

Mapping as Part of Medical and Ecological Services



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Abstract: *Medical and ecological mapping is quite difficult at any level of the territorial hierarchy in terms of methodology. The main problem is to select indicators and characteristics, as well as certain methods that most accurately and qualitatively describe both the level of public health and specific medical and demographic problems of the region. The purpose of this article is to consider the approaches and methods of medical and ecological mapping of regions as part of medical and ecological services.*

In the article the state of and the approaches to medical and ecological mapping of regions and settlements have been analyzed. The development method has been introduced. The structure and content of medical and ecological maps of the region, settlements and administrative regions have been described by using the methods of mathematical-cartographic and geographic information modeling when creating maps. The prospects and areas for medical and ecological mapping have been defined.

Keywords: *medical and ecological research, medical and ecological mapping, medical and ecological maps, regional approach.*

I. INTRODUCTION

Human health care is documented in the relevant article of the Constitution of the Russian Federation, as well as other state documents. They state about the need to take preventive measures. When solving health care problems, there is a need in the in-depth study of the spread of diseases. Hence, this makes the studying of the ecological and geographical aspects of this problem urgent. The spread of human diseases and the peculiarities of their occurrence are determined by both social and natural factors.

The human health and the incidence rate are known to be determined by four groups of factors: medical genetic (20 %), lifestyle and food quality (50 %), environmental conditions (20 %), and health care (10 %) [1]. The issues on the quantitative estimation of the contribution of each group of

factors into the general structure of the population's morbidity are important because they define the volume and specificity of preventive measures [2].

Medical and ecological studies as a component of the complex of medical and ecological services are most often carried out within the medical geography and include studies of geographical aspects of the human ecology and the prerequisites for optimizing the interaction between the society and the environment. However, it is as important to define the role of ecological factors in the formation of the general state of health and to determine the dependencies and relationships between these phenomena, which, according to the authors, is nearly the most important problem in the regional medical and ecological analysis.

The development of medical and ecological maps in order to study the impact of the ecological situation on the health of the population has its own specifics substantiated by the complexity of the object of mapping, the diversity of views on the subject of mapping and approaches to studying the interaction in the *nature-society* system, as well as an imperfect study of theoretical and methodological issues of this problem in geography and related sciences.

The integrated medical and ecological mapping improves the role of the subjective (authors') factor, which influences the substantiation of the theme, the selection of objects, and the generalization of mapping indicators. It is also important to determine the principles of combining objects and indicators on one map or a group of maps.

II. LITERATURE REVIEW

In the scientific cartographic references, there are many cartographic support schemes for optimizing the interaction among the environmental, economic and social components of the geosystem. They are based on various scientific and methodological principles and are focused on reflecting the main aspects of environmental and nature protection activities. However, almost all researchers in the area of ecological and geographical mapping agree that the criterion for the environmental quality and nature protection activities is the population's health [3].

Modern medical and ecological studies, and accordingly mapping, are associated, first of all, with the natural prerequisites for the occurrence of the disease (incidence rate of tularemia, tick-borne infections, etc.) and pathologies caused by a significant or insufficient amount of certain dietary minerals in the human body (e.g., the incidence rate of the thyroid gland diseases) [4, 5, 6]. In her studies devoted to mapping the prerequisites of the disease sites for the Russian population, S.M.

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Malzahova adheres to the same approach, but from the standpoint of medical and geographical mapping [7].

The impact of not only natural, but also anthropogenic conditions for the formation of environmental situations is estimated in the works of S.A. Kurolap, O.V. Klepikov [8] A. Novoselov [9], M.V. Grafkina [10], M.N. Dudin [11], I.V. Khorechko [12], and T.I. Bakinova [13]. The population's health indicators (diseases, incidence rate, general dynamics and by types of diseases, primarily allergic, endocrine systems) to be mapped were considered in the works of S.M. Malkhazova, T.V. Kotova, V.S. Tikunov [14], I.A. Khlebovich, I.N. Rotanova, A.L. Shibko., and N.Yu. Kurenina [15].

The methods for developing regional medical and ecological maps are described in multi-authors books [16 – 18] where authors offer to show the integrated estimation of the sanitary and hygienic state of the environment that takes into account the ecological state of the environment, population, and susceptibility of the population to diseases (common non-infectious pathologies).

In his study of medical and geographical mapping A.I. Chistobaev wrote the following: "... analyzing the available information according to the territorial principle, the obtained results can be mapped, while determining the object of mapping that is mainly an incidence rate and the reasons that cause it" [19, p. 110]. Thus, the researcher recommends creating incidence maps for diseases of the cardiovascular system and malignant neoplasms as somatic diseases whose occurrence is most correlated with the environment. To his mind, based on the characteristics of the study object, during the medical and ecological mapping, it is necessary to take into account the following:

The type of maps whose content should be informative and detailed (as far as the scale of the map allows) and should comply with the purpose — to be sources of information to optimize the interaction in the *nature-society* system. At the same time, it is possible to develop overview and reference maps intended for general familiarization and propaganda of knowledge about the ecological situation in the region and areas for its improvement among the population,

The specifics of environmental and nature protection activities aimed at improving the living conditions of the population; therefore, the maps should include not only the inventory indicators characterizing the object of the study, but also the estimations, predictions and recommendations,

National and foreign experience in developing maps of this theme, taking into account regionalization and analysis of the situation and suggesting the most representative of them [19]. The study hypothesis: the use of the methods of mathematical cartographic analysis allows determining the areas of the maximum impact of ecological factors on the population's health and identifying the areas that are most comfortable for living and those of immediate evacuation of people.

III. METHODS

A. General description

The theoretical study was based on the system analysis method. The references review resulted in analyzing the characteristics of medical and ecological mapping that made it possible to arrange the approaches and methods defined in

scientific references for medical and ecological mapping.

Besides, the expert survey method was used in the study to determine the stages and algorithm for developing a medical and ecological map, as well as a set of medical and ecological maps of the administrative region, city, administrative district of the city and medical and ecological atlases of the region and city.

Twenty-four experts took part in the online survey, including 16 employees of the regional departments of Rosprirodnadzor, and eight university employees and teachers of the Department of Ecology.

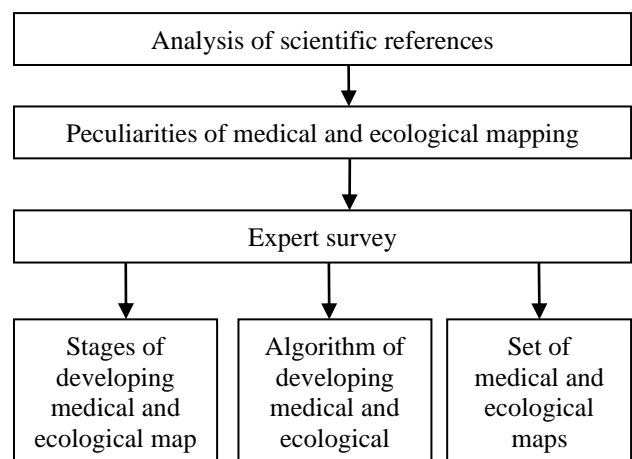
The experts were asked a number of questions on the problems of medical and ecological mapping, methods and approaches to developing medical and ecological maps.

B. Algorithm

At the first stage of the study, the scientific references on medical and ecological mapping as part of medical and ecological services were analyzed.

At the second stage of the study, there was the expert survey on determining the stages and algorithm for creating a medical and ecological map, as well as a set of medical-ecological maps.

C. Flow chart



IV. RESULTS

According to the experts, a medical and ecological map of a region and a settlement is developed in several stages:

1. *Preparatory medical and geographical stage* – the development of maps on the population's incidence rate according to the data obtained from the city sanitary and epidemiological center – the information on the population's health is found in polyclinics and medical units. As a result, a series of analytical maps of the population's incidence rate corresponding to a certain disease, and a map of the general incidence rate of the population are obtained.
2. *Preparatory ecological stage* – the development of a number of analytical maps on the environmental pollution. Maps are based on the data from the hydrometeorological center of the region and the regional department of the environmental protection, and show the degree of exceeding the maximum permissible levels of pollution of the atmosphere, surface and groundwater,



soils for both certain ingredients, and the general level of pollution.

3. *Preparatory medical and ecological stage* – the methods and techniques of the mathematical cartographic analysis are widely used:

- a) The correlation coefficients are determined by using the generally accepted method [6]. Picking areas are formed. The shape and closeness of the relationship between pairs of phenomena, e.g., between the atmospheric pollution with lead and the general morbidity of the population, morbidity of the respiratory system, immune system, etc. are determined. All possible pairs of maps, including physical-geographical and socio-geographical maps, are determined in a similar way. The interpolation data are entered into one of the computing programs (Excel, Statistika, etc.), and as a result of the cartographer’s simple actions, the maximum possible number of values of pair correlation coefficients is obtained,
- b) The information is ranged by the closeness of the relationship between the pairs of maps. Only the maps that can be used to confirm the relationship between the environment and the population’s incidence rate, i.e., when the pair correlation coefficient is above 0.5, are used for the further analysis,
- c) Regression maps are developed. This is done for the same localization points as the sample when determining the closeness of the relationship. As a result, a series of regression maps used to make maps of deviation from regression are obtained. When developing these maps, it is reasonable to use ArcGIS and Surfer software products, and
- d) Maps of deviation from regression are developed in the same manner as regression maps: at the sample points defined at the beginning of the second stage of the study, the values of deviation from regression are charted, and the map is made by interpolation. The first is the zero isoline that delimits the areas of maximum and minimum localization of the impact of the natural component on the human health or the level of a certain disease.

4. *The final cartographic stage* – it aims at making a map on the comfort of the environment for the population. All previous maps of deviation from regression are formed into groups by type of disease. The number of groups coincides with the number of the population’s disease maps. For example, the group of respiratory disease maps includes maps of deviation from regression between morbidity and

pollution of air (the total pollution and pollution by dust, lead, zinc, carbon dioxide, soot, etc.), surface water (the general pollution and pollution with oil products, iron, etc.), groundwater, and soil. Within each of the four groups of maps, a map of the impact of the relevant natural component on the population’s health is developed, and after that a map of its impact on the environment as a whole is made.

As a result, according to the interviewed experts, a number of zones are distinguished in the region (city) according to the degree of dependence of the population’s incidence rate on the ecological condition of the territory.

According to the experts, the objectivity of the obtained maps is verified by determining the congruence coefficient.

Due to the above, the experts have suggested the following algorithm for developing medical and ecological maps of the region and city:

- Developing inventory ecological (quality of atmospheric air, surface water, soil, food) and medical-geographical maps (diseases and morbidity of adults and children by types of diseases of the circulatory system, respiration, gastrointestinal tract, nervous system, malignant tumors, infectious diseases, etc.) as the basis for developing correlation maps (methods of cartograms and isolines),
- Determination of the coefficients on the correlation between the pollution of the nature components with various ingredients and the public health, as well as developing correlation maps to determine the closeness of relationship between the environment and public health (the method of cartograms),
- Development of regression maps and maps of deviation from regression for each correlation map to determine the areas of maximum and minimum impact of each of the natural components on the population’s health (the isolines method), and
- Development of integrated maps for determining the territories of “significant”, “relatively significant”, and “insignificant” “impact of the environment on the public health.

In general, according to various expert estimations, when creating a system of regional environmental and nature protection maps, a set of medical and ecological maps of the administrative region, city, administrative district of the city and medical and ecological atlases of the region and city should include the following components (Table 1).

Table 1: Sets of Medical and Ecological Maps

No.	Basic map	%*	Attachments	%*
1	Map “Estimation of the public health in the region”	100 %	Insert map “Natural movement of the population”	83 %
			Insert map “Public health protection”	88 %
			Diagram “Ratio of the children who died from congenital anomalies in the total number of the children who died”	79 %
			Diagram “Number of people who died and reasons of people’s mortality”	100 %
			Graph “Dynamics of children’s mortality”	100 %
2	Map “Ecological estimation of the public	100 %	Insert map “Ecological estimation”	100 %
			Insert map “Natural movement of the population”	83 %

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	health in the regional center”		Diagram “Number of the people who died and reasons of their death”	100 %
			Graph “Number of children under 4 y.o. who died and reasons of their death”	79 %
			Graph “Dynamics of the children’s mortality in the city”	100 %
3	Map “Medical and ecological situation in a certain area of the regional center”	100 %	Insert map “Medical and ecological situation in the city”	100 %
			Graph “Dynamics of the natural movement of the population in the region”	83 %
4	Medical and ecological atlases of the region and the city	100 %		

Note: * – references on the total number of the surveyed experts

Giving more complete characteristics of the offered set, the experts specified that the map “Estimation of the public health in the region” (scale 1:500,000) should provide data on the incidence rate of the region’s population against the environmental situation.

The main map should be supplemented with insert maps – 1. “Natural movement of the population” where the population’s birth and mortality rates are shown as a cartogram, while the rate of the natural population growth is shown as chart diagrams. 2. “Public health protection” – the number of hospital facilities by districts (the method of cartograms) and the availability of places in hospital facilities (the method of cartograms).

The map “Ecological estimation of the public health in the regional (oblast, territory) center” (scale 1:50,000) is compiled according to the statistics of diseases and morbidity of the population from medical institutions and districts of the city. When developing this map, it is necessary to use the methods of correlation and regression analysis. The general morbidity of the population should be shown by isolines, the number of cases and the structure of diseases – by map diagrams, and medical facilities – as icons.

The main map should be supplemented with insert maps: 1. “Ecological estimation of the environment” that zones the city according to the environmental tension (the method of a qualitative background). 2. “Natural movement of the population” that shows the mortality and birth rate of the population (the method of cartograms) and the dynamics of the population’s incidence rate by area (the method of cartograms).

The map “Medical and ecological situation in a certain area of the regional center (oblast, territory) center” (scale 1:20,000) should provide the data on the volume and structure of the incidence rate and morbidity of the population according to polyclinics (the method of localized diagrams), the dynamics of the population’s incidence rate (the method of icons), and zoning of the territory according to the population’s morbidity (the method of high quality background).

The main map should be supplemented with the insert map “Medical and ecological situation in the city” that zones the city according to the impact of the environment on the public health (the method of high-quality background).

Medical and ecological atlases of the region and the city should provide the information structured in three sections:

1. Medical and geographical section containing the information that is traditional for medical-geographical maps

on the population dynamics, natural growth, mortality, birth, diseases and incidence rate, types of diseases, etc.).

2. Ecological section represented by estimation maps of the unfavorable state of natural components and natural complexes of the region, ecological monitoring maps, etc.

3. Medical and ecological section represented by maps of the environment correlation and its components according to the impact on the human health and maps of the correspondence of the anthropo-technogenic load and morbidity of the population.

Each section should begin with a fundamental text essay. The maps are supplemented by the charts that show the dynamics of the incidence rate for certain groups of diseases (circulatory system, digestive system, respiratory system, nervous and genitourinary systems, and malignant tumors).

According to the experts, when developing maps of the last section of the atlas, it is necessary to use the methods of mathematical cartographic analysis to determine the closeness of the relationship and the correspondence between certain components of the natural environment or the food quality and the incidence rate of certain types of diseases.

V. DISCUSSION

According to the experts, when reflecting the medical and ecological, and medical-geographical information, the selection of mapping units is of primary importance. In the context of environmental protection measures, the regional approach is gaining paramount importance because, according to one of the experts surveyed (Konstantin R.), “the nature protection activities have been carried out, and are going to be carried out within the territorial-administrative division”. The issues related to financial support, organization of measures, statistical monitoring, etc. have an impact on this. Therefore, according to the experts, now environmental and nature protection mapping as an applied area of thematic mapping and a component of a range of medical and ecological services is a priori associated with such territorial units as a region, district, settlement, household, and enterprise. O.A. Evteev also mentioned this feature of geo-ecological mapping, when he wrote that geo-ecological mapping was aimed at maximizing the adaptation of ecology, which did not know the administrative boundaries,



and organizing and financing of ecological measures; and the administrative and economic approach was a standard for this [1].

The experts who participated in the survey recommend the following as mapping units when showing medical and ecological information:

1) Administrative regions when developing regional atlases. This is facilitated by the specifics of the collection and processing of source information,

2) Therapeutic sites when designing atlases of administrative districts or cities. Accordingly, the output information should be based solely on data on the population's incidence rate at the place of residence.

According to the experts, the creation of any cartographic work is preceded by the study and analysis of cartographic sources. When developing medical and ecological maps, out of all cartographic sources, statistical data from regional (oblast, district, city) sanitary and epidemiological centers, annuals of the Federal State Statistics Service, reports made by regional environmental protection departments and data from Roshydromet become the most important. It is necessary to take into account that the information provided by these organizations is not adapted to the specifics of cartographic works and is formed both by content and by structure and indicators, according to the functional purpose of a certain service.

The experts indicate that when creating a system of medical and ecological maps of cities, it is necessary to prefer the information on the population's incidence rate (sanitary-epidemiological service of the city) and background environmental pollution (the data from the regional weather center). According to the experts, the priority of selecting information sources is determined by the specificity of the medical and ecological map and its difference from the medical-geographical map. As a rule, the latter ones reflect the population's incidence rate and dynamics within the administrative regions, which makes it possible to use cartograms and cartographic diagrams methods when mapping. These methods give an average idea of the mapping object, and this is absolutely acceptable for medical-geographical maps of cities to compare the population's incidence rate by the city districts.

However, according to the experts, such approach is absolutely unacceptable for medical and ecological maps because in order to estimate the medical and ecological situation, it is important to determine the closeness of relationships between the phenomena, the ranges of the maximum (minimum) impact of the environment on the people's health, i.e., to make a functional and regression analysis, which is possible only if the information is presented by using the isoline methods

VI. CONCLUSION

The medical and ecological analysis makes it possible to identify the factors affecting the public health, to develop ways to improve and ensure an adequate sanitary and epidemiological situation in the region, and to solve many medical-geographical, sanitary-epidemiological, and ecological-hygienic problems. In the context of environmental protection measures, the regional approach is

of great importance. It is influenced by the issues related to financial support, organization of events, statistical monitoring, etc.

The results of the study have confirmed the hypothesis that the use of methods of the mathematical cartographic analysis allows identifying the areas where environmental factors have maximum impact on the public health and defining the areas that are the most comfortable for living and the areas of immediate evacuation of people.

The prospects for the development of regional medical and ecological mapping are found in improving the environmental monitoring system and using geo-information technologies when creating maps, including by developing a regional environmental and geo-information system of the region that should contain medical and ecological maps.

REFERENCES

1. L.S. Kiseleva, "Faktoy, formiruyushchiye zdorovye naseleniya: sushchnost i tipologiya" [Factors that form public health: essence and typology], *International Journal of Experimental Education*, 8(1), 2015, pp. 17-20.
2. Yu.K. Bakhtin, "Faktoy formirovaniya zdorovya cheloveka i ih znacheniya" [Factors in the formation of human health and their importance], *Young Scientist*, 5, 2012, pp. 397-400.
3. N.N. Mamas, "Ekologicheskoye kartografirovaniye" [Ecological mapping], Krasnodar: Kuban State Agrarian University, 2017, pp. 117.
4. R.K. Plowright, S.H. Sokolow, M.E. Gorman, P. Daszak, J.E. Foley, "Causal inference in disease ecology: investigating ecological drivers of disease emergence", *Frontiers in Ecology and the Environment*, 6(8), 2008, pp. 420-429.
5. N.V. Stepanova, S.F. Fomina, E.R. Valeeva, A.I. Ziyatdinova, "Heavy metals as criteria of health and ecological well-being of the urban environment", *Journal of Trace Elements in Medicine and Biology*, 50, 2018, pp. 646-651.
6. S.O. Vanwambeke, C. Linard, M. Gilbert, "Emerging challenges of infectious diseases as a feature of land systems", *Current Opinion in Environmental Sustainability*, 38, 2019, pp. 31-36.
7. S.M. Malkhazova, "Mediko-geograficheskiy analiz territoriy: kartografirovaniye, otsenka, prognoz" [Medical and geographical analysis of territories: mapping, assessment, forecast]. Moscow: Scientific World, 2001, pp. 239.
8. S.A. Kurolap, O.V. Klepikov, P.M. Vinogradov, V.A. Gritsenko, "Geoinformatsionnoye obespecheniye regionalnoy sistemy mediko-ekologicheskogo monitoringa" [Geoinformation support of the regional system of medical and ecological monitoring], *Baltic Region*, 8(4), 2016, pp. 146-167.
9. Andrey Novoselov, Irina Novoselova, Ruslan Aliev, Andrey Avramenko, "Preventing Regional Social and Environmental Conflicts During Oil Pipeline Construction Projects", *Entrepreneurship and Sustainability Issues*, 7(1), 2019, pp. 773-785.
10. M.V. Grafkina, B.N. Nyunin, E.Y. Sviridova, "Environmental Monitoring and Simulation of Infrasound Generating Mechanism of Traffic Flow", *Journal of Ecological Engineering*, 20(7), 2019, pp. 90-97.
11. M.N. Dudin, N.P. Ivashchenko, A.G. Gurinovich, O.M. Tolmachev, L.A. Sonina, "Environmental entrepreneurship: characteristics of organization and development", *Entrepreneurship and Sustainability Issues*, 6(4), 2019, pp. 1861-1871.
12. I.V. Khorechko, Y.M. Rogatnev, M.N. Veselova, T.A. Filippova, E.V. Kotsur, "Environmental and Economic Problems Related to Rationalizing the Use of Agricultural Lands in The Irtysh Land", *International Journal of GEOMATE*, 17(61), 2019, pp. 248-256.
13. T.I. Bakinova, N.E. Darbakova, G.Y. Kazakova, S.A. Sangadzhieva, I.E. Darbakova, "Information Support of Monitoring as a Tool of Ecological Optimization of Agricultural Land Use", *Journal of Environmental Management and Tourism*, 10(1), 2019, pp. 195-201.
14. S.M. Malkhazova, T.V. Kotova, V.S. Tikunov, "Kartografirovaniye dinamiki zaboylevayemosti naseleniya: podkhody i novye resheniya" [Mapping the dynamics of the incidence rate of the population: approaches and new solutions], *Geodesy and Cartography*, 10, 2015, pp. 25-33.

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15. I.A. Khlebovich, I.N. Rotanova, A.L. Shibko, N.Yu. Kurenina, "Sistemnoye mediko-geograficheskoye kartografirovaniye" [Systemic medical and geographical mapping], *Siberian Journal of Ecology*, 2, 2003, pp. 193-294.
16. V.Z. Makarov, B.A. Novakovsky, A.N. Chumachenko, "Ekologo-geograficheskoye kartografirovaniye gorodov" [Ecological and geographical mapping of cities]. Moscow: Scientific World Publishing House, 2002, pp. 176.
17. S.M. Malkhazova, V.Yu. Semenov, N.V. Shartova, A.N. Gurov, "Zdorovye naseleniya Moskovskoy oblasti: mediko-geograficheskiye aspekty" [Health of the population of the Moscow Region: medical and geographical aspects]: monograph. Moscow: GEOS, 2010, pp. 112.
18. S.A. Kurolap, N.P. Mamchik, O.V. Klepikov, "Mediko-ekologicheskiy atlas Voronezhskoy oblasti" [Medical and ecological atlas of the Voronezh Region]: monograph. Voronezh: Sources Publishing House, 2010, pp. 167.
19. A.I. Chistobaev, Z.A. Semenova, "Mediko-geograficheskoye kartografirovaniye v byvshem SSSR i sovremennoy Rossii" [Medical and geographical mapping in the former USSR and modern Russia], *Bulletin of St. Petersburg State University*, 7(4), 2013, pp. 109-118.