

Svetlana M. Malkhazova¹, Varvara A. Mironova^{1*}, Tatyana V. Kotova²,
Natalya V. Shartova³, Dmitry S. Orlov¹

¹Department of Biogeography, Faculty of Geography, Lomonosov Moscow State University, 119991, Russia, Moscow, Leninskie Gory, 1, Tel: +7 (495) 9394717

²Scientific Laboratory of Complex Mapping, Faculty of Geography, Lomonosov Moscow State University, 119991, Russia, Moscow, Leninskie Gory, 1, Tel: +7 (495) 9392354

³Department of Landscape Geochemistry and Soil Geography, Faculty of Geography, Lomonosov Moscow State University, 119991, Russia, Moscow, Leninskie Gory, 1, Tel: +7 (495) 9392123

*Corresponding author; e-mail: mironova.va@gmail.com

NATURAL FOCAL DISEASES IN RUSSIA: MONITORING AND MAPPING

ABSTRACT. The paper discusses a mapping method for compilation of maps for a medical-geographical Atlas of Russia "Natural Focal Diseases" and potential that this Atlas presents for assessment and monitoring of the epidemiological situation in a number of diseases. A series of analytical, integrated, and synthetic maps shows disease incidence in the population at both the national and regional levels for the last 15 years. The Atlas contains maps of the mean annual incidence of certain infections and maps of incidence dynamics and nosological profiles that allow detailed analysis of the situation for each of 83 subjects of the Russian Federation. The degree of epidemic hazard in Russia by naturally occurring is reflected in a synthetic medical-geographical map that allows one to estimate the risk of a disease manifestation in a given region.

KEY WORDS: natural focal diseases, atlas mapping, medical-geographical atlas, morbidity rate.

INTRODUCTION

The outcome document of the United Nations Conference on Sustainable Development, held in Rio de Janeiro on 20–22 June 2012, emphasized the notion that health is a fundamental condition, the result, and an indicator of sustainable development. People's health remains a vitally important

criterion for measuring the impact economic, environmental, and social policy because its outcomes are readily assessable and health concerns are immediate, personal, and local [UN, 2012]. Therefore, special attention should be paid to research of environmental factors that may have an adverse effect on the health of the population.

Numerous natural focal diseases represent a serious risk to human health; while their agents and vectors are part of natural landscapes. Therefore, medical geography has an important task – to evaluate the risk of epidemic hazard of natural ecosystems and to provide public health authorities with recommendations necessary to prevent mass disease outbreaks and conduct activities for full remediation of the focal territory. In recent decades, increasing human activities (e.g., the economic development of new regions, intensive suburban construction areas around the cities, the expansion and growth of recreational pressure) have led to a significant increase of contacts among of the population and the natural foci and the creation of epidemiological conditions for the spread of natural focal diseases. "Humans have come closer to the like never before have approached sources of infections that exist in the nature as they have never done before" [Bogomolov, 2008]. In addition, there is a growing inflow of migrants from epidemic-prone areas, many-

fold increase of tourist flows, and increase in international traffic that also elevate the risk of infections, due to natural conditions. Monitoring of the epidemiological situation and the development of sanitary measures to protect public health requires investigation of the geography of natural focal diseases, natural and socioeconomic background of their distribution, and spatial structure of the focal areas at different spatial and temporal levels.

Despite the increased attention to this issue in the past decade, many research questions of natural focal diseases remain unanswered. These questions include the development of the principles and methods of synthesizing the medical-geographical information and obtaining new knowledge about the spatial distribution patterns of natural focal diseases using mathematical and cartographic models.

One important aspect of such studies is atlas mapping, combining general scientific methods (system, integrated, historical, etc.) and specific (statistical, landscape, medical-geographical, etc.) approaches with geographic information technologies. The experience of the Soviet and Russian medical-geographic medical-geographical mapping is rather extensive. The scientific and methodological basis of medical-geographical mapping that uses the landscape approach, methods of mathematical statistics, multivariate analysis, conjugate mapping studies, and synthesis of the information is well developed [Vershinsky, 1964; Prokhorov, 1968; Malkhazova et al., 2001, Malkhazova et al., 2011b; Malkhazova and Shartova et al., 2011, etc.]. However, the scientific-methodological and practical experience of the national medical-geographical mapping, in particular, mapping of natural focal diseases is significant in the field of regional and local mapping only and is extremely limited in the overview mapping at the federal (national) level. In terms of the status of cartographic studies of natural focal diseases for Russia as a whole, it may be stated that the coverage of the territory is not consistent in reliability and level of detail of cartographic representation. Differences in quality and incompleteness of the initial information and the use of different

methodological mapping approaches make it difficult to obtain a complete picture of the distribution of natural focal diseases within the Russian Federation territory [Malkhazova and Kotova, 2010]. Despite the existence of several cartographic products that reflect the distribution of natural focal diseases in Russia, a cartographic summary showing the geography of natural focal diseases for Russia as a whole, i.e., at the national level, is still lacking.

Currently, the Faculty of Geography at the Lomonosov Moscow State University is working on the compilation of a medical-geographical atlas of Russia "Natural Focal Diseases". The concept and the main issues related to the compilation of the atlas are described in a number of publications [Malkhazova and Kotova, 2010; Malkhazova et al., 2011a; Malkhazova et al., 2011b; Kotova et al., 2012; Malkhazova et al., 2012]. The purpose of the Atlas is to reflect the spatiotemporal distribution of natural focal diseases for Russia as a whole taking into consideration a set of conditions and factors that influence it. The main goals associated with the compilation of the atlas were as follows:

- systematization and analysis of the role of natural and socioeconomic factors in the spread of natural focal infections;
- mapping of natural foci of infections in the territory of Russia and some of its regions; identification of the most active foci and assessment of their potential danger to humans;
- analysis of the incidence of natural focal diseases in the population in Russia in general and in some model regions.

According to these goals, the atlas has seven thematic blocks and 110 maps:

1. Introductory section.
2. Natural conditions.
3. Demographic and socioeconomic conditions.

4. Agents and vectors of focal diseases.
5. Distribution ranges of natural focal diseases.
6. Disease incidence in the population.
7. Organization of public health system and preventive measures for natural focal diseases.

A significant part of the themes is implemented in the maps supplemented by charts, graphs, and text material. The main scales of the maps for the territory of Russia are 1:20 000 000 and 1:30 000 000, and for the maps of the individual regions are 1:4 000 000 and 1:10 000 000, respectively.

The work on the atlas includes several stages. To date, the maps on natural focal disease incidence have been compiled for Russia in general. This allows for analysis of the obtained cartographic material. This paper discusses the potential of the atlas to assess and monitor the epidemiological situation for a number of diseases.

DATA AND MAPPING METHODS OF SECTION "MORBIDITY RATE"

The background data for the atlas included the ROSSTAT statistics on socioeconomic indicators and the data of the Federal Service on Customers' Rights Protection and Human Well-Being Surveillance, representing the statistics on the disease incidence in the population (for infectious and parasitic diseases). In addition, the atlas used other materials available to the authors: mapping of the natural environment; previously compiled maps of the federal and regional atlases; field, report, and archival material; and the results of interpretation of satellite images.

The work on the section included the following steps: 1) preparation, update, and analysis of the database on infectious and parasitic natural focal diseases within the Russian territory; 2) selection of mapping methods; 3) mathematical-cartographic modeling; and 4) medical-geographical

analysis based on the compiled maps. The process of the maps' compilation may be broken in two stages: compilation of analytic (inventory) maps and compilation of integrated and synthetic (assessment) maps.

Twenty two nosological units were covered in the maps: 14 infectious diseases (rabies, Lyme disease, brucellosis, hemorrhagic fever with renal syndrome [HFRS], tick-borne rickettsiosis of North Asia, tick-borne encephalitis, legionellosis, leptospirosis, Q fever, ornithosis, pseudotuberculosis, anthrax, tetanus, tularemia) and eight parasitic diseases (diphyllobothriasis, opisthorchiasis, beef tapeworm infection, taeniasis, toxocariasis, trichinosis, trichuriasis, echinococcosis).

The section "Morbidity Rate" includes several groups of maps; one of the maps shows the average long-term incidence of certain natural focal infections and another – its multiannual dynamics. In addition, the section contains six maps on the dynamics of the incidence of the natural focal infections, the most relevant to the Russian Federation, and one comprehensive map of nosological profiles of the administrative units (federal subjects of Russia).

The maps of the mean annual morbidity were compiled using the cartogram method and reflect the relative and absolute values for each administrative unit.

The maps of the multiannual dynamics of morbidity show variations in the number of cases in relation to the average annual value. The line diagrams for the federal subjects reflect the positive and negative deviations of the values of the incidence data from the mean annual values. Thus, each region has its linear diagram where each year is depicted with its own color, which makes it possible to compare specific years and variations of disease incidence at the national level.

The compilation of a series of maps on the types of dynamics was done using the data of mathematical-cartographic modeling, the analysis of the relative parameters of disease morbidity for 1996–2010, and the typological



Fig. 1. A fragment of the map “Nosological profiles of federal subjects of the Russian Federation”

classification of disease morbidity using the methodology introduced by V.S. Tikunov [1997]. At this stage of work, we have identified the main spatiotemporal patterns in the distribution of this parameter for the six diseases relevant to the territory of the Russian Federation: tick-borne encephalitis, Lyme disease, HFRS, beef tapeworm disease, opisthorchiasis, and trichuriasis.

The map of the nosological profiles shows the sets of specific natural focal diseases in the

context of the Federal subjects presented in the form of a matrix showing the presence or absence of a disease in the population for each year for 11 years. The matrices are arranged vertically by nosological units (diseases) and horizontally – by the years (Fig. 1).

RESULTS AND DISCUSSION

The maps included in Section “Disease Morbidity” are based on the national statistics. Because of the nature of the

data collection and submission based on the administrative-territorial principle, the basic map units are the administrative units of the Russian Federation. These maps represent the level of disease incidence for a given period. With their help, one can evaluate the general characteristic of a specific disease in a particular area, identify the most affected regions, and improve the understanding of the natural confideness of the endemic territories.

These maps can be easily updated with new temporal data.

Map "Nosological Profiles" shows characteristics of the distribution of the most important natural focal diseases at the national level and can be used in assessment of the representativeness of the nosological units and frequency of manifestation of certain infections in different regions. It reflects the most common natural focal

TICK-BORNE ENCEPHALITIS

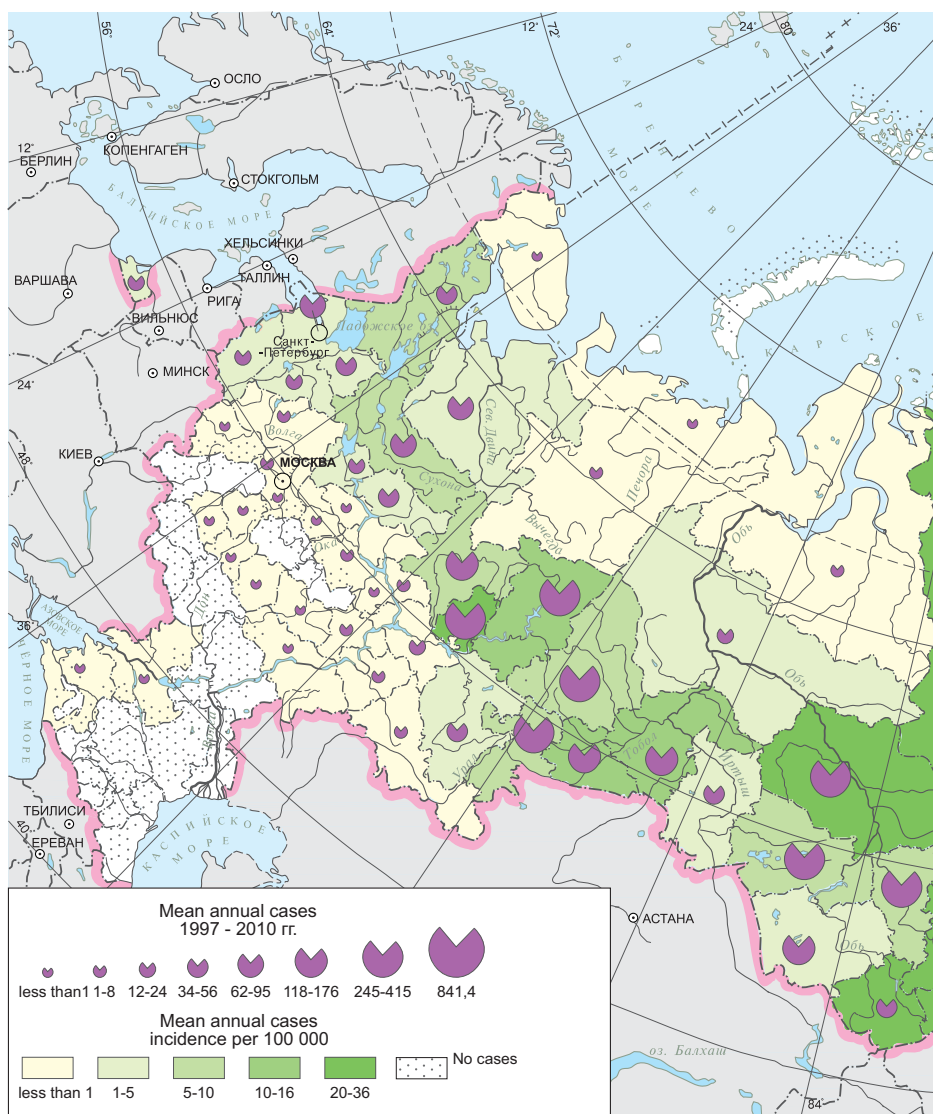


Fig. 2. The incidence of tick-borne encephalitis: A: mean annual incidence (a map fragment)



DYNAMICS OF TICK-BORNE ENCEPHALITIS INCIDENCE. 1997-2010

SCALE 1:40 000 000

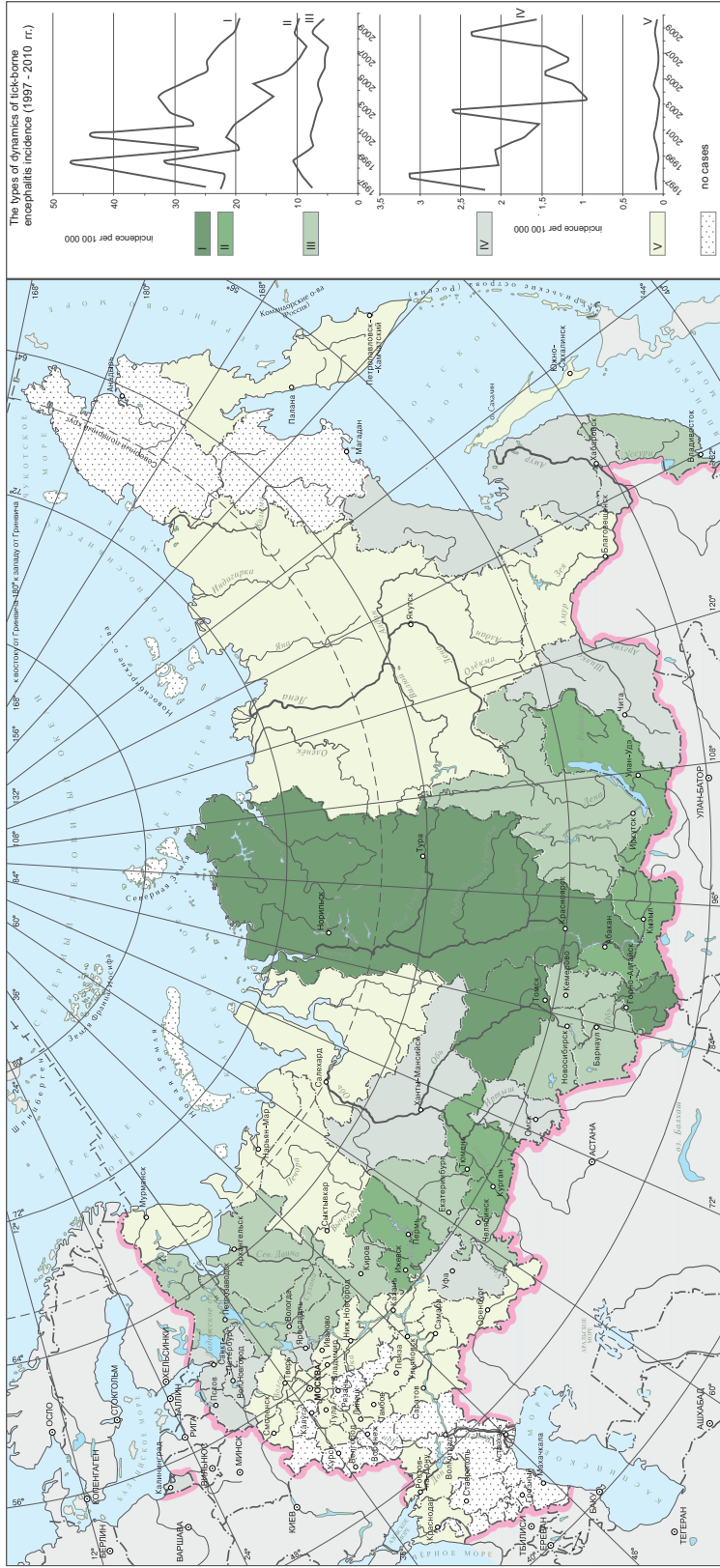


Fig. 2. The incidence of tick-borne encephalitis: B: the types of dynamics of the disease (a map fragment)

infections in Russia, among which, as the maps' analysis has shown, the leading role is played by Lyme disease, leptospirosis, and HFRS that occur in most parts of Russia, as well as by tick-borne encephalitis and opisthorchiasis.

For example, in order to analyze the incidence of certain diseases, let us consider the maps showing the incidence of tick-borne encephalitis, i.e., one of the most dangerous natural focal infections in the Russian Federation (Fig. 2).

The map (Fig. 2A) reflects the distribution of the morbidity over 14 years. The map on the typological classification of the Russian Federation by the dynamics of the encephalitis incidence parameters (Fig. 2B) reflects different subtypes of taxa derived from the estimated indices and semantic analysis of the results. Each subtype is characterized by the reference path of the dynamics of the disease incidence in the population for a given period (decrease, increase, with significant or insignificant fluctuations in amplitude, etc. – five taxa in total). This map gives an indication of the degree of uniformity of epidemic outbreaks of tick-borne encephalitis in different regions, which provides a tool for the optimization of planning control measures.

Mapping the morbidity for such large territorial units, as the federal subjects of the Russian Federation, is a necessary but not sufficient element in the assessment of the spread of natural focal diseases. This representation is the epidemiological characterization of the population rather than that of specific diseases, whose ranges are determined primarily by the parameters of the environment. However, the nature of the information on disease incidence in the population at a small scale (i.e., covering a large area) does not allow using the natural boundaries. In order to overcome this limitation, along with the maps on disease incidence, the atlas contains sections on the distribution ranges of the main hosts,

vectors, and disease agents, and their natural and socioeconomic determinants. This approach allows creating maps of distribution ranges of diseases and, in the end, an integrated medical-geographical map of natural focal diseases in the territory of Russia. In the future, the maps at the federal level will be supplemented by the regional and more detailed maps with in depth assessment of the character of distribution of the foci and spread of the natural focal diseases.

CONCLUSION

The compiled series of maps "Disease Morbidity" allows to:

- 1) determine the spectrum of the most diagnosed natural focal diseases observed over the past 15 years at the level of the subjects of the Russian Federation and the country as a whole;
- 2) quantify disease morbidity in both absolute and relative terms;
- 3) forecast incidence based on the types of dynamics of disease incidence using mathematical-cartographic modeling for the current natural focal diseases;
- 4) identify the most visual ways of cartographic representation of the dynamics of disease incidence;
- 5) carry out medical and geographic analysis of the territory for the spread of the basic nosofoms of natural focal diseases in the regions of the Russian Federation and in the territory of Russia as a whole.

Taken together, the maps allow assessing the persistence in the manifestation of the diseases and the degree of specific diseases spread risk of the territories. The results of analysis can be used for the purposes of health monitoring and targeted preventive measures, especially in the areas of new development and the areas affected by the recreational load. ■

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Svetlana M. Malkhazova has a degree of Doctor of Geographical Sciences. She is Professor, Head of the Department of Biogeography, Faculty of Geography, Lomonosov Moscow State University. The main research interests relate to the problems of biogeography, ecology, and medical geography. She is the author of over 250 scientific publications, including 10 books, several textbooks, and medical and environmental atlases.



Varvara A. Mironova is PhD in Geography, she is Scientific Researcher at the Department of Biogeography, Faculty of Geography, Lomonosov Moscow State University. Her main research interests include medical geography, especially problems related to nosogeography of natural focal and natural endemic diseases, medico-geographical mapping and ecological and evolutionary parasitology. She is the author of 30 scientific publications.



Tatyana V. Kotova is PhD in Geography, works at the Faculty of Geography, Lomonosov Moscow State University since 1964. At present she is Leading Researcher of the Laboratory of Integrated Mapping. The main area of research interests is integrated thematic, biogeographic, and ecological mapping. She published over 180 papers and participated in creation of complex cartographic products as a managing editor, an editor, or an author of individual chapters (World Atlas of Resources and Environment, 1998; Atlas of the Khanty-Mansiysk Autonomous Region – Ugra, 2006; Atlas of Kuril Islands, 2009; The National Atlas of Russia, 2007, 2009, etc.).



Natalya V. Shartova is PhD in Geography, she is Scientific Researcher at the Department of Landscape Geochemistry and Soil Geography, Faculty of Geography, Lomonosov Moscow State University. Her main research interests are in medical geography and human ecology, particularly in relation to the problems of urban ecology and urban population health. She is the author of 30 scientific publications.



Dmitry S. Orlov graduated from the Lomonosov Moscow State University in 2008. At present he is Scientific Researcher, Faculty of Geography, M.V. Lomonosov Moscow State University. His main scientific interests include ecology, medical geography and environmental epidemiology. He is the author of 20 scientific publications.