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SPATIAL PATTERNS OF PUBLIC HEALTH IN RUSSIA

ABSTRACT. The paper presents the characteristics of the status of public health in the regions of Russia in 2002–2012 conducted considering life expectancy of men and women, as well as infant mortality. Public health trends were identified in comparison with 1990–2001. Five groups of regions with specific status of public health were isolated and analyzed. Cross-spectrum analysis of environmental and socio-economic factors was conducted in order to explain the existing level of mortality of the population.

KEY WORDS: public health in Russia, mortality, life expectancy, territorial differentiation, correlation analysis.

INTRODUCTION

Health of the population is one of the main criteria for the sustainable development of regions. It is characterized by such health and demographic indicators as morbidity, mortality, life expectancy, disability, temporary disability; its status is an indicator of the quality of the environment [Environment…, 1979; Urbanization and Health..., 2011]. It is necessary to draw a clear distinction between individual health and public (population) health. Individual health is a combination of all the individual systems of the body of a single person. Public health quite objectively reflects the socio-economic sphere of life and characterizes the environmental status of a particular region [Prokhorov, Shmakov, 2013]. Currently, the model of public heal is undergoing transformation into the model of "environmental public health." This concept treats a person as part of an ecosystem, not removed from it, but not at its center [Bentley, 2013]. The assessment criterion implies, as a rule, the population-based level of biological responses (physiological responses, morbidity, and mortality) to environmental changes [Revich, Avaliani, Tikhonov, 2004].

PROBLEM STATEMENT

The study of public health is a multifaceted problem. Initially in Russia (the beginning of the XX century), public health research mainly included assessment of incidence and identification of the causes of the spread of infectious diseases. These studies involved identification of the distribution of typhoid, smallpox, and malaria in Russia and relationship between these diseases and the railways and river routes, the quality of health monitoring, etc. The League of Nations Epidemic Commission noted that the statistical data provided by the People's Commissariat of Health for such work were quite correct, and sanitary measures implemented based on this research were very effective [Guest, 1923].

Subsequently, the importance of non-communicable diseases and the role of environmental factors in the status of public

health were becoming increasingly apparent. However, by the middle of the XX century, despite the significant number of "descriptive" works on medical and demographic situation in Russia, virtually no studies that would present comprehensive information on mortality and morbidity, environmental factors, housing and sanitation conditions, social stratification etc., had been conducted [Brockington, 1956; Mazique, 1961]. It is also typical of the works of the later, post-Soviet period, when many of the factors that determine the health of the population in Russia were identified, however, they were usually not analyzed in depth [Heilig, 1999; Tkachenko, McKee, Tsouros, 2000].

By the beginning of the XXI century, a number of works analyzing the status of public health in Russia in great detail were published [Prokhorov, 2000; Public Health... 2007; Prokhorov, Gorshkova, Tarasova, 2003; Prokhorov, Tikunov, 2005; Prokhorov, 2009]. These works are based on a comprehensive comparison of the regional status of public health, the economic situation, and the levels of contamination of the environment and the comfort of natural conditions of the regions for the life of the population.

Dozens of indices and indicators of public health have been developed [Rothenberg et al., 2015]. The main characteristic of the health status of the population, according to the recommendations of the World Health Organization, currently include life expectancy for men and women, the infant mortality rate, i.e., mortality of children under 1 year of age per 1000 of live births [Bulletin..., 2009; Malhazova, Koroleva, 2011; Agenor, 2012].

This paper presents a medical-geographic assessment of the Russian territory for 2002–2012 based on one of the indices of public health to reflect the current situation and to identify its trends compared to 1990–2001. Several major environmental and socio-economic indicators have been analyzed to determine the possible causes of the specific status of public health [Malkhazova et al., 2014; Shartova, Krainove, Malhazova, 2015]. The indicators of public health used in the analysis and identification of the potential risk factors included the mortality of men and women by the causes of death and life expectancy in the cities, because urban population may have more distinct responses to environmental change [Addington, Weiss, 1999; Pascal et al., 2013].

Materials and methods

Medical-geographic assessment of the regions of Russia conducted using demographic indicators (life expectancy, infant mortality, the urban population mortality by causes) from the Federal State Statistics Service (Rosstat), published in the collected volumes "Regions of Russia" and "Demographic Yearbook of Russia" and bulletins "The Natural Movement of the Population of the Russian Federation" and "Healthcare in Russia" for 2003–2013.

For comparative assessment of public health in Russia by its regions, an integrated parameter was used, specifically, the index of Public Health (IPH) which combines coefficients of infant mortality and life expectancy for men and women [Prokhorov Tikunov, 2005]. Its calculation is based on an assessment algorithm that includes normalizing of the system of the initial parameters with the formula:

$$\hat{X}_{ij} = \frac{\left| x_{ij} - \overset{o}{x}_j \right|}{\left| \max/\min x_j - \overset{o}{x}_j \right|},$$

$$i = 1,2,3, \ldots, n;\ j = 1,2,3, \ldots, m.$$

where $\overset{o}{x}$ is the worst conditions (for each parameter) out of all occurring situation over the entire period (maximum infant mortality and the lowest life expectancy); $_{\max/\min} x$ is the parameter that deviates the most from the $\overset{o}{x}$ values; n is the number of territorial units under consideration (83 regions and Russia as a whole); m is the number of indicators used for the calculations (3). The calculations were performed for 2002–2012.

Correlation analysis was used to identify the relationships between the status of public health and environmental factors. It was conducted using the 2010–2012 data for 168 Russian cities with a population of over 100 thousand. Two groups of parameters were selected as environmental factors. The first group includes ecological parameters, e.g., certain characteristics of atmospheric pollution. The second group includes socio-economic parameters that characterize the state of the economy, health care system, and social services (Table. 1). Based on the nature of the distribution of the data used in the calculation, the non-parametric Spearman correlation coefficient with the 0.95 confidence interval was used.

Table 1. Ecological and socio-economic indicators

Indicators	Units of measurement
Environmental	
Release from stationary sources, including: solids sulfur dioxide carbon monoxide nitric oxide *hydrocarbons and volatile organic compounds*	*thousand tones/yr*
Socio-economic	
Population density	*people/ha*
Increase (decrease) of population due to migration	*per 1000 people*
Number of retirees	
Average monthly wage of workers	*rouble*
Living area per one person	m^2
Number of doctors	*per 10 000 people*
Capacity of outpatient clinics	*per 1000 people*
Number of sports facilities	
Number of recorded crimes	

The mortality of men and women by the causes of death and life expectancy was used as a characteristic of public health in the analysis. A total of 24 parameters for men and women were utilized in the analysis (Table. 2).

Mortality rates were standardized according to the European standard and presented per 100 000 population of the corresponding sex and age [Denisenko, Kalmykova, 2007].

Table 2. Public health indicators

Indicators	Units of measurement
Life expectancy for men/women	years
Overall mortality for men/women	per 1000 people
Mortality by cause of death for men/women	
Diseases of the respiratory system	*per 100 000 people*
Diseases of the digestive system	
Diseases of the circulatory system	
Disease caused by human immunodeficiency virus (HIV)	
External causes of death	
Congenital anomalies (birth defects), deformations, and chromosomal abnormalities	
Malignant melanoma of the skin	
Malignant neoplasms of breast	
Malignant neoplasms of female genital organs	
Malignant neoplasms of male genital organs	
Malignant neoplasms of the respiratory system	
Malignant neoplasms of the urinary tract	
Malignant neoplasms of digestive organs	
Coronary artery diseases	
Neoplasms	
Pneumonia	
Event of undetermined intent	
Deaths caused by alcohol	
Suicides	
Tuberculosis, all forms	
Murders (assault, rape)	
Cerebrovascular diseases	

Results and discussion

Changes in the socio-economic and political situation in Russia are accompanied by a change of basic health and demographic

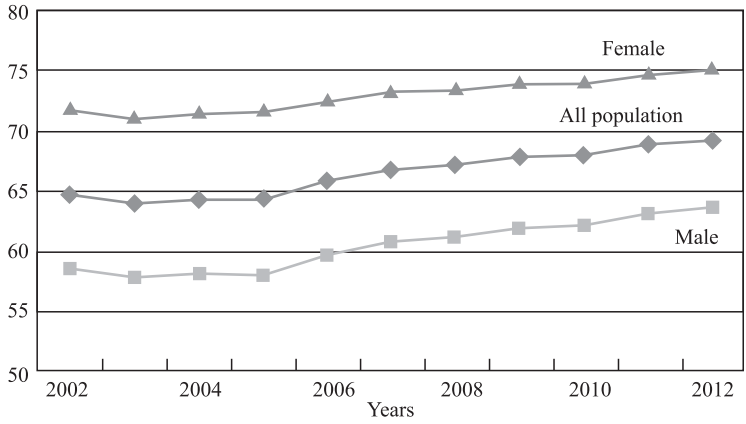

Fig. 1. Life expectancy in Russia in 2002–2012.

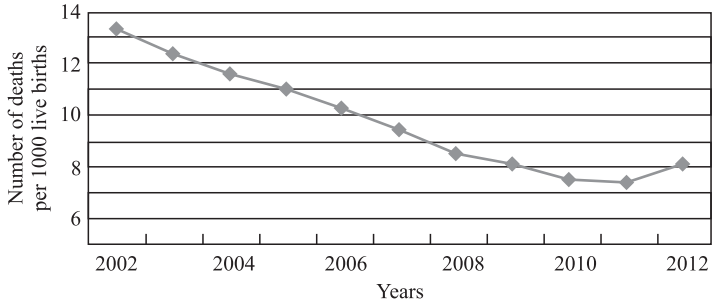

Fig. 2. Infant mortality in Russia in 2002–2012.

indicators. After the financial and economic crisis of 1998, the life expectancy in Russia was minimal and until 2005 did not exceed 65 yrs (Fig. 1). With the improvement of the socio-economic situation in the country, the average life expectancy has steadily increased, reaching 69.5 years in 2012, while male life expectancy has remained low (lower than 60 yrs in 2002–2006.).

Among the positive changes in health outcomes that have occurred in recent years, there is also a significant reduction in infant mortality, which, however, has stalled somewhat in 2012, probably as a consequence of the economic crisis at the end of the first decade of the XXI century (Fig. 2).

Overall, in 2002–2012, the status of public health in Russia varied (Fig. 3). From 2002 to 2006, it worsened, which was reflected in the decrease of IPH which reached the absolute minimum for this period. In subsequent years, there was a gradual improvement in medical and demographic situation, and in 2009–2010, the IPH value reached the level of 2002. However, in the next two years, the status of public health declined again, which may be partly due to changes in the statistical criteria of live births in infant mortality registration, which took place since 2011.

The status of public health for the 2002–2012 in average is presented on the map (Fig. 4). IPH calculation for each year has allowed ranking of the country's regions in terms of public health for each year and for 11 years overall for further comparative analysis. As a result, the regions were grouped into five categories according to the ranking.

The *first group* includes 8 regions with a satisfactory status of health: ranking from 1 to 8 (IPH 1.0–0.8) – Belgorod Oblast, the Republics of Dagestan, Ingushetia, Tatarstan,

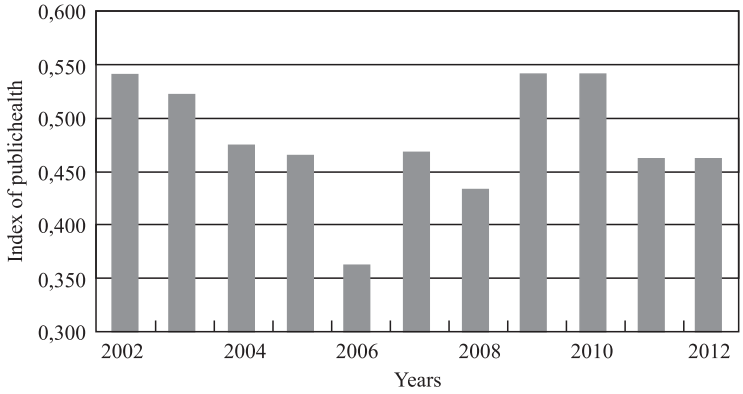

Fig. 3. The status of public health in Russia in 2002–2012.

Kabardino-Balkaria, Karachay-Cherkessia, and Moscow and St. Petersburg.

The *second group* is the most extensive and consists of 41 regions (ranking from 9 to 49 (IPH 0.8–0.7) with a somewhat worse health status. Almost all regions in this group have IPH above the average for Russia; however, they differ substantially among themselves. In this group, the highest status of public health is in the Krasnodar Krai, the Republics of Adygea and Chuvashia, and the Tambov Oblast. The lowest IPH values are in the Republic of Mari El, the Ryazan and Kaluga Oblasts, and the Altai Krai.

The *third group* includes 15 regions with a low health status (ranking from 50 to 64; IPH 0.7–0.6). This group includes Tula, Ivanovo, Kostroma, Smolensk, Leningrad, and Murmansk Oblasts, the Krasnoyarsk Krai, and the Republic of Yakutia.

The *fourth group* consists of 15 regions with very low health status (ranking from 65 to 78; IPH 0.6–0.5); the status is especially low in the Trans-Baikal and Khabarovsk Krais, the Republic of Khakassia, and the Magadan Oblast.

The *fifth group* includes 5 regions with critical health indicators (ranking from 79 to 83; IPH lower than 0.4): the Republic of Tyva, the Jewish and Chukotka Autonomous Districts, Altai Republic, and the Amurskaya Oblast.

The trend in the major regional IPH parameters over the past two decades shows relative stability of health and demographic indicators in most regions of Russia: in 56 out of the 83 subjects of the Russian Federation, the IPH ranking positions over 20 years have not changed; in 10 regions, the situation has worsened (especially in the Amur Oblast and the Chukotka Autonomous District); and only in 13 administrative units, including Moscow and St. Petersburg, the situation has improved.

Public health, especially the urban population, is influenced by environmental factors. For example, analysis of 25 European cities shows that air pollution is still playing a major role in determining the status of public health. Thus, reduction of the content of particulate matter and ozone in the atmosphere is expected to increase life expectancy and lower mortality [Pascal et al., 2013]. A number of studies found an association between low socio-economic status and high levels of morbidity and mortality from certain pathologies [Addington, Weiss, 1999]. Issues of health risk assessment of Russia's population in relation to exposure to pollutants in the atmosphere [Gurvich et al., 2004; Reshetin, Kazazyan, 2004; Zemlyanalya, Solenova, Kislitsyn, 2006; Lukjanova, Popova, 2011; Revich et al., 2015; Yakovenko, Kravchenko, 2015], as well as to the impact of socio-economic factors [Vandenheede et al., 2014; Chubirko et al., 2014; Trifonova, Shirkin 2015] at the regional level are considered in a relatively large number of works.

Fig. 4. Assessment of the status of public health in Russia in 2002–2012.

Table 3. Significant correlation coefficients (R) between the causes of death and environmental indicators

Causes of death \ Environmental indicators	Release into atmosphere of pollutants from stationary soruces	including:			
		solid pollutants	nitrogen oxide	carbon monoxide	sulfur dioxide
Respiratory diseases, men	0.38*	0.40/0.41*	0.36*	0.36*	–
Respiratory diseases, women	–	0.36	–	–	–
Malignant neoplasm of the respiratory system, men	–	0.36/0.36*	–	–	–
Malignant neoplasm of the respiratory system, women	–	0.36*	0.37	–	–
Pneumonia, men	0.36*	–	–	–	–
Pneumonia, women	0.37*	–	0.37*	0.36*	–
Malignant neoplasm of the urinary system, women	0.35	–	0.36	–	–
Digestive diseases, women	–	0.35*	–	–	0.36*

Note. An asterisk indicates correlation coefficients for the sample of cities with a population between 100 and 800 thousand with a confidence interval of 0.95; values without an asterisk indicate correlation coefficients for the sample of cities with a population of 100 thousand to 11 million with a confidence interval of 0.95; dash indicates that a statistically significant correlation was not established.

The analysis conducted for the entire territory of Russia produced rather low correlation coefficients between the environmental parameters and public health parameters. The most significant coefficients are presented in Table 3. For example, mortality from respiratory diseases, including pneumonia, as well as malignant tumors of the respiratory system, has statistically strong association with release of solid pollutants into the atmosphere. A correlation between the mortality of men from respiratory diseases and emissions of nitrogen oxides and carbon monoxide has been established. Noteworthy the relationship between female mortality from cancer of the respiratory system and release of solid pollutants, and between diseases of the digestive system and release of solid pollutants and sulfur dioxide. The findings are consistent with other studies on the effects of air pollution on human health [Pascal et al., Shaposhnikov et al., 2014].

The calculations showed extremely low statistically significant correlation coefficients between the status of public health in the regions of Russia and the considered socio-economic parameters, which require additional research.

Conclusion

Analysis of long-term indices of life expectancy and infant mortality rates and the calculation of the integral IPH has allowed us to evaluate the medical and demographic situation in the regions of Russia and to reach the following conclusions:

– The subjects of the Russian Federation differ substantially in terms of public health, first and foremost, on infant mortality and life expectancy; a critical status is observed in the Far East (Chukotka Autonomous District, Jewish Autonomous District, Amur Oblast) and Southern Siberia (Altai and Tyva Republics);

– Trends in the status of public health for the 1990–2012 indicate a relative stability of the situation. In most regions of Russia, the status of public health has not changed; the deterioration occurred primarily in the Far East (Amur Oblast, Chukotka Autonomous District); in Moscow and St.

Petersburg, there has been a significant improvement in public health;

– Long-term dynamics of the basic indicators of public health reflects trends in socio-economic sphere of the country, above all, the consequences of the crisis period characterized by a general decline of the economy and an increase in social tension;

– Cross-spectrum analysis of the environmental and socio-economic factors, taking into account the health care system, can explain the current level of mortality or morbidity. Thus, a positive correlation between mortality from respiratory diseases, including pneumonia and malignant neoplasm of the respiratory organs, and emissions of pollutants into the atmosphere has been established. In order to obtain data on other causal relationships it is necessary to develop and use additional approaches and methods of medical and geographic analysis. ■

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