08‰ additional cases of skin diseases and subcutaneous tissue diseases for the whole Moscow population and about 0.53‰ additional cases for children population in Moscow. Additional cases of urogenital system diseases associated with unsatisfactory drinking water quality not conforming to hygienic standards per sanitary and chemical parameters may amount to 0.38‰ for the whole Moscow population, to 0.39‰ for adults, and about 0.31‰ additional cases for children. Drinking water quality not conforming to hygienic standards per sanitary-chemical parameters may probably cause about 0.13‰ additional cases of digestive organs diseases for the whole Moscow population, 0.86‰ for children; 0.11‰ additional cases of malignant neoplasms for the whole Moscow population, 0.08‰ for children. High Fe and tetrachlormethane contents are drinking water risk factors.

Cause-and-effect relations between mortality levels for the whole Moscow population and air quality parameters were statistically analyzed; the results proved the correlation between high content of nitrogen dioxide (α=1.695±0.39; F=37.9; p=0.006; R^2=024), and suspended substances (α=0.089±0.021; F=26.341; p=0.005; R^2=0.18) in the atmosphere and population mortality in Moscow caused by respiratory organs diseases: 0.048‰ additional mortality cases for the whole population and 0.057‰ additional cases for adults, cause by air pollution with nitrogen dioxide. Air pollution with suspended substances may probably cause about 0.0001‰ additional mortality cases due to this reason for the whole population and 0.001‰ for children in Moscow.

We detected the correlation between high benzpyrene content in the atmosphere (α=0.27±0.07; F=23.9; p=0.02; R^2=0.23) and population mortality in Moscow due to malignant neoplasms which may probably cause about 0.003‰ additional mortality cases for the whole population and about 0.003‰ additional mortality cases for adults.

Analysis of cause-and-effect relations between the whole population morbidity in Moscow and air quality revealed that high ammonia content (α=503.5±120.8; F=37.9; p=0.007; R^2=0.24), chlorine and its compounds (α=799.5±191.9; F=37.9; p=0.007; R^2=0.24) in air correlated with respiratory organs diseases of the whole population. Air pollution with ammonia probably causes about 2.75‰ additional cases in this nosologic category for the whole Moscow population, about 1.35‰ additional cases for adults, 10.85‰ additional cases for children. Chlorine and its compounds contained in air in concentrations exceeding hygienic standards may probably cause about 0.45‰ additional morbid cases in this nosologic category for the whole Moscow population and 3.04‰ additional cases for children in Moscow.

Statistical analysis of cause-and-effect relations proved there were no valid correlations between population mortality in the megacity and soil quality. Unsatisfactory soil quality per microbiological parameters may probably cause about 0.23‰ additional morbid cases for certain infectious and parasitic diseases for the whole Moscow population (α=21.1±7.2; F=13.3; p=0.016; R^2=0.16). Megacity population morbidity in "Neoplasms' category is associated with unsatisfactory soil quality per radioactive substances content (α=43.97±7.9; F=32.7; p=0.009; R^2=0.29), and it may probably cause about 0.059‰ additional morbid cases due to this reason for the whole exposed population, 0.068‰ additional cases for adults, 0.008‰ for children per year in Moscow.

In general, negative influence of environmental factors in Moscow may probably cause up to 29.2‰ additional morbid cases and up to 0.056‰ additional mortality cases per year. The primary risk factors are phenol, benzpyrene, nitrogen dioxide, suspended substances, ammonia, chlorine and its compounds, sulfur dioxide, and other pollutants contained in the atmosphere, and cadmium, microbiological agents, and radioactive substances contained in soil.

Conclusions:

1. Environmental quality parameters in the megacity are characterized with constant adverse factors influence on people. It is confirmed by air pollutants content in the atmosphere exceeding hygienic standards (up to 6.6 daily average maximum permissible concentrations); a substantial growth (up to 65.8%) of centralized water supply sources number where water quality doesn't conform to hygienic standards; a great number of soil samples not conforming to the standards (more than 50% per certain sanitary-chemical and microbiological parameters in some administrative districts). At the same time we detected a decrease in number of water samples taken from distribution network of centralized household water supply and not conforming to the standards (from 4.36% to 2.45%). Environmental quality parameters in different administrative districts in Moscow vary considerably and are determined by transport load, volumes of industrial emissions, wind rose, quality of drinking water sources and supply systems, etc. Hygienic standards violation concerning living environment factors may result in negative consequences for population health.

2. Spatial-dynamic analysis of megacity population primary morbidity revealed a number of positive trends showing decrease in analyzed parameters values in all main age groups (decrease rate was 8.0-11.5%). At the same time, taken over the whole analyzed period, primary morbidity for Moscow adult population was higher than the corresponding average country level by 5.2%-11.0% in "Respiratory organs diseases" category; primary morbidity for children population was higher by 4.1-68.3% in various categories including "Respiratory organs diseases", "Skin diseases and subcutaneous tissue diseases", "Urogenital system diseases", "Eyes and their accessory apparatus diseases", "ear and mastoid diseases", "Musculoskeletal apparatus and connective tissue diseases", "Injuries, intoxications, and some other external causes".

3. All priority mortality causes for the whole population either tended to decrease (decrease rate was 1.75-17.97%) or they remained stable (female population mortality caused by "Certain infectious and parasitic diseases" over 2012-2014, 6.2 cases per 100 thousand people). Standardized mortality levels for the whole population in Moscow, including both male and female population, were up to 2.6 times lower than corresponding average country levels, except female population mortality caused by "Malignant neoplasms" (slightly exceeding average country level, 1.03 – 1.05 times higher).

4. Analysis of cause-and-effect relations in "living environment quality (danger factor) – population health (morbidity, mortality)" system revealed that, in spite of certain positive trends detected in both subsystems, adverse environmental factors still exert negative influence on Moscow population health causing up to 29.2‰ additional morbid cases and up to 0.056‰ additional mortality cases per year. Hygienic standards violation concerning air quality and soil quality makes the greatest contribution into occurrence of additional morbid cases; unsatisfactory air quality also makes the greatest contribution into occurrence of additional mortality cases. Risk factors are phenol, benzpyrene, nitrogen dioxide, suspended substances, ammonia, chlorine and its compounds, sulfur dioxide and other air pollutants; as for soil, risk factors include cadmium, microbiological agents, and radioactive substances contained in it.

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