DOI: 10.22363/2313–0245–2024–28–2–216–229
EDN: ZYFJZX

ОРИГИНАЛЬНОЕ ИССЛЕДОВАНИЕ
ORIGINAL RESEARCH

Cartograms in oncology: analysis of the regional situation

Yuri V. Samsonov[1] ✉, **Andrey A. Kostin**[2]

[1] National Medical Research Radiological Centre, *Moscow, Russian Federation*
[2] RUDN University, *Moscow, Russian Federation*
✉ samsonovu@list.ru

Abstract. *Relevance.* Over the past few years, there has been a worldwide trend towards an increase in cancer morbidity and mortality. Health officials and epidemiology researchers often use disease maps to identify potential disease groups. Cartograms are cartographic images of various territories that contain information not about the area of the occupied territory, but about a variable of interest to the reader, for example, the population or a specific disease. This tool has been used for data visualization for more than a century, but right now it is becoming increasingly popular to display patterns and directions of changes in the world around us. The introduction of cartograms into the healthcare sector is gradual, depending on the results obtained in the development of various types of cartograms. It is difficult to fully assess the importance of collecting and analyzing information about the course of cancer. However, with the improvement of this system, good results can be achieved in preventing the occurrence of oncological diseases and increasing the level of cancer care provided. The purpose of this study is to analyze existing information about cartograms used in oncology. This publication discusses issues related to the need to use cartograms in oncoepidemiology, the causes of oncology, the advantages of using cartograms to consider a variety of diseases from simply infectious to HIV and technical issues related to geographical visualization, related problems and ways to solve them. Cartograms are a tool that clearly demonstrates the changes taking place in a small area, for example, in a certain area, within a large territory, for example, an entire republic in a format that can be perceived by all users and "readers" of cartograms. *Conclusion.* Oncology is a disease that spreads through the population by leaps and bounds. In this regard, it is necessary to collect as much statistical data as possible for more accurate predictions of the outcome of the disease, treatment of oncology and, most importantly, the preparation of preventive measures for this disease. Digitalization of healthcare in the form of digital cartograms will undoubtedly help in this.

Keywords: cartograms, oncology, mapping, oncoepidemiology, oncological risk, geoinformation system

Funding. The authors received no financial support for the research, authorship, and publication of this article.

Author contributions. All authors have made significant contributions to the development concepts, research, and manuscript preparation, read, and approved final version before publication.

Conflicts of interest statement. The authors declare no conflict of interest.

Ethics approval — not applicable

Acknowledgements — not applicable

Consent for publication — not applicable

Received 17.03.2024. Accepted 08.04.2024.

For citation: Samsonov YV, Kostin AA. Cartograms in oncology: analysis of the regional situation. *RUDN Journal of Medicine*. 2024;28(2):216–229. doi: 10.22363/2313–0245–2024–28–2–216–229

Introduction

Oncology is the leading cause of death worldwide, regardless of the level of development of the country and the income of the population. According to the literature, the cancer epidemic will only grow. To date, there are no such technologies that could manage oncology. There is a possibility of reducing the fatal outcome with early diagnosis of cancer, and humanity also needs to take control of its health into its own hands, since a negative lifestyle increases the risk of cancer. Similar lifestyle-related risk factors include tobacco use [1, 2], lack of physical activity, overweight, and situations associated with deterioration of human reproductive function [1].

The most dangerous oncological diseases are those associated with neoplasms of the pancreas, liver, lungs and bronchi, prostate/chest, colon, rectum and ovaries [3]. The greatest danger lies in the fact that most cancers do not have obvious symptoms until the disease reaches the terminal stage. Early cancer diagnosis is an important step in the treatment of cancer, but it does not always help. Research in the field of oncology is carried out everywhere and constantly, respectively, cancer biomarkers have long been nothing new to anyone, but it is still difficult to apply them in early diagnosis of cancer. Thus, to date, the research and discovery of biomarkers that will allow the detection of cancer even with an asymptomatic course is a priority task of basic research in oncology [3, 4].

One of the most important criteria in the field of cancer healthcare is patient survival. In The Lancet [5], one of the publications reports that the survival rate of cancer patients has increased in recent years, but this is not typical for the global community as a whole, although the welfare of countries is also important [5]. However, the different financial well–being of countries, cities and each individual is not the root cause of cancer. One of the generally recognized factors in increasing the incidence of cancer is the high level of urbanization and industry in the regions where the population of a particular country lives. The environmental component of this issue is putting more and more pressure on the health of the population, as residents are increasingly exposed to various types of pollutants of a natural and man-made nature, many of them are potential carcinogens [6]. According to WHO, up to 90 % of cancer cases can be caused by an unstable environmental situation in a human habitat [6, 7]. To date, most often statistical data on mortality and survival are calculated for the region, the city, at best an administrative urban area and no less. However, the actual oncoepidemiological situation in small towns or areas of a large city is not being investigated [6]. Thus, the purpose of this work is to analyze the mapping of oncological diseases depending on the region of residence of the population.

Cartograms

Cartograms have a whole history of development, which strives for further development and is subject to constant modification, adapting to user requests. According to the literature [8], the first cartograms in medicine were introduced and used in 1926 by Wallace. Cartograms were developed for the state of Iowa in the USA and diseases marked with colored labels were used as a variable in them. This was done in order to analyze the morbidity situation in this state in order to understand the prevalence of infections and track the real foci of occurrence, that is, the more tags are concentrated in one place, the higher the probability that a focus is found in this particular area. In 1955, Ian Taylor conducted similar studies only in London, drawing up an "epidemiological map" of the spread of polio based on the results of his research [8].

Further, in 1970, Melvin Howe introduced a cartogram in the second edition of his Atlas of Mortality from Diseases. This map was externally formed from geometric shapes (squares and rhombuses), which meant various settlements. These figures were painted in certain colors depending on the studied disease by age and gender.

Back in 1965, in the USA, M.E. Levison and W. Haddon [8, 9] began using cartograms of New York in order to track the geographical prevalence of Wilms tumor or cervical carcinoma. And further in 1971, based on the data and experience already obtained, these scientists managed to share their experience of using cartograms when creating a similar map for the flu epidemic [9, 10].

The digitalization of cartograms in the USA began its development in 1985 by a group of scientists led by S. Selvin [11]. The process of introducing computer technologies in this area at that time did not receive a wide response, since scientists were only introducing man-made cartograms into everyday life, and they were already offered to create them on computers, this created more difficulties than one might have expected. Thus, at that time, it was possible to get acquainted with only a series of cartograms on mortality (from various diseases) depending on the region in the atlas of Great Britain [11].

An accessible and improved algorithm for the development of cartograms, which can be used in medical mapping, began to be introduced into the world community relatively recently, in the period from 2018 to 2020. Its action is based on the physics of heat transfer [8, 12]. The strategy of this algorithm allows you to create a relationship between the density of a variable and changes in the size of territories on the map. For example, on the map, which describes statistics on mortality caused by vitamin A deficiency, the territory of Pakistan, which is the epicenter of mortality for this reason, is marked as a large territory, in contrast to this, the territory of Brazil is not marked on this map at all, since even low mortality associated with deficiency is not recorded in this country of this vitamin. The use of this methodology makes it possible to divide regions by mortality without paying attention to the territorial component of states [8].

One of the decisive factors for creating maps is their availability. And this factor faces the challenge of collecting and evaluating data at the international level. To date, we can track the improvement in the statistics of the data provided by WHO. There has been an increase in the number of States that provide data for the formation of global statistics. However, due to the large amounts of information, it is worth stating for sure that the quality of the data provided to WHO is different. The baseline data, which is publicly available, includes an indicator of the level of uncertainty for each country for each cause, as well as a set of confidence limits for all-cause mortality in each country. Even in what is the most reliable, there are still problems of uncertainty. However, according to literary sources, today the modernization of processes is still underway and there has been an improvement in the situation compared to ten years earlier. An indicator of these improvements is the report "World Mortality in 2000: Mortality tables for 191 countries", which was published because this information is key to shaping the further development of health policy [8].

Today, ordinary users have free access to various cartograms, this is a manifestation of progress, as people can assess the situation of morbidity and mortality around the world, thereby increasing their horizons and being inspired to reduce factors that can affect health. One of the publicly available maps related to medicine is the Worldmapper project map (Figure 1) [8]. This map consists of items that contain information about medical personnel working in hospitals, HIV prevalence, maternal mortality, stillbirth, infant mortality, malnutrition and other information. However, this medical orientation of the card is not only its one direction, it is multifunctional and, due to the digitalization of its processes, it can also illustrate information about wars, education, etc. [8].

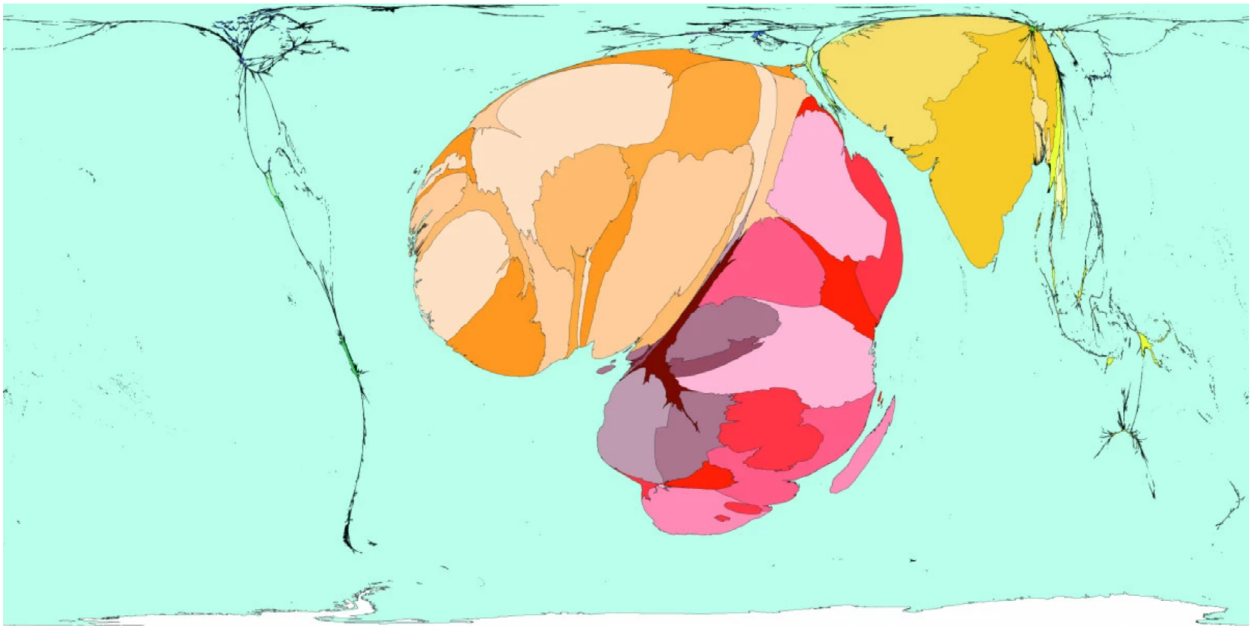

Fig. 1. Worldmapper 413 map: Mortality from vitamin A deficiency in 2002

Cartograms in oncology

According to U.K. Zhumashev, for the population of any region, it is necessary to conduct a comprehensive medical and geographical zoning of the territory, which will allow assessing the impact of the environment on the health of the population [13]. Such zoning will make it possible to clearly trace the quantitative and qualitative dynamics of survival, mortality and, most importantly, will provide an opportunity to identify the root cause of such a devastating human problem as cancer. This interdisciplinary approach, which includes geography, medicine, and ecology, will make it possible to study the peculiarity of the prevalence of oncological diseases within the framework of natural objects and industrial and territorial complexes [9].

Mapping in oncology is a rather interesting way to conduct analysis, obtain statistical data on the distribution of the incidence of cancer survival and mortality, and study spatial correlations of the studied diseases. L.P. Volkotrub believes that oncological mapping is an excellent way to conduct research in the field of oncology to identify the causes of this disease, assess the prevalence of cancer depending on the region, the area of residence of patients, for subsequent assessment and identification of risk zones. A cartogram is a kind of map of the prevalence of the disease, which, in addition to territorial information, contains information about survival, mortality, various stages and features of the course of the disease in the form of colored notes and sketches for greater clarity. To date, technological progress simplifies mapping, since this process is already automated [6]. There are many examples of the use of mapping in oncology, for example, in the publication of M. Sh. Osombaev and co-author. A cartogram of the incidence and mortality of colorectal cancer in the world is vividly presented, which clearly demonstrates the territories affected by this disease (Figures 2 and 3) [14].

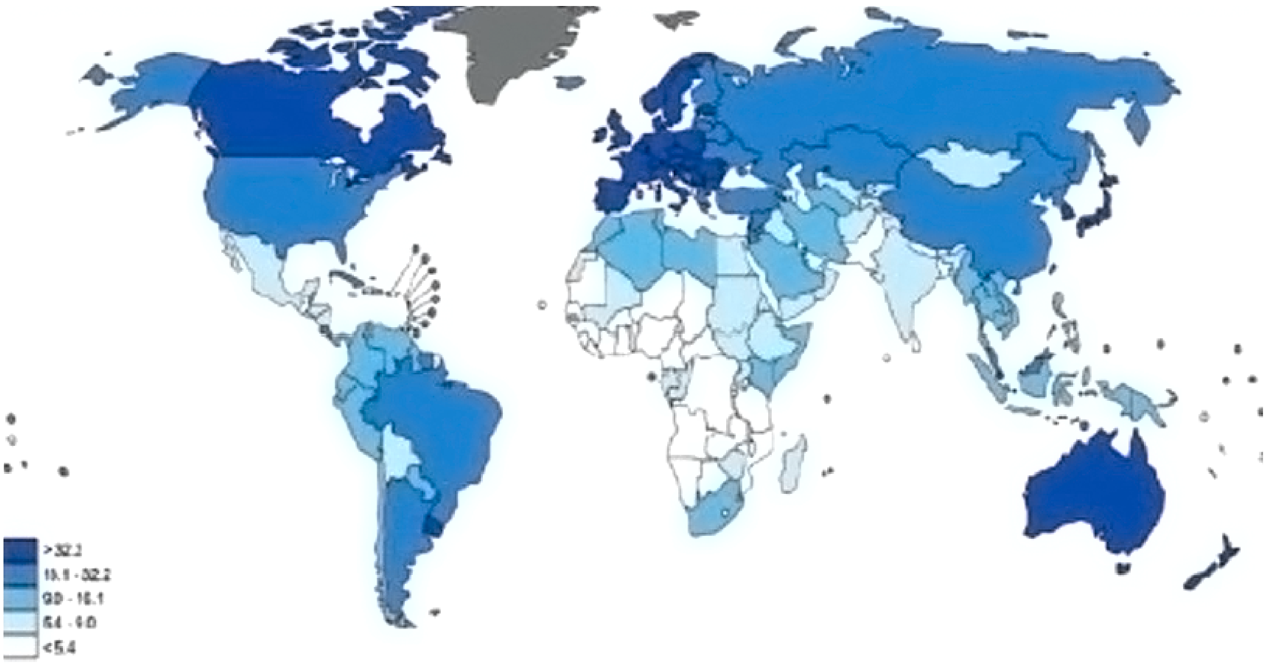

Fig. 2. Cartogram of the incidence of colorectal cancer in the world

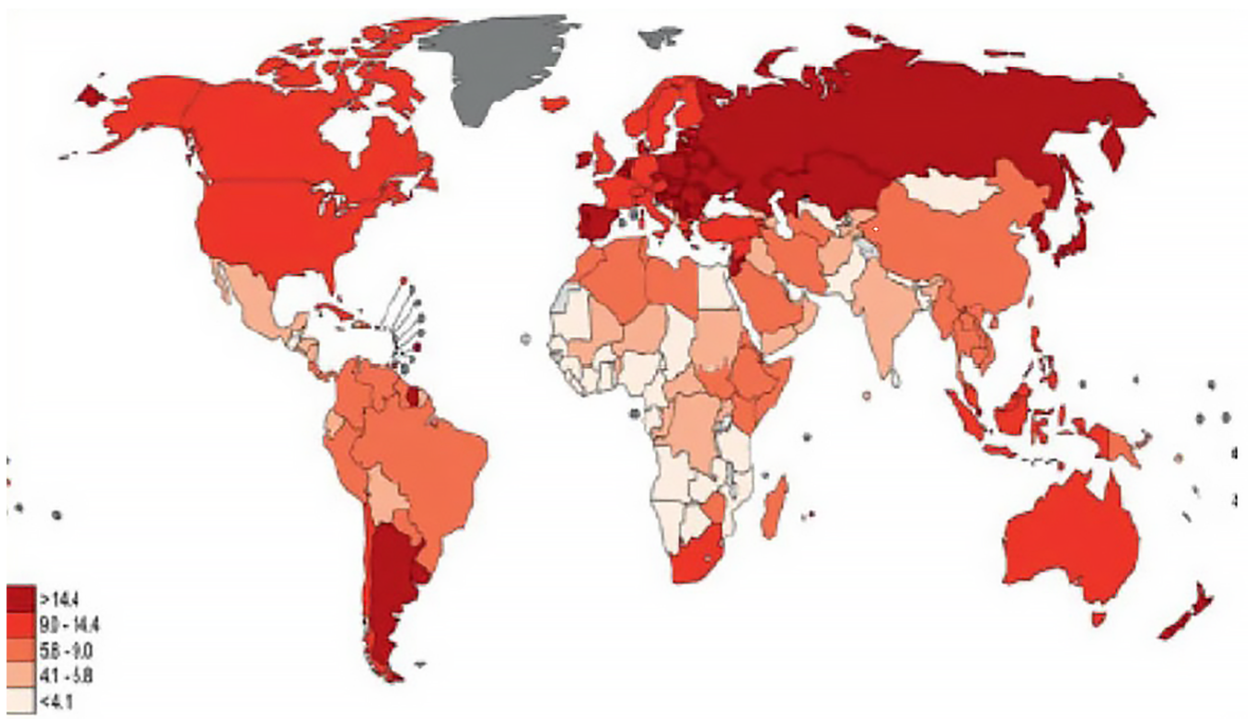

Fig. 3. Cartogram of colorectal cancer mortality in the world

In the publication of V.M. Merabishvili and colleagues a more detailed distribution of standardized indicators of lung cancer incidence in the male and female populations of the Northwestern Federal District of the Russian Federation, as well as the index of reliability of accounting for lung cancer at the regional level, is demonstrated, the cartogram presented below in Figures 4, 5 and 6 was prepared by Doctor of Medical Sciences I.A. Krasilnikov and taken from this article [15].

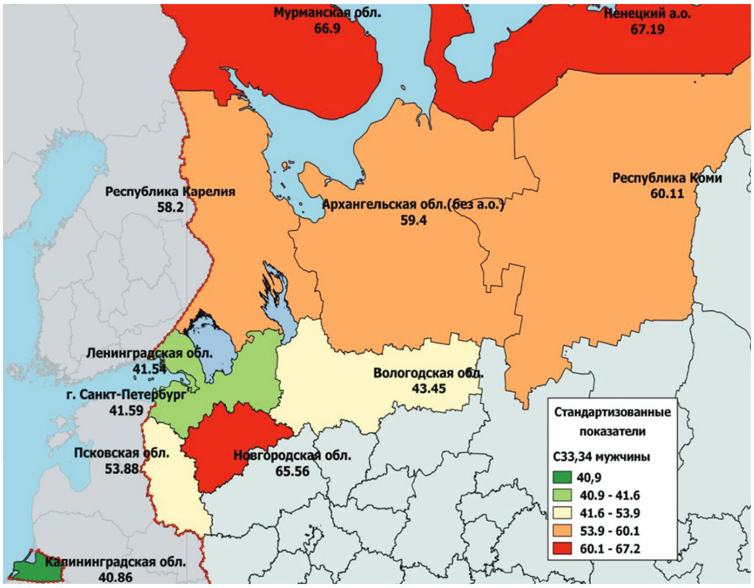

Fig. 4. Distribution of standardized lung cancer incidence rates in the male population of the Northwestern Federal District of the Russian Federation according to [15]

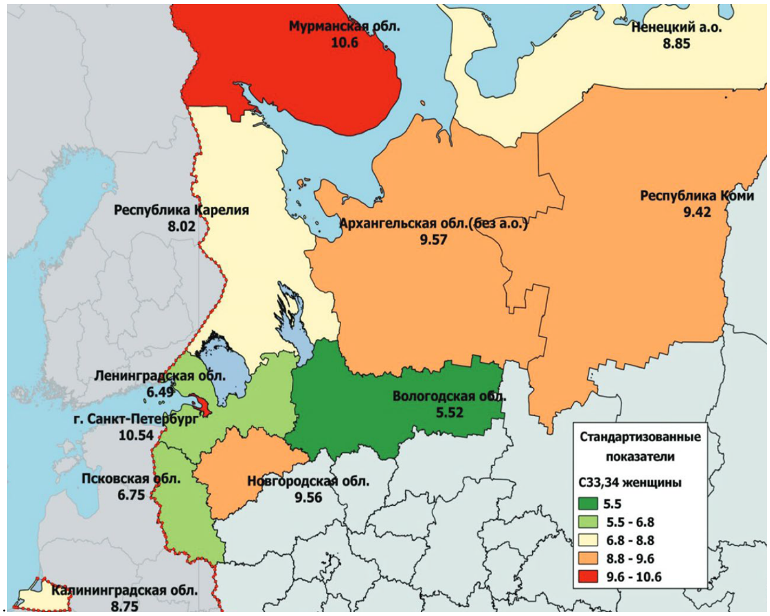

Fig. 5. Distribution of standardized lung cancer incidence rates in the female population of the Northwestern Federal District of the Russian Federation according to [15]

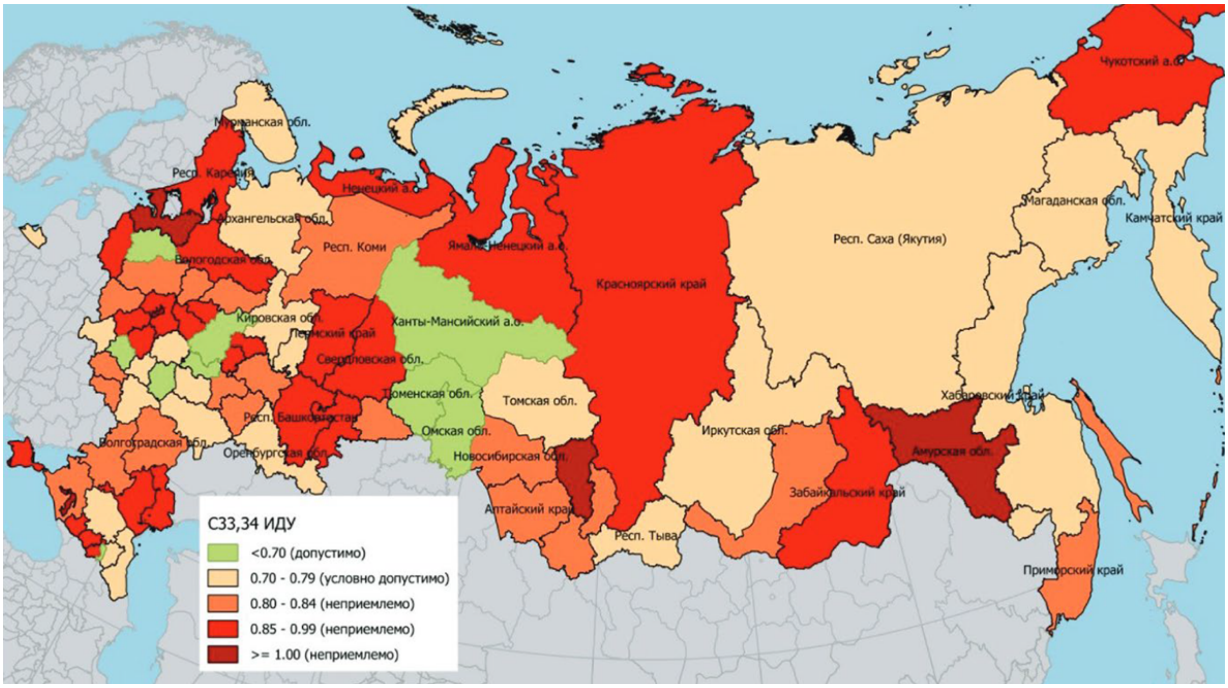

Fig. 6. The index of reliability of accounting for lung cancer according to [15]

Epidemiological analysis has a long history of mapping diseases and related medical and socio-demographic data. Cartograms are used to study patterns occurring in space in order to identify a causal relationship between the occurrence of a disease [16, 17]. According to statistics, visual analyzers analyze information best, which is why epidemiological maps are created and based on their visual analysis, there is a possibility of detecting the “root causes” of diseases. In addition, cartograms are the final product formed during the coordinated work of the cartogram creators and a group of scientists who collected and analyzed information before publishing it to the general public. In addition, public unrest over this issue stimulated the development of automated systems for building maps [16–19].

Advantages and disadvantages of mapping

But not everything is so rosy, despite the large number of advantages in the development of cartograms, there are also disagreements about their use. On maps, territories are most often defined sectors, highlighted by some attribute, in our case by the prevalence of oncological diseases. A number of scientists believe that when ordinary readers perceive maps, there is a possibility of being misinformed, since those sectors that are marked on them may simply be the result of random variation or a slight degree of clustering of similar values. In this regard, this area of research focuses on the fact that creating cartograms requires a large amount of resources to determine their statistical significance. For this reason, the transmission of statistical uncertainty is an important problem in disease mapping [16].

This fact is the main problem in epidemiological mapping and is openly recognized by cartographers, especially difficulties arise when mapping rare diseases and uneven spatial distribution of the main population. These factors influence and exacerbate each other, since the standard map may pay disproportionate attention to geographically large but sparsely populated areas, and these same areas have relatively unreliable observed incidence rates, which is reflected in their large standard errors or related statistics. In this regard, a problem arises for the so-called “map readers”, since it will be difficult for them to visually distinguish statistically significant sectors and areas with high incidence rates, but not statistically significant due to the small sample size [16].

But not everything is so hopeless, in the publication of J. Barry [16] proposed a method that can avoid a disproportionate visual emphasis on geographically large but sparsely populated areas — population density equalization maps, or "cartograms". In his understanding, a cartogram is a map on which the shapes of districts are changed in such a way that their size is proportional to a certain variable, usually the population. This leads to a uniform density of variable population, which is why cartograms are also called density equalization maps [19]. Population cartograms, used as a basis for disease mapping, reduce the size and, consequently, the visual identification of sparsely populated areas in which high incidence rates can occur exclusively by chance [16].

The advantage of the proposed geovisual analytics system is that it supports the rapid determination of statistical significance for user-defined regions consisting of several districts or parts of districts. Essentially, it supports a truly exploratory analysis, using the visual perception and spatial thinking of the map reader to identify and evaluate sectors that are unknown in advance and may not be detected by automatic search methods. Most standard statistical significance tests are applicable to pre-defined areas and are therefore problematic in a research framework due to the problem of testing multiple hypotheses. To support the assessment of the statistical significance of a posteriori defined areas, we use scanning statistics, which provides a more rigorous test based on the probability of a given cluster appearing anywhere on the map under the null hypothesis. The compactness measure is also used to mitigate problems that arise when considering irregularly shaped clusters [20].

Geographic visualization-problems and solutions

The main problem in the visualization of conventional maps is the comparison of geographical data with information on morbidity. When studying the map, untrained readers may encounter incorrect interpretation of the results. For example, when studying any patterns of the occurrence of diseases, their large dynamics can be traced in small territories, and in large territories there is a low level or complete absence of manifestations of the disease, however, due to the difference in territories, the information that "readers" study is distorted.

Cartograms are well suited to solve these problems.

Emile Levassera is the founder of modern cartograms by area [21, 22]. His work is based on rectangles that differ in size, which are variable and indicate some kind of criterion. These rectangles are grouped according to their geographical location, for a better interpretation of the results.

The basis of D. Dorling maps [23] are circles whose size corresponds to the selected variable, without preserving the natural topography.

The first computer cartogram was created by Waldo Tobler and called a "pseudo-cartogram". Its structure incorporated the functions of expanding or contracting regions in latitude and longitude in order to achieve an equal density of values.

The method of M.T. Gastner and M.E.J. Newman [24], a type of W. Tobler maps called density equalization maps, is based on the diffusion process. During this process, the geography expands until a uniform density of the selected variable is reached, which leads to distortion of real geographical data. This method provides the ability to change parameters to adjust the degree of geographical conservation and achieve uniform density. The development of a density equalization visualization method was supposed to solve problems related to spatial resolution, small sample sizes and variable population density.

The development of the algorithm by M.T. Gastner and M.E.J. Newman aimed to simplify the use of cartograms. However, when using a cartogram with a high resolution of a large area and high heterogeneity of data, data visualization problems arise [25].

To date, public health researchers and epidemiologists have recognized the benefits that cartograms can bring to identify many groups of diseases. More recently, cartograms have been used in the United States to display the prevalence of obesity. This was done to assess the relationship between obesity and various socio-economic factors by policy makers, taking into account geographical and social inequalities. In another study, Appalachian County was singled out, the situation with dental services was considered there, and despite the high demand for these services, the level of services provided and the number of dentists left much to be desired, compared with other counties whose population was many times larger. In North Carolina, cartograms were used to describe the epidemiological situation of hypertension during pregnancy, as well as to assess the spread of diseases and plan medical interventions during pregnancy. A significant contribution to public health is the fact that cartograms can help describe the distribution of populations living with HIV and HIV-related outcomes by showing where populations and regions that are more susceptible to the disease live, through the simultaneous use of colors, patterns and geometric shapes; this contrasts with cartograms that allow for differential coloring or drawing only within natural geographical or political boundaries [26, 27]. In the publications of M.U.G. Kraemer with colleagues and the article. D.E. Sack with colleagues [26, 27] the authors emphasized the importance of cartography in infectious disease research and discussed the extent of its capabilities when used for geographic mapping of disease risk, which is especially important when studying diseases or populations that are strongly influenced by geography and time, including people with HIV. For the global community, it is necessary to understand the distribution of the population, since then it is easier to assess risks (for example, contact with another person with HIV). Modern computing technologies, combined with greater availability of spatially continuous data, have proved particularly useful in identifying the heterogeneity of the risk of infectious diseases. Using mapping to create density-aligned maps eliminates the problems associated with exaggerating the importance of low-density areas and hiding potential sectors in high-density urban areas. This provides a platform for implementing public health measures. The ability to determine the distribution of key population groups and predict the results is of paramount importance when it comes to planning further actions, identifying specific measures and attracting funding [27].

One of the problems when creating cartograms is the fear of reloading too much information into it, which can confuse the "readers" of cartograms. However, this coin has a second side, experts in the field of oncology, on the contrary, prefer to get as much information and details as possible. The solution is to use interactive technologies — this is a design feature of modern cartography methods that can be used to include additional information without overloading the user. Effective interactive user-oriented actions lead to rapid, gradual and reversible changes on the designed display [28]. M. Monmonier and S. Kolobakin with colleagues [28, 29] recommend the use of interactivity so that all users can study and use the map to obtain additional information and provide a more informative and interesting interpretation of the results. The user or reader will be able to switch between different interfaces, variables, map views and even receive several predicted outcomes for the treatment of patients. This is a good way for users or readers of such maps to get all the answers to their questions and analyze all the information in general. It is also worth considering that the needs of the audience are always changeable and are a priority for the creators of the map, which is why interactivity will make the process of information consumption more dynamic and interesting. The advantage of user interaction with maps is the fact that it helps to collect more data, assess the spatial distribution of diseases and allows you to explain the presented statistics and their relationship.

There is such a thing as online atlases. So the use of interactivity will just improve the performance of these resources. Interactive design features present on online cancer maps include tooltips, drop-down menus, data selection, zooming and panning, which allows users to explore the map as needed and provides display flexibility [28].

Thus, all of the above is a great help in the development of the atlas of cancer. Map makers should consider using additional mapping methods, and it is also worth paying attention to the needs of the audience that "reads" such maps, time intervals, and financing. However, effective communication of cancer statistics to the public is of paramount importance. The advantage of the old type of cards is that they are more familiar in shape to more people, but it is a clear fact that they can give a wrong perception of information. Public atlases can be useful educational tools and are used everywhere in healthcare. Already, many statistics are commonly used in the analysis of the primary symptomatic manifestations of cancer. It is often possible to see morbidity rates or coefficients that show how much the region is above or below the average level. Interaction with maps is an important component of publicly available atlases, and with the development of modern technologies, it is becoming easier to use. Map and atlas developers need to provide access to as many users as possible with as much information as possible. Thus, the development of cartograms evolves to publicly available atlases.

Regional spread of oncology

When studying issues related to the spread of oncology at the level of one country, one can observe heterogeneity of results, which is associated with differences in population and their habitat. However, the issue of the relationship between the region and cancer outcomes is interesting and open, it should be given attention at the level of the socio-ecological structure of healthcare. It is necessary to analyze the impact of the region on a cancer patient in order to possibly identify new aspects related to the disease itself. When detecting differences in the spread or manifestation of cancer at the regional or national level, the main thing that medical personnel should do is to correctly interpret the results to determine whether they are genuine or statistically insignificant, in order to avoid false positive results. Regional differences exist. Regional differences lead to lower absolute survival in one region compared to another. In the article by B.E. Wilson with colleagues it is described that 50.5 % of patients in the Asia-Pacific region received additional anticancer therapy after the study, compared with 28 % in the Western region. The frequency of subsequent use of anticancer therapy was 53.9 % in the Asia-Pacific region, compared with 45.2 % in the Western region [30].

If we analyze the situation in Russia, according to official data from Internet sources, by 2020 278,992 people died from malignant neoplasms, 3,940,529 people are patients with an established diagnosis of malignant neoplasm, 296.9 billion rubles were spent by the state on providing medical care to patients with cancer. On the figure 7, taken from the source [31], there is demonstrated the prevalence of cancer in Russia.

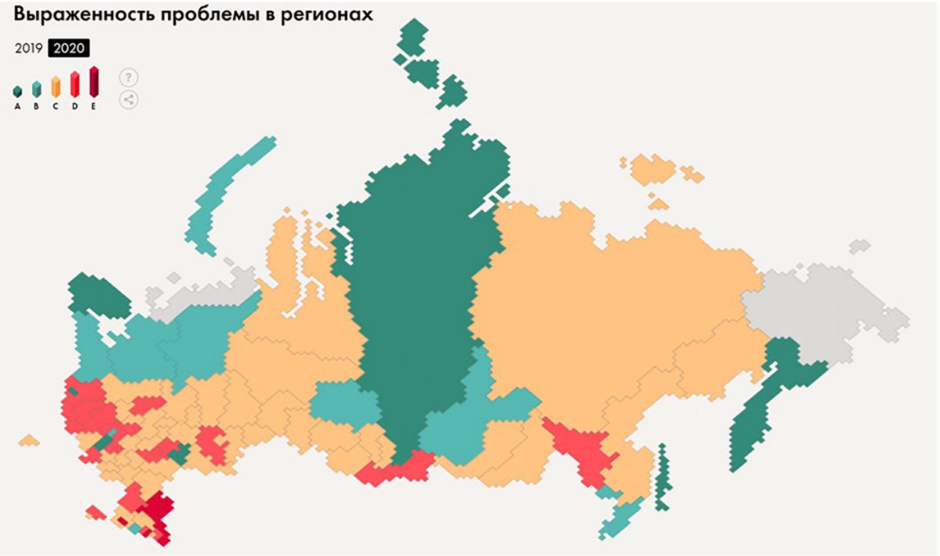

Fig. 7. Severity of the problem in the regions of Russia
(from A to E, the prevalence from the lowest to the highest is highlighted in colors) according to [31]

The authors argue that “low morbidity is not always an indicator that everything is good in the region, but may indicate that the procedure for detecting and registering new cases is working worse in the region.” The authors cite breast cancer as an example. This type of cancer is not associated with external negative behavioral habits, for example, smoking, etc., which can form a relationship with the incidence of this particular type of cancer in a particular region. The standardized incidence rate of breast cancer in women, according to 2018 data, is 51.6 per 100 thousand. The average value for all regions was 49.9 people, that is, in half of the subjects, the value of the indicator did not exceed this limit. However, in some regions it deviated significantly from the median, among them: Nenets Autonomous District, Republic of Dagestan, Republic of Sakha (Yakutia), Republic of Kalmykia, Udmurt Republic, Republic of Altai, Chukotka Autonomous District, Sevastopol, Leningrad Region, Perm Territory, Republic of Buryatia, Jewish Autonomous District, Chuvashia [31].

When analyzing the situation in Russia, it was found that the following regions took precedence in terms of favorable outcomes in the rating of regions of the Russian Federation in terms of the scale of the problem: Kaluga Region, Kamchatka Territory, Krasnoyarsk Territory, Murmansk Region, St. Petersburg, and Tomsk Region. In all regions, good early diagnosis and a high level of qualified medical care were noted.

The least favorable situation in the work of the oncological service has developed in the Republic of Adygea, the Republic of Altai, the Republic of Dagestan, the Republic of North Ossetia — Alania and the Kostroma region. These regions are characterized by poor diagnosis in the field of oncology. In the Republic of Adygea and the Republic of North Ossetia, there is a low level of therapy for the detection of malignant tumors. In the Republic of Dagestan and the Republic of North Ossetia and the Kostroma region, there are high detection rates at late stages, and in the Kostroma region, Adygea and Altai there are some of the highest mortality — to-morbidity ratios for five nosologies. Migration of patients for treatment to other regions is noted in all regions.

Thus, the cartograms in this example perfectly demonstrate the situation in the field of oncology within one country. Looking at the map, you can immediately assess the position of each of the 83 regions of the Russian Federation and make assumptions about why they have low or high activity in the spread of cancer [31].

Conclusion

Oncology is a disease that spreads through the population by leaps and bounds. To date, there is no exact data on why and at what point in certain people cancer cells begin to divide uncontrollably. In this regard, it is necessary to collect as much statistical data as possible for more accurate predictions of the outcome of the disease, treatment of oncology and, most importantly, the preparation of preventive measures for this disease. Digitalization of healthcare will undoubtedly help in this. And one of the ways to collect data and visually analyze the oncological situation at the global and regional levels is the use of cartograms. The use of cartograms radically changes the clinical workflow, providing both healthcare providers and patients with access to big data-based information. Experiential medicine is being replaced by a scientifically based, patient-centered approach. Given the state of geographic information systems and increasingly powerful analytical software, cartograms should be embedded, accessible and reliable tools that complement traditional cartography in visualizing important epidemiological data. The use of cartograms to determine the geographical spread of oncology worldwide is a necessity. Modern cartograms are a tool that demonstrates the territories where cancer patients live in a more diverse and clear way, compared with using only cartographic methods. The developers have built in functions that allow you to visualize changes in small areas or vice versa in larger areas. However, it is worth recognizing that today the world community still needs a more in-depth study of the issues of formation, construction, and development of cartograms in order to adapt to the needs of a changing world.

References/Библиографический список

1. Torre LA, Siegel RL, Ward EM, Jemal A. Global Cancer Incidence and Mortality Rates and Trends — An Update. *Cancer Epidemiol Biomarkers Prev*. 2016;25(1):16–27. doi: 10.1158/1055–9965.EPI-15–0578
2. Dwyer-Lindgren L, Mokdad AH, Srebotnjak T, Flaxman AD, Hansen GM, Murray CJ Cigarette smoking prevalence in US counties: 1996–2012. *Popul Health Metr.*2014;12(1):5. doi: 10.1186/1478–7954–12–5
3. Shajari E, Mollasalehi H. Ribonucleic-acid-biomarker candidates for early-phase group detection of common cancers. *Genomics*. 2020;112(1):163–168. doi: 10.1016/j.ygeno.2018.08.011
4. Smith RA, Manassaram-Baptiste D, Brooks D, Doroshenk M, Fedewa S, Saslow D, Brawley OW, Wender R. Cancer screening in the United States, 2015: a review of current American Cancer Society guidelines and current issues in cancer screening. *CA Cancer J Clin*. 2015;65(1):30–54. doi: 10.3322/caac.21261
5. Coleman MP, Forman D, Bryant H, Butler J, Rachet B, Maringe C, Nur U, Tracey E, Coory M, Hatcher J, McGahan CE, Turner D, Marrett L, Gjerstorff ML, Johannesen TB, Adolfsson J, Lambe M, Lawrence G, Meechan D, Morris EJ, Middleton R, Steward J, Richards MA; ICBP Module 1 Working Group. Cancer survival in Australia, Canada, Denmark, Norway, Sweden, and the UK, 1995–2007 (the International Cancer Benchmarking Partnership): an analysis of population-based cancer registry data. *Lancet.* 2011;377(9760):127–38. doi: 10.1016/S0140–6736(10)62231–3
6. Volkotrub LP, Odintsova IN, Chemeris TV. Mapping as a method for identifying areas of increased cancer risk in industrial cities. *Hygiene and sanitation.* 2001;(1). (In Russian). [Волкотруб *Л.П., Одинцова И.Н., Чемерис Т.В.* Картографирование как метод выявления территорий повышенного онкологического риска в индустриальных городах // Гигиена и санитария. 2001. № 1.С.72–74. (Дата обращения: 07.02.2024).]
7. Chan HM, Trifonopoulos M, Ing A, Receveur O, Johnsont E. Consumption of freshwater fish in Kahnawake: risks and benefits. *Environ Res.* 1999;80(2 Pt 2): S213-S222. doi: 10.1006/enrs.1998.3930
8. Barford A, Dorling D. The shape of the global causes of death. *Int J Health* Geogr. 2007;6:48. doi: 10.1186/1476–072X-6–48
9. Levison ME, Haddon W. The area adjusted map: an epidemiological device. *Public Health Rep.* 1965;80(1):55–59.
10. Hunter JM, Young JC. Diffusion of influenza in England and Wales. *Ann Assoc Am Geogr.* 1971;61(4):637–653. doi: 10.1111/j.1467–8306.1971.tb00815.x
11. Selvin S, Shaw G, Schulman J, Merrill DW. Spatial distribution of disease: three case studies. *JNCI.* 1987;79(3):417–423.
12. Dorling D, Barford A, Newman M. Worldmapper: the world as you have never seen it before. IEEE *Trans Vis Comput Graph.* 2006;12(5):757–764. doi: 10.1109/TVCG.2006.202
13. Zhumashev UK. Cartogram of the incidence of malignant tumors in children in certain regions of Kazakhstan. *Medicine of Kyrgyzstan.* 2011;(5). (In Russian) URL: https://cyberleninka.ru/article/n/kartogramma-zabolevaemosti-zlokachestvennyh-opuholey-detskogo-naseleniya-v-otdelnyh-regionah-kazahstana (Accessed 2024 February 7) [Жумашев У.К. Картограмма заболеваемости злокачественных опухолей детского населения в отдельных регионах Казахстана // Медицина Кыргызстана. 2011. № 5. С.44–47. URL: https://cyberleninka.ru/article/n/kartogramma-zabolevaemosti-zlokachestvennyh-opuholey-detskogo-naseleniya-v-otdelnyh-regionah-kazahstana (Дата обращения: 07.02.2024).]
14. Osombaev MSh, Dzhekshenov MD, Satybaldiev OA, Abdrasulov KD, Makimbetov EK, Kuzikeev MA. Epidemiology of colorectal cancer // *Scientific review. Medical Sciences.* 2021;1:37–42 URL: https://science-medicine.ru/ru/article/view?id=1169 (Accessed 2024 March 16) (In Russian). [Осомбаев М.Ш., Джекшенов М.Д., Сатыбалдиев О.А., Абдрасулов К.Д., Макимбетов Э.К., Кузикеев М.А. Эпидемиология колоректального рака // Научное обозрение. Медицинские науки. 2021. № 1.С. 37–42. (Дата обращения: 16.03.2024].
15. Merabishvili VM, Arsenyev AI, Tarkov SA, Barchuk AA, Shcherbakov AM, Demin EV, Merabishvili EN. Morbidity and mortality of the population from lung cancer, taking into account reliability. *Siberian journal of oncology.* 2018;17(6):15–26. (In Russian) doi:10.21294/1814–4861–2018–17–6–15–26 [Мерабишвили В.М., Арсеньев А.И., Тарков С.А., Барчук А.А., Щербаков А.М., Демин Е.В., Мерабишвили Э.Н. Заболеваемость и смертность населения от рака легкого, достоверность учета. Сибирский онкологический журнал. 2018. Т. 17. № . 6. С. 15–26.]
16. Kronenfeld BJ, Wong DWS. Visualizing statistical significance of disease clusters using cartograms. *Int J Health Geogr.* 2017;16(1):19. doi: 10.1186/s12942–017–0093–9
17. Elliott P, Wartenberg D. Spatial epidemiology: current approaches and future challenges. *Environ Health Perspect.* 2004;112(9):998–1006. doi: 10.1289/ehp.6735
18. Aylin P, Maheswaran R, Wakefield J, Cockings S, Jarup L, Arnold R, Wheeler G, Elliott P. A national facility for small area disease mapping and rapid initial assessment of apparent disease clusters around a point source: the UK Small Area Health Statistics Unit. *J Public Health Med.* 1999;21(3):289–298. doi: 10.1093/pubmed/21.3.289
19. California Cancer Registry. Age-adjusted invasive cancer incidence rates by county in California, 2009–2013. Based on December 2015 Extract. Available from: http://cancer-rates.info/ca/. (Accessed 2016 June 19,)
20. Gastner MT, Newman MEJ. Diffusion-based method for producing density-equalizing maps. *PNAS.* 2004;101(20):7499–7504. doi: 10.1073/pnas.0400280101
21. Lovett DA, Poots AJ, Clements JT, Green SA, Samarasundera E, Bell D. Using geographical information systems and cartograms as a health service quality improvement tool. *Spat Spatiotemporal Epidemiol.* 2014;10:67–74. doi: 10.1016/j.sste.2014.05.004
22. Tobler W. Thirty Five Years of Computer Cartograms. *Ann Assoc Am Geogr*. 2004;94(1):58–73.
23. Dorling D. The visualization of local urban change across Britain. *Environ Plan B: Plan Des.* 1995;22(3):269–290.
24. Gastner MT, Newman MEJ. Diffusion-based method for producing density-equalizing maps. Previous Methods for Constructing Cartograms. *PNAS.* 2004;101(20):7499–7504. doi: 10.1073/pnas.0400280101
25. Kaspar S, Fabrikant SI, Freckmann P. Empirical Study of Cartograms. *In: International Cartographic Conference,* Paris, 2011;1–8.
26. Sack DE, Gange SJ, Althoff KN, Pettit AC, Kheshti AN, Ransby IS, Nelson JJ, Turner MM, Sterling TR, Rebeiro PF. Visualizing the Geography of HIV Observational Cohorts With Density-Adjusted

Cartograms. *J Acquir Immune Defic Syndr*. 2022;89(5):473–480. doi: 10.1097/QAI.000

27. Kraemer MUG, Hay SI, Pigott DM, Smith DL, Wint GRW, Golding N. Progress and Challenges in Infectious Disease Cartography. *Trends Parasitol.* 2016;32(1):19–29. doi: 10.1016/j.pt.2015.09.006

28. Kobakian S, Cook D, Roberts J. Mapping cancer: the potential of cartograms and alternative map displays. *Annals of Cancer Epidemiology*. 2020;4:1–17.

29. Monmonier M. How to Lie with Maps. *3rd ed. Chicago: University of Chicago Press*, 2018. 256 p.

30. Wilson BE, Pearson SA, Barton MB, Amir E. Regional Variations in Clinical Trial Outcomes in Oncology. *J Natl Compr Canc Netw*. 2022;20(8):879–886.e2. doi: 10.6004/jnccn.2022.7029. PMID: 35948036.

31. Project «To Be Precise», 2024. URL: https://tochno.st/materials/onkologiya-v-regionakh-rossii-new#part6. (Accessed 2024 March 16) (In Russian). [Проект «если быть точным», 2024 URL: https://tochno.st/materials/onkologiya-v-regionakh-rossii-new#part6 (Дата обращения: 16.03.2024)].

Картограммы в онкологии: анализ региональной ситуации

Ю.В. Самсонов[1] ✉, А.А. Костин[2]

[1] Национальный медицинский исследовательский центр радиологии, *г. Москва, Российская Федерация*
[2] Российский университет дружбы народов, *г. Москва, Российская Федерация*
✉ samsonovu@list.ru

Аннотация. *Актуальность.* За последние несколько лет во всем мире наблюдается тенденция к росту заболеваемости и смертности от рака. Представители здравоохранения и исследователи-эпидемиологи часто используют карты заболеваемости для выявления потенциальных групп заболеваний. Картограммы — это картографическое изображение различных территорий, которые содержат информацию не о площади занимаемой территории, а о интересующей читателя переменной, например, численности населения или о конкретном заболевании. Данный инструмент используется для визуализации данных уже более века, однако именно сейчас приобретает все большую популярность для отображения закономерностей и направленности изменений в окружающем нас мире. Внедрение картограмм в сферу здравоохранения происходит постепенно в зависимости от полученных результатов при разработке различных типов картограмм. В полной мере сложно оценить важность сбора и анализа информации о течении онкологических заболеваний. Однако при совершенствовании этой системы можно добиться хороших результатов в предотвращении возникновении онкологических заболеваний и повышении уровня оказываемой онкологической помощи. *Целью* данного исследования является анализ существующей информации о картограммах, применимых в онкологии. В данной публикации рассматриваются вопросы, связанные с необходимостью применения картограмм в онкоэпидемиологии, причины возникновения онкологии, преимущества использования картограмм для рассмотрения различного спектра заболеваний от просто инфекционных до ВИЧ и технические вопросы географической визуализации, а также проблем и пути их решения. Картограммы — инструмент, который наглядно демонстрирует изменения, происходящие на небольшой территории, например, в определенном районе, внутри большой территории, например, целой республики в том формате, который могут воспринять все пользователи и «читатели» картограмм. *Выводы.* Онкология — заболевание, которое распространяется по популяции семимильными шагами. В связи с этим необходимо собрать как можно больше статистических данных для более точных прогнозов исхода заболевания, лечения онкологии и самое главное составление мер профилактики данного заболевания. В этом, без сомнения, поможет цифровизация здравоохранения в виде цифровых картограмм.

Ключевые слова: картограммы, онкология, картографирование, онкоэпидемиология, онкологический риск, геоинформационная система

Информация о финансировании. Авторы не получали финансовой поддержки за исследование, авторство и публикацию этой статьи.

Вклад авторов. Самсонов Ю.В — обзор литературы, написание текста и Костин А.А. — концепция и дизайн исследования. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

Информация о конфликте интересов. Авторы заявляют об отсутствии конфликта интересов.

Этическое утверждение — неприменимо.

Благодарности — неприменимо.

Информированное согласие на публикацию — неприменимо.

Поступила 17.03.2024. Принята 08.04.2024.

Для цитирования: *Samsonov Y.V., Kostin A.A.* Cartograms in oncology: analysis of the regional situation // Вестник Российского университета дружбы народов. Серия: Медицина. 2024. Т. 28. № 2. С. 216–229. doi: 10.22363/2313–0245–2024–28–2–216–229

Corresponding author: Samsonov Yuriy V. — MD, PhD, Head of the Medical Care Coordination Department at the Coordination of activities of regional institutions Center of the Russian Federation in field of radiology and oncology National Medical Research Radiological Centre of the Ministry of Health of the Russian Federation, Obninsk, Russian Federation; Leading Researcher of Russian Center of informational technologies and epidemical researches in oncology P.A. Hertsen Moscow Oncology Research Institute — Branch of the National Medical Research Radiological Centre, 125284, 2nd Botkin passage, 3, Moscow, Russian Federation. E-mail: samsonovu@list.ru
Samsonov Y.V. ORCID 0000–0002–2971–5873
Kostin *A.A.* ORCID 0000–0002–0792–6012

Ответственный за переписку: Самсонов Юрий Владимирович — к. м. н., заведующий отделом координации медицинской помощи Центра координации деятельности учреждений регионов Российской Федерации в области радиологии и онкологии ФГБУ «НМИЦ радиологии» Минздрава России, г. Обнинск, Российская Федерация; ведущий научный сотрудник Российского центра информационных технологий и эпидемиологических исследований в области онкологии МНИОИ им. П.А. Герцена — филиал ФГБУ «НМИЦ радиологии» Минздрава России, Российская Федерация, 125284, г. Москва, 2й Боткинский проезд, д. 3. E-mail: samsonovu@list.ru
Самсонов Ю.В. ORCID 0000–0002–2971–5873
Костин А.А. SPIN 8073–0899; 0000–0002–0792–6012