Population and Economics

Population and Economics 6(4): 189–208
DOI 10.3897/popecon.6.e97380

RESEARCH NOTE

Spatial analysis of the spread of Covid-19 and its demographic consequences in the regions of the South of European Russia

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Received 9 November 2022 ♦ **Accepted** 5 December 2022 ♦ **Published** 31 December 2022

Citation: Tikunov VS, Belozerov VS, Shchitova NA, Sopnev NV (2022) Spatial analysis of the spread of Covid-19 and its demographic consequences in the regions of the South of European Russia. Population and Economics 6(4): 189-208. https://doi.org/10.3897/popecon.6.e97380

Abstract

The article presents results of the multi-scale analysis of the processes of coronavirus infection spread and its impact on the demographic situation in the world, Russia and regions of the South of the European part of Russia. The methodological basis of the study was the principles of geoinformation monitoring, making it possible to process and visualize large volumes of diverse materials. The information base was statistical data from the Russian and foreign sources reflecting the spread of coronavirus infection at various spatial levels from global to regional-local. The characteristic features of changes in the parameters of the disease during its active expansion are described. The article also deals with dynamics in demographic indicators and identifies trends in their widespread deterioration. The contribution of the South of European Russia macro-region to the all-Russian Covid-19 situation is determined. Development of the coronavirus pandemic at the level of municipal districts is analyzed using individual regions as an example. The study identifies main factors of the Covid-19 pandemic development and demonstrates some of its features and consequences in the largest urban agglomerations.

Keywords

Covid-19, South of European Russia, geoinformation monitoring, spatio-temporal analysis, multi-scale analysis, coronavirus infection incidence, coronavirus infection mortality, demographic processes

JEL codes: J11; I1; R23

Introduction

In the second decade of the XXI century, the mankind faced a new infectious disease – Covid-19, the virus has quickly spread around the world becoming a global threat to humanity. In general, the disease spread followed the T. Hegerstrand's theory of spatial diffusion according to the expansion diffusion scenario (Zemtsov, Baburin 2020b; Pilyasov et al. 2021). The rate of the spread was influenced by various factors: the level of urbanization, population behavior, migration, etc. The most important prerequisite was the system of settlement that stimulated a cascade dissemination: the vector of infection penetration was directed from megacities to less-populated cities, and then to large and small rural settlements.

Increased research interest in the phenomenon is accounted for by a rapid spatial development and formation of vast areas of the disease. A comprehensive approach to identify causes and consequences of COVID-19 for the population, economy, politics, and environment at the level of macro-regions of the world or individual countries is presented in a number of publications by foreign researchers (Brunn, Gilbreath 2022). These papers analyze causes and nature of the impact of the pandemic on health, education, tourism, everyday life, economy, etc. There are studies devoted to Covid-19-induced changes in various socio-demographic parameters (mortality, income level, age structure, etc. on the example of Germany (Staerk et al. 2021), Mexico (Torres-Ibarra et al. 2022), densely populated areas of India (Cai et al. 2021), etc.).

One of the first examples of the integral analysis of various spatial parameters of the new infection in Russia was the publication developed by IE Kalabikhina & AN Panin (Kalabikhina, Panin 2020) that analyzed both the features of the disease spread and geographical distribution of various preventive measures (testing, lockdown, etc.) on the basis of geoinformation technologies. Articles authored by AI Zyryanov (Zyryanov 2020; Zyryanov et al. 2020) have attempted at identifying spatial patterns of the COVID-19 spread according to the development of tourism in the context of multi-scale with the use of GIS technologies. The authors have identified the following three main centers of infection in Russia: Moscow and the Moscow region, the northern oil and gas regions, and the North Caucasus. A number of papers have focused on the pandemic impact on educational process (Oborin 2020), including transformation of educational strategies of graduates (Artemenkov, Sukhova 2020), situation with foreign students in Russia (Pletneva, Ochirova 2020). Mathematical modeling of the spread was carried out by ES Kurkina, AM Vasetsky, EM Koltsova, AN Pilyasov, NY Zamyatina, E. Kotov (Kurkina et al. 2020; Pilyasov et al. 2021).

A number of researchers focused on socio-economic and demographic effects associated with the pandemic (Ryazantsev, Ange 2020; Ryazantsev, Levashov 2021; Ryazantsev, Smirnov 2021, 2021a, 2021b; Ryazantsev, Khramova, Smirnov 2021; Gnevasheva, Topilin 2021; Pletneva et al. 2021; Panin 2020; Panin et al. 2021; Kalabikhina 2020). Of particular interest were changes in migration processes (Ryazantsev, Vazirov, Garibova 2020; Ryazantsev, Bragin, Ryazantsev 2020; Ryazantsev, Pismennaya, Khramova 2021; Ryazantsev, Molodikova, Bragin 2020). There are numerous geographical works aimed at finding chorological features and factors of the Covid-19 spread (Ryazantsev, Ange 2020; Zyryanov et al. 2020; Chetverikov 2020; Pilyasov et al. 2021; Gerasimenko, Gerasimenko 2020). Regional specifics of the pandemic spread are detailed in the studies of SP Zemtsov and VL Baburin (Zemtsov, Baburin 2020a, 2020b), exemplified by individual territories (Askhabova et al. 2020; Narkevich et al. 2020). All publications emphasize that the unprecedented rapid increase in the number of cases and rapid expansion of the area covered by the coronavirus require a prompt collection and evaluation of a large array of quantitative, spatially-oriented

information. Successful implementation of this objective is possible with the use of geoinformation monitoring technology.

The purpose of the study is to conduct a spatial analysis of the COVID-19 spread and its demographic consequences in the regions of the South of European Russia.

Material and methods

The study is based on the synthesis of monitoring and geoinformation approaches to studying the new coronavirus infection, making it possible to develop a schematic diagram of geoinformation monitoring of the Covid-19 spread (Fig.1). Development of the proposed scheme is based on the principles outlined in the article authored by R. Tomlinson (Tomlinson 2004), as well as experience in the development of geoinformation monitoring systems of various socio-demographic processes (Panin 2005; Rauzhin 2011; Cherkasov 2013; Tikunov et al. 2014, 2015; Cherkasov et al. 2020).

The main parameters of geoinformation monitoring include the following ones: hierarchy of spatial levels, variety of data sources, possibility of modeling and visualizing dynamics in processes under study. A spatial database integrated with the cartographic basis is the heart of monitoring. The proposed monitoring system includes the following two related groups of data – indicators characterizing the Covid-19 situation (the number of cases, deaths, incidence, mortality, etc.) and major indicators reflecting demographic dynamics (fertility, mortality, natural growth, the number of arrivals, departures, migration growth). All possible open sources of information were used, including materials from Rosstat, Rospotrebnadzor of the Russian Federation, website стопкоронавирус.рф, databases of municipal indicators, the World Health Organization, Johns Hopkins University and Our World in Data project, Yandex DataLens service data; the period under study – January 1, 2020 – January 1, 2022.

An important component of the GIS monitoring system is the possibility to consolidate the obtained results in a single information space on a Web resource. The integration is possible as follows:

- through Esri «Story Map Series» application, which provides for direct data from Arc Map, ArcGIS Pro, ArcGIS Online to the Esri online server, making it possible to create separate plots on various topics in the format of text description and graphic information;
- through GIS WebServer Special Edition Server Web application, providing for online publication of spatial information resources in the form of electronic maps and various reference information.

Results and discussion

A brief outline of the Covid-19 spread in the world and Russia

As we know, the first cases of Covid-19 were registered in Wuhan, China in December 2019. Further, from mid-January 2020, it extended to the Asian countries neighboring China: Thailand, Japan, South Korea, Taiwan, Nepal, Singapore, and Vietnam. The first confirmed cases outside the Asian region were registered in the U.S., France, Canada, Germany, and by the end of January – in Italy, Spain, and Russia. During the first month of 2020, Covid-19 was detected in 26 countries, while in February – in 36 more countries in Africa, Southwest Asia, and Latin America. In March, the pandemic had already spread to 150 countries, and by the beginning of April, almost the whole world (Fig.2). The number of confirmed cases exceeded 1 million.

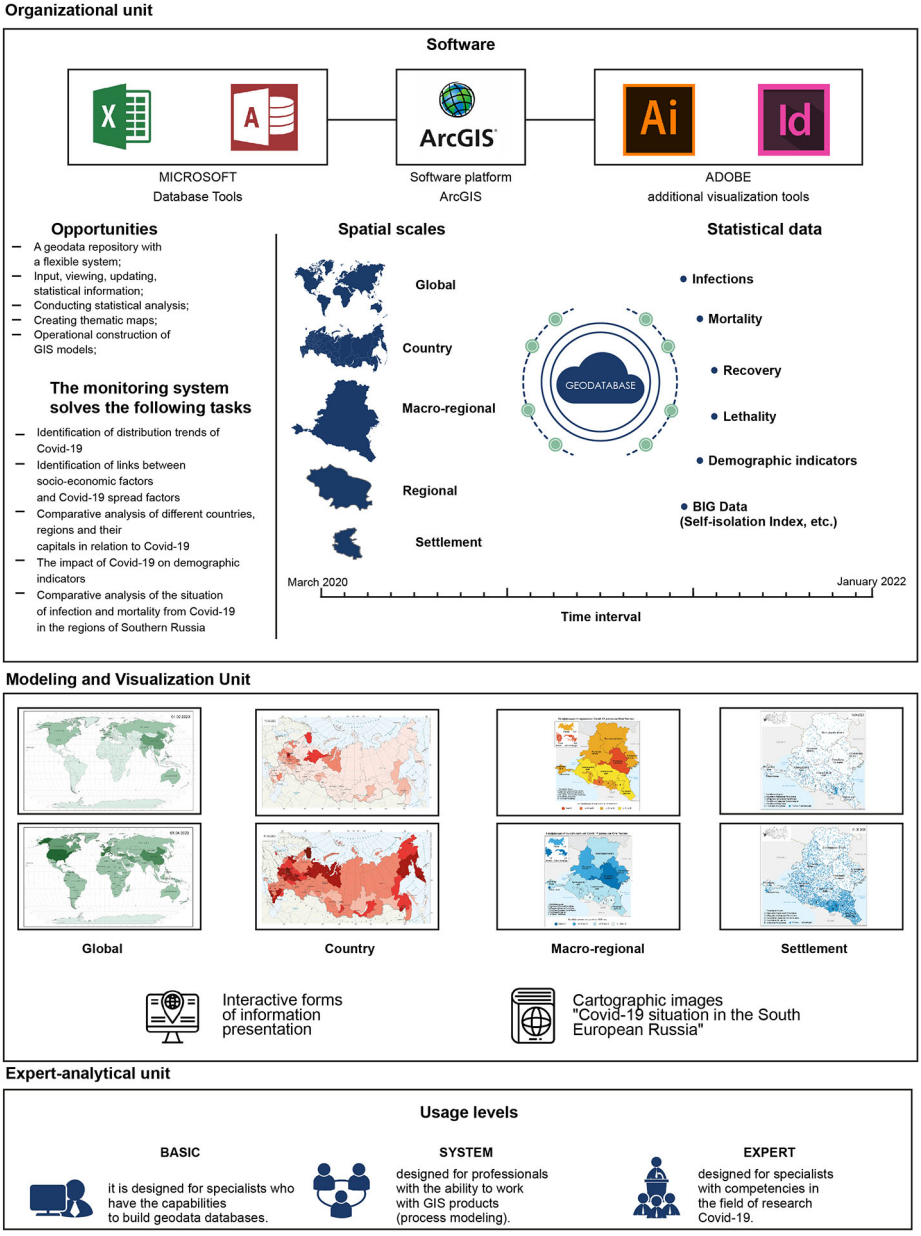

Fig. 1. Scheme of the Covid-19 geoinformation monitoring

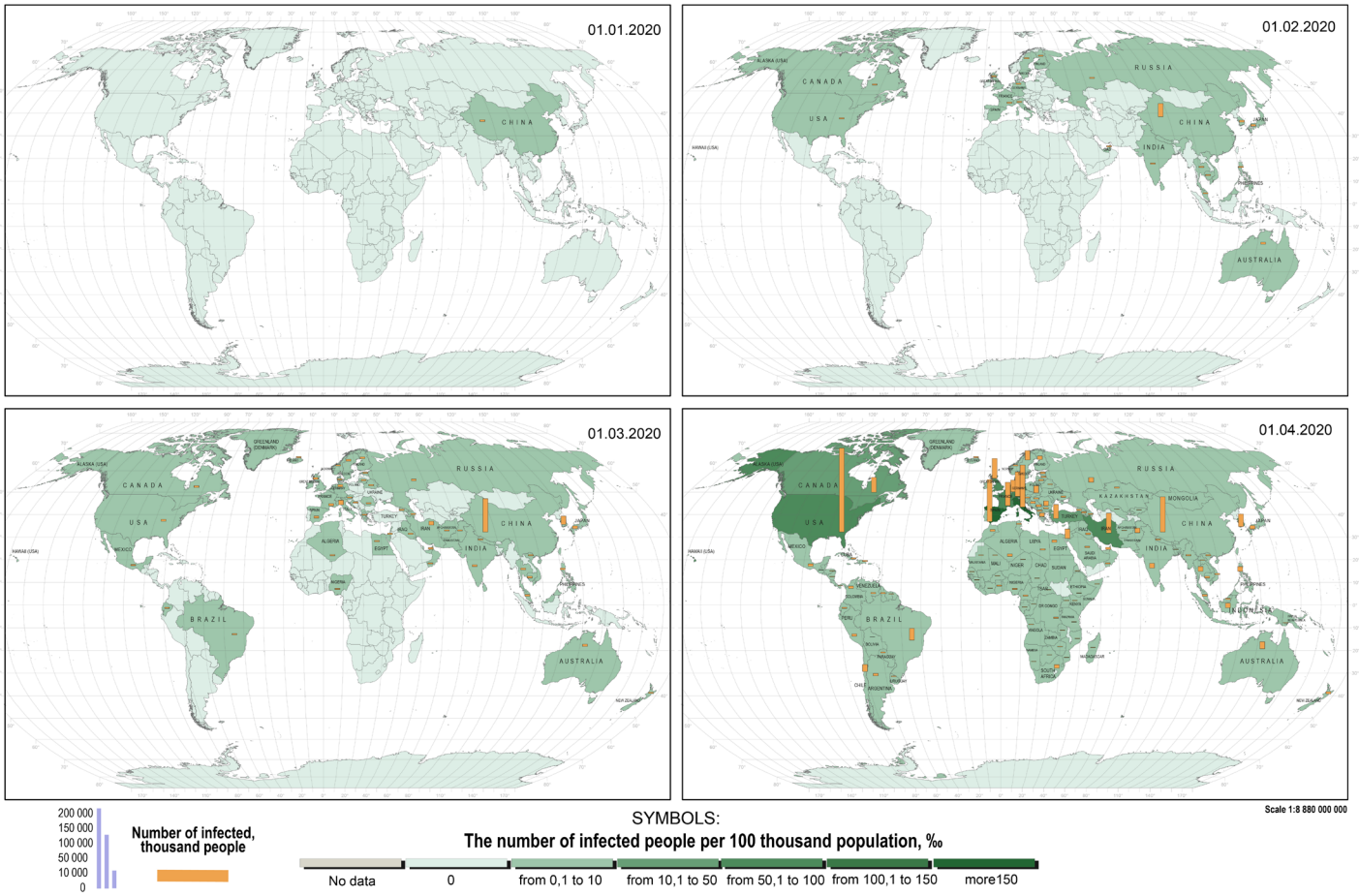

Fig. 2. Geographic distribution of Covid-19 in the world at the initial stage of the pandemic, by country, 01.012020– 01.04.2020

A hard situation was developed in the North American countries, especially the U.S., where the number of confirmed cases added up to 55.8 million, and the number of deaths equaled to 847.1 thousand people by the beginning of 2022. These are the world's highest rates. In Europe, the first cases of the disease were registered in January 2020 in France, and by March, cases were reported by all countries (except for the Vatican). The infection was most severe in Italy and Spain – countries with older age structure of the population, which had the highest global infection rate (2.23%). Europe was declared the center of the epidemic, which served as the basis for introducing a total quarantine affecting more than 250 million people. By mid-May 2020, the epicenter of the pandemic had moved to South America, but by the end of 2021, with emergence of a new strain of the Omicron virus, it returned to Europe. At the beginning of 2022, a total of over 20.5 million people were infected in the European macroregion, 499.1 thousand people died from Covid, while people aged over 65 accounted for 88% of all deaths (Brunn, Gilbreath 2022; Levin et al. 2022).

Among Asian countries, the highest absolute number of cases was registered in India, South Korea, Iran, Turkey, and per 10,000 population – in Georgia, Armenia, and Iran. At the beginning of 2022, there was no information about cases in only two closed countries – North Korea and Turkmenistan.

Countries have differently reacted and coped with the new challenge. East Asian countries (Japan, China, etc.) acted most effectively due to strict compliance with restrictive measures and some traditional behavioral norms (Brunn, Gilbreath 2022).

Russia joined the pandemic at the beginning of 2020. The most intensive spread of the virus was registered in the period from 01.04 to 15.05.2020. By the beginning of April, the number of registered cases in Russia exceeded 2.3 thousand people, while by May 1, – already 114.4 thousand cases, that is, the number increased 50 times, and by May 15 – more than 100 times (262.8 thousand). At the beginning of this period, the indicator "number of infection cases per 100,000 population" in 2 regions exceeded $5^0/_{0000}$ (Moscow – $15{,}03^0/_{0000}$, the Komi Republic – 6,42‰), by May 15 – already 33 regions reported this indicator more than $100\ ^0/_{0000}$, while in Moscow – more than $1000^0/_{0000}$. Initially, over 80% of all cases of infection were concentrated in Moscow, the Moscow region and the largest urban agglomerations. Then the disease incidence started to increase in those regions where temporary labor migrants and summer residents began to return from Moscow, the Moscow region and the largest urban agglomerations (Zyryanov 2020; Zyryanov et al. 2020). In general, the number of cases was decreasing from west to east, reaching local peaks in the core cities of large agglomerations, a number of regions of the North Caucasus, northern regions of oil and gas production. In the transport "dead ends" (the Tomsk region, Republic of Tyva), the epidemic somewhat slowed down (Fig. 3.) (Zyryanov 2020; Zyryanov et al. 2020; Zemtsov, Baburin 2020a, 2020b).

Dynamics in the Covid spread in the regions of the South of European Russia

The spread of Covid-19 in the South of European Russia, generally repeating the all-Russian trends, was somewhat delayed. The first case of infection was registered in the Krasnodar Territory on March 12, 2020, (i.e., 10 days later than in Russia as a whole), by the beginning of April the situation slowly deteriorated, Dagestan (25 people) ranked first, the Krasnodar Territory – second (22 people), and Crimea – third (16 people). By the beginning of May, the incidence in these regions increased by more than 50 times – there were already more

than a thousand cases in each. The top three were followed by the Rostov region, Ingushetia, North Ossetia, Stavropol Territory (Fig. 3). In several ethnic republics, the infection rate per 100,000 population reached the maximum in Russia: in the Republic of Ingushetia -157, Republic of North Ossetia-Alania -119, Chechen Republic – 104, Kabardino-Balkarian Republic -85.3, Republic of Kalmykia – 83.9. By mid-May, the situation continued to escalate. Ingushetia, North Ossetia, Kabardino-Balkaria and Kalmykia were among the top ten Russian regions with the worst indicators. Then the situation in these regions stabilized yet remaining alarming, while the situation in the Karachay-Cherkess Republic worsened. At the same time, a number of southern Russian regions were characterized by rather low absolute and relative infection rates. At the beginning of the pandemic, the regions of the North Caucasus Federal District (NCFD) left behind the regions of the Southern Federal District (SFD) in terms of the number of cases (despite the fact that SFD total population is 1.5-fold higher the NCFD one), but then the indicators equaled, and by the end of 2021, the regions of the SFD prevailed (Zemtsov, Baburin 2020a, 2020b; Askhabova et al. 2020).

Comparisons of the dynamics in the growth of the number of detected cases of coronavirus infection in the world, Russia as a whole and the South of the European part of Russia show that the pandemic has a wave-like character (Fig. 5), but the amplitude, period and length of fluctuations coincide only partially. The "global average" trend is characterized by a smoother course with even ups and downs at approximately equal intervals. The last highest rise falls out of the general trend at the end of 2021, associated with mutations of the virus and appearance of more contagious, but generally less dangerous forms. The all-Russian trends are gustier and more relief, the ups deviate from the global course and repeat unevenly with different amplitude and duration. In total, four waves have been identified, the fifth one, caused by Omicron, was not detected, because it turned out to be shifted to 2022. In the South of the European part of Russia, dynamics in incidence is almost identical to the country one, with slight delays. (Fig. 4).

Development of the epidemic in Russia followed the ascending scenario with a sharp increase in the number of cases, while the wavelength decreased and the amplitude increased. The fourth wave was the most powerful, the number of cases more than four times exceeded the number in the first wave. The peak values of the number of cases per day amounted to 41.3 thousand people. During this period, cases of Covid-19 were registered in all regions of Russia without exception. The top five regions in terms of the number of cases included Moscow and the Moscow region, St. Petersburg, Sverdlovsk, Samara, and Nizhny Novgorod regions (i.e. territories with the largest urban agglomerations).

According to official statistics, regions of the South of the European part of Russia accounted for more than 10% of the all-Russian indicators in terms of the share of cases, and more than 16% in terms of the share of deaths from Covid–19. As of 01.01.2022, about 1.1 million cases (10.9%) and 49.1 thousand deaths (16.1%) were registered out here. Considering the fact that 18.1% of the country's population live in this macroregion, in terms of morbidity the epidemiological situation is relatively positive, but it is unfavorable in terms of mortality. For example, as of 01.01.2022, the share of Moscow in terms of population is 8.7%, the share of cases is 19.7%, while the share of deaths from Covid is 12.1% (Rosstat; Official information…2022). This comparison clearly reflects the effect of the two major factors of the pandemic development. High population density in urbanized territories and emerging agglomeration effects that stimulate pendulum migrations, contribute to higher infection with Covid-19, however a more advanced organization of the health system is more successful in treating the disease.

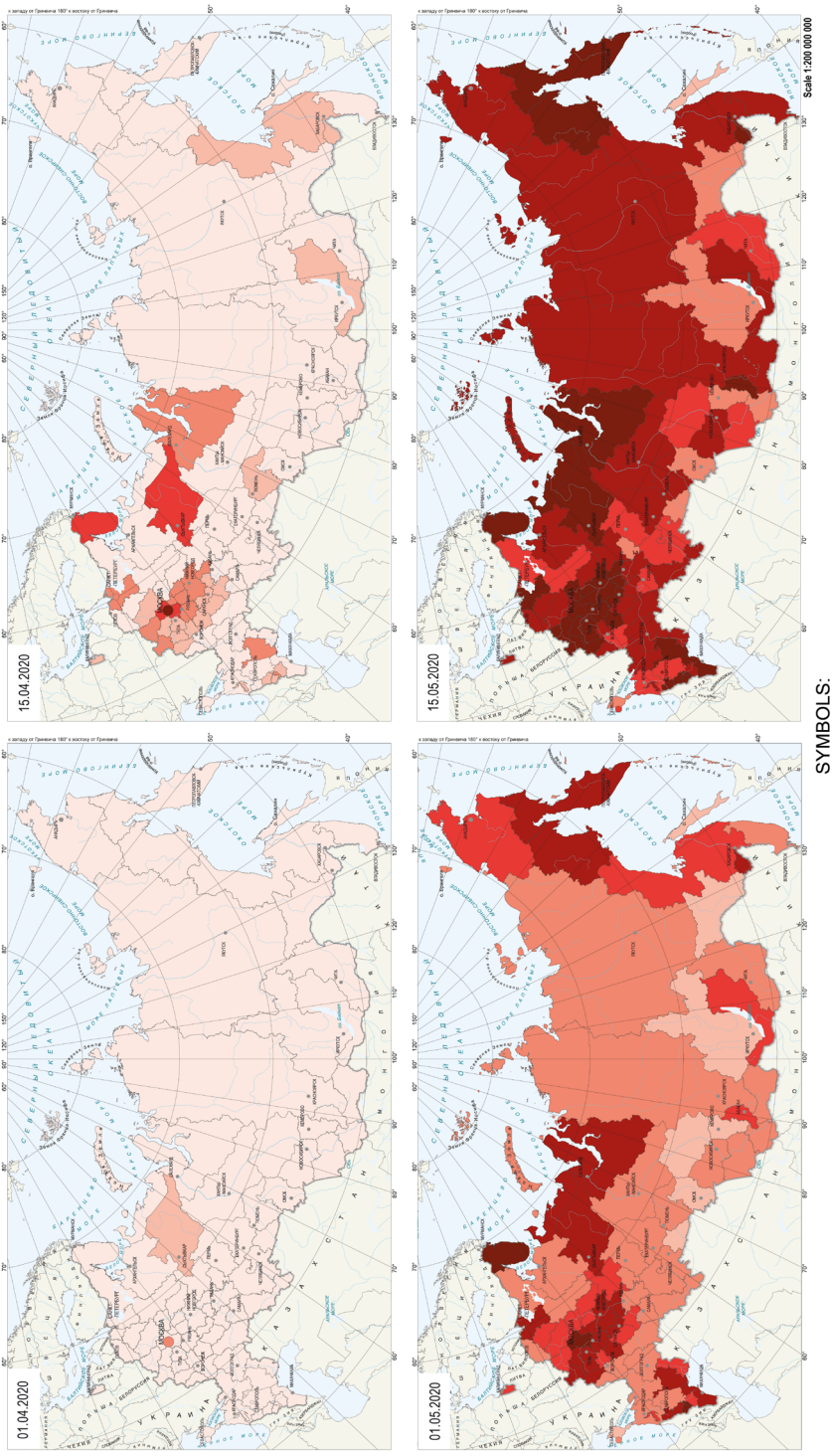

Fig. 3. Geographical distribution of Covid-19 in Russia at the initial stage, by region, 01.04.2020 – 15.05.2020

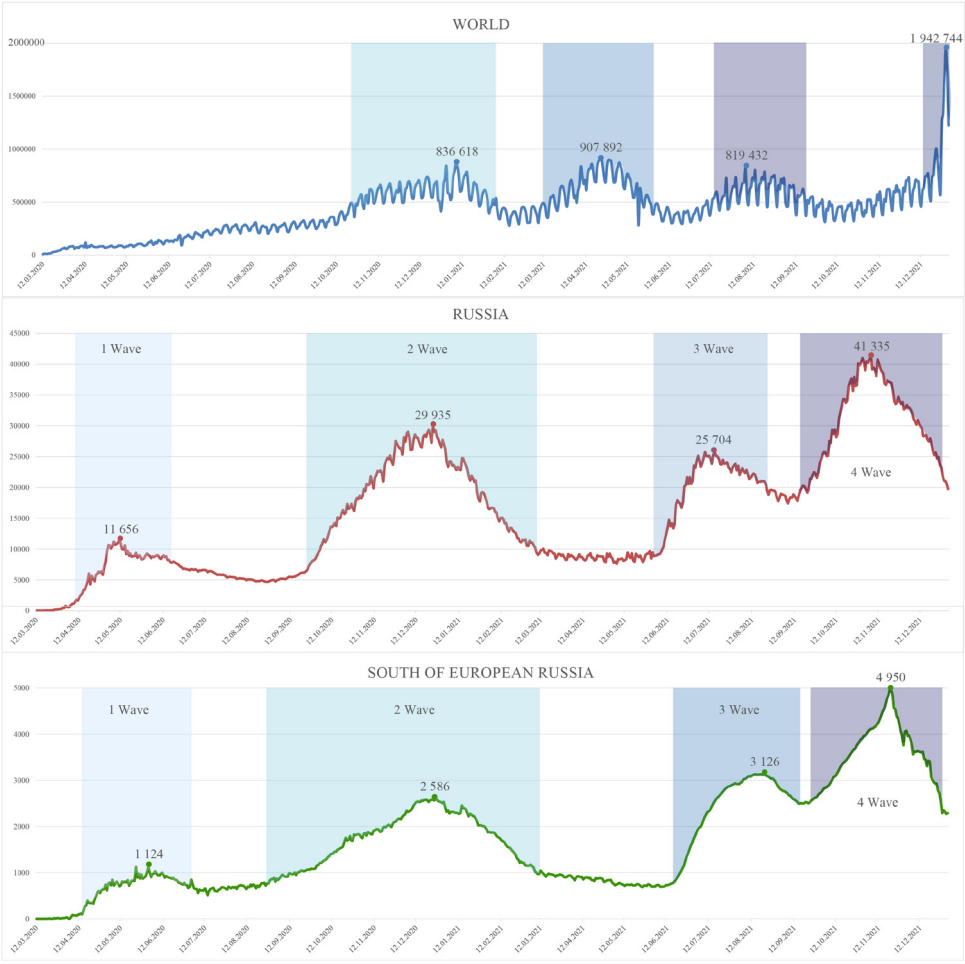

Fig. 4. Covid-19 pandemic waves, World, Russia, and the South of European Russia

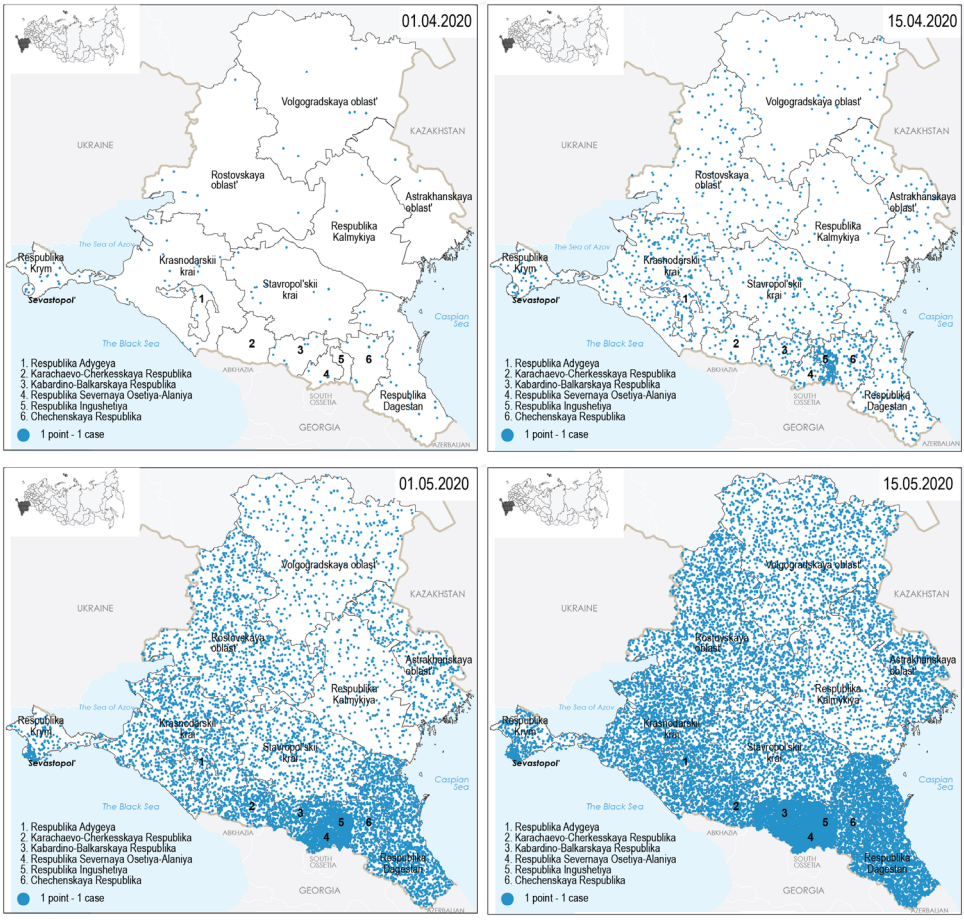

Fig. 5. Geographical distribution of Covid-19 in the South of European Russia at the initial stage, by region, 01.04.2020 – 15.05.2020. 1 point – 1 case of infection

Spatial and temporal features of the Covid-19 spread in the southern Russian regions

The pandemic development in the south of Russia was uneven and spatially differentiated.

The first wave (14.04. – 30.06.2020, the wave peak: 1.06.2020). The wavelength was two and a half months. The number of confirmed cases per day ranged from 4 in Sevastopol to 189 in the Volgograd region. In terms of the total number of cases, the Rostov Region, Republic of Dagestan, Krasnodar Territory and Volgograd Region are in the lead. This situation was due to a number of factors, among which were likely to be the size and presence of the largest agglomerations, location on the northern border of the macroregion towards the epidemic movement, and return of a large number of migrant workers. In Dagestan, the migration factor was reinforced by the ethno-cultural features of the lifestyle, contributing to higher contacts between people. However, a stronger "epidemiological pressure" was mani-

fested in small ethnic republics, especially Ingushetia and North Ossetia, with the infection rate per 100,000 population reaching maximum adding up to 436 and 428, respectively.

High, yet somewhat lower indicators were registered in Kalmykia, Kabardino-Balkaria, Karachay-Cherkessia (the exception was the Chechen Republic with relatively low indicators, which, in our opinion, is due either to a faster and stricter introduction of restrictive measures, or statistical errors). The Covid-19 mortality rate in most regions (except for Ingushetia, North Ossetia and Dagestan) did not exceed 2‰. The situation was especially unfavorable in Dagestan with the average daily number of deaths during the first wave adding up to 5 people with the peak of 50; the total number equaled to 371. From mid-May to mid-June 2020, Dagestan ranked third in the country in terms of the number of deaths after Moscow and the Moscow region.

The second wave (25.08 2020 – 11.03 2021, the wave peak – 26.12.2020). This wave was the longest (more than six months) and asymmetric one. The rise lasted for more than four months, and the decline – about two. Infection rates have increased two or more times in all regions. The highest number of cases of infection per day was registered in a number of largest regions with capitals with a million-plus population: the Volgograd region (281 people) and Rostov region (389 people), Stavropol Territory (246 people) and Crimea (342 people), where the holiday season is likely to make a contribution. The same regions led in the total number of confirmed cases – from 2.5 to 4.5 thousand people. The lowest rates (less than 150 people per day) are registered in ethnic republics, although the growth rates are different out here. Thus, in the Chechen Republic, the daily number of cases increased more than seven times from 20 to 145, in Kalmykia – five times, while mortality from Covis-19 in Karachay-Cherkessia increased 1.3-fold from 70 to 93.

The maximum was registered in the Rostov region (21 per day, a total of 1958), the minimum – in the Karachay-Cherkess Republic (less than 1 per day and 41 in total). The maximum infection rates remained in Ingushetia and North Ossetia. The situation in Dagestan has somewhat stabilized. Apparently, the operational emergency measures on deploying additional medical care have made a difference. The number of cases per day slightly increased compared to the previous wave – from 141 to 158 people, while the number of deaths per day decreased from 5 to 4, the infection rate was significantly lower than in other neighboring regions. Specifics of the epidemic development in the Krasnodar Territory, the largest southern Russian region with a resort and recreational specialization, are not fully understood. There are significantly lower infection rates out here compared to other crowded regions (the daily number of cases equals to 147, the total number of cases during this wave adds up to 29325, the infection rate is 478 – the lowest infection rate in the South of Russia). At the same time, the mortality rate is among the highest (the daily number of deaths is 10, the total number of deaths during the 2nd wave equals to 1916 people).

The third wave (16.06. – 16.09.2021, the wave peak – 21.08.2021). The wavelength has reduced to three months with a relatively slow rise and a faster decline. The overall picture of the spread generally coincides with the previous period. The largest regions take the lead in terms of infection rates and mortality, the lowest indicators are registered in the republics of the North Caucasus. The Krasnodar Territory continues to be discordant, its infection rates are almost twice lower than, for example, in the Rostov region, but at the same time mortality is high. By the beginning of September (Fig. 8), the most difficult situation was registered in the Republic of Kalmykia, which joined the top three regions of Russia in terms of infection rate per 100,000 population, slightly second only to Moscow and St. Petersburg.

The fourth wave (23.09.2021 – 01.01.2022, the wave peak – 21.11.2021). This period is characterized by a rapid rise and a rapid decline with main parameters reaching their maximum at the peak. The top three in the number of daily cases include the Rostov region (602), Crimea (511), and Krasnodar Territory (477), other regions report either a slight increase or decrease. Mortality reaches the maximum peak values for the entire period under study adding up to 69 in the Krasnodar Territory, 38 – in Rostov region, 35 – in Dagestan, and 34 – in Stavropol Territory. In terms of mortality rate per 100,000 population, the Sevastopol region (4th ranking in Russia) and the Republic of Kalmykia (5th ranking in Russia) stood out. The top 10 with the lowest mortality rates included the Chechen Republic and North Ossetia-Alania.

Using the Krasnodar Territory as an example, it was possible to analyze dynamics in the spread of the pandemic at the municipal level. The spread started in the Primorsko-Akhtarsky district, relatively high rates were recorded in the Vyselkovsky and Pavlovsky districts. By the peak of the second wave, more than 26.5 thousand cases and 187 deaths were registered in the region with Krasnodar and Goryachy Klyuch, Pavlovsky and Vyselkovsky districts taking the lead, i.e. territories through which the main transport corridors pass. During the third and fourth waves, the pandemic reaches its maximum development. More than 90 thousand cases have been identified, and the number of newly diagnosed cases added up to one thousand per day. The worst indicators are registered in the regional capital – Krasnodar and the suburban Dinsk district, as well as the resort area: the cities of Sochi, Novorossiysk, Gelendzhik, Anapa, Yeisk district (Fig. 7).

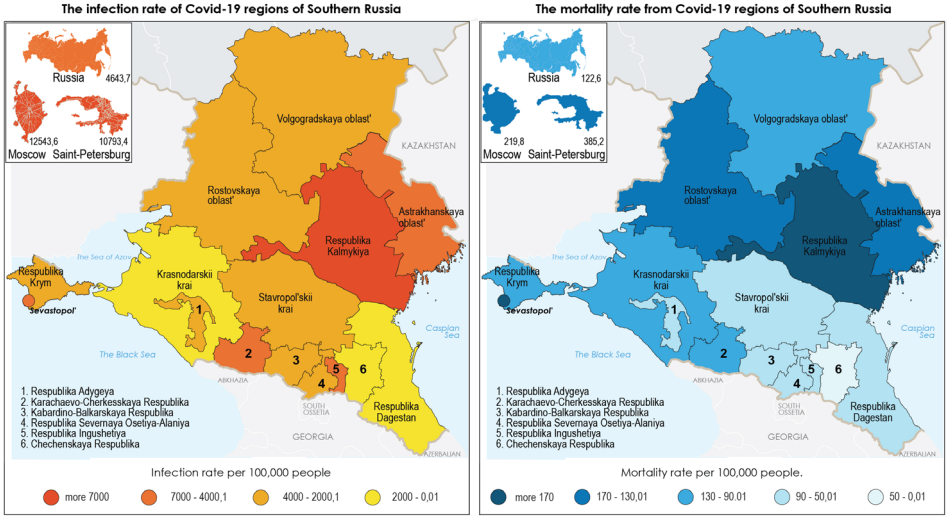

Fig. 6. Covid-19 infection rate and mortality from Covid-19 in the Southern regions of European Russia as of 01.09.2021

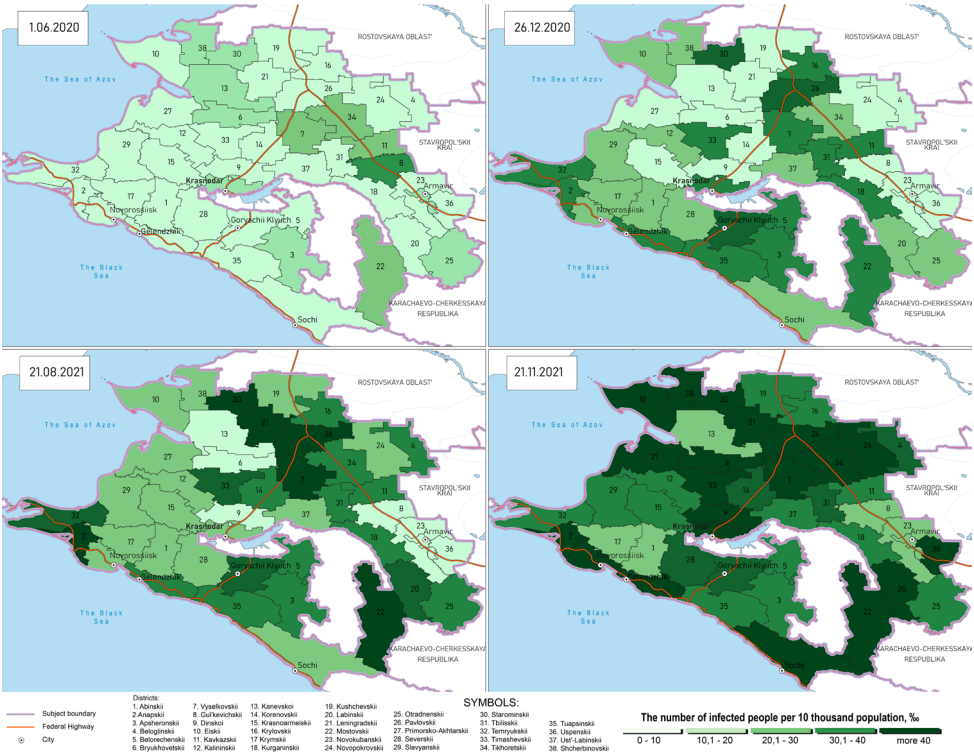

Fig. 7. Geographical distribution of Covid-19 at the intraregional level (exemplified by the Krasnodar Territory)

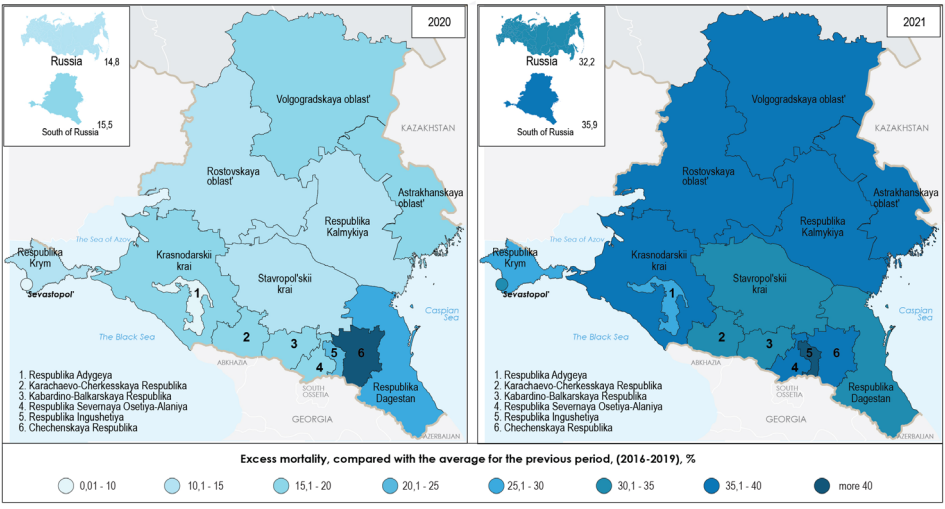

Fig. 8. Excess mortality in the Southen regions of European Russia in 2020, 2021, %

Demographic indicators during the pandemic

The spread of coronavirus has resulted in increased mortality and decreased birth rate worldwide. From 2019 to 2021, the indicators of natural growth decreased from 10.3 to 8.1‰. In Russia in 2020, mortality increased by 17.9% compared to 2019, or by 395 thousand people, while in 2021 the number of deaths exceeded 1 million people. The mortality rate in 2019-2021 increased by 4.3 points and amounted to 16.7‰. Although not so obvious, but there is still a tendency towards pandemic-associated impact on fertility rates. In 2021, the birth rate equaled to 9.6‰ versus 10.1‰ in 2019. The average number of births over the past five years exceeded 1.72 thousand people, 1.44 thousand in 2020, and 1.40 thousand people in 2021. The indicator of natural population loss increased more than 3 times up to -7.2‰. It is obvious that the coronavirus is not the only reason for deteriorated demographic situation. Indicators of natural population movement have been steadily declining in the last decade in most Russian regions. However, Covid-19 has significantly intensified this process. In the depopulating regions of Central and Northwestern Russia, the indicators of natural population loss doubled, deterioration, although to a lesser degree, was manifested in relatively favorable territories (oil-producing regions of western Siberia, mountain republics of the North Caucasus). Negative demographic shifts are especially noticeable in the regions of the South of the European part of Russia. In 2019, the average coefficient of natural growth was positive (0.5‰, and 1.1‰ in the regional capitals), by 2021 it had become negative (-3.9‰ and – 4.9‰, respectively). Before the pandemic, the positive natural growth was reported by 7 regions, in 2021 – by only 4. The largest demographic loss was registered in regions with the dominant Russian population. In the Volgograd and Rostov regions, the decline exceeded 10 ‰, while in the Stavropol and Krasnodar Territories – more than 5-6 ‰. In the mountainous republics, despite increased mortality, the population increased by 47.6 thousand people, while in the plain regions – decreased by 150.7 thousand people.

There is no doubt that the most important indicator of the Covid-19 impact on demographic situation is excess mortality, which is considered as a cumulative indicator of the pandemic impact.

Excess mortality is calculated as the difference between the number of deaths per year (2021, 2020) and the average number of deaths in the previous period 2016-2019. (Pilyasov et al. 2021). In 2020, excess mortality in the regions of the South of European Russia exceeded the average mortality by 15.5% with the worst indicators registered in the Chechen Republic. In 2021 excess mortality dramatically increased in almost all regions except for Chechnya, where it slightly decreased. During this period, the leaders in excess mortality include regions with capitals with a million-plus population (the Volgograd and Rostov regions, Krasnodar Territory) and Republic of Ingushetia (Fig. 7, Table 1).

Demographic consequences of the coronavirus spread have intraregional features as well. They turned out to be the most negative in cities with a million-plus population and centers of large, well-developed agglomerations. During the period under study (2019-2021), in Rostov-on-Don, Volgograd, Simferopol, Krasnodar, Astrakhan, Stavropol, and even Pyatigorsk, the decline exceeded the regional averages, however, there has been registered a not so obvious loss in cities – centers of less-developed agglomerations (Elista, Vladikavkaz, Nalchik). In ethnic republics with high demographic indicators (Ingushetia, Dagestan, the Chechen Republic), the natural growth has decreased, yet remaining positive due to preserved fertility and that births exceed mortality.

Table 1. Excess mortality in the South of European Russia by region, 2020-2021.

Region	Average number of deaths, 2016-2019, thou. people	Deaths, 2021, thou. people	Change, 2021, thou. people	Chang, 2021, %	Deaths, 2020, thou. people	Change, 2020, thou. people	Change, 2020, %
Adygea	5.7	7.4	1.7	29.2	6.0	0.3	6.1
Astrakhan region	11.7	16.2	4.4	37.8	13.6	1.9	15.9
Volgograd region	33.5	46.6	13.1	39.1	39.1	5.6	16.7
Dagestan	15.1	19.8	4.6	30.6	19.4	4.3	28.3
Ingushetia	1.5	2.2	0.7	43.3	1.9	0.4	23.5
Kabardino-Balkaria	7.2	9.4	2.2	30.3	8.6	1.4	19.1
Kalmykia	2.7	3.6	1.0	36.1	3.0	0.3	12.4
Karachay-Cherkessia	4.3	5.7	1.4	32.9	4.9	0.7	15.6
Krasnodar Territory	70.0	97.1	27.2	38.8	80.8	10.8	15.5
Crimea	27.6	35.7	8.2	29.6	30.6	3.0	11.0
Rostov region	56.9	78.4	21.5	37.8	64.2	7.3	12.9
Sevastopol	5.7	7.6	1.9	32.8	6.2	0.5	8.8
North Ossetia	7.2	9.8	2.6	35.8	8.4	1.2	16.1
Stavropol Territory	31.9	42.3	10.4	32.5	36.2	4.3	13.5
Chechnya	6.5	8.9	2.4	37.0	9.2	2.7	41.3
South of European Russia	287.6	390.7	103.1	35.9	332.3	44.7	15.5
Russia	1 850.4	2 445.5	595.1	32.2	2 124.5	274.0	14.8

Based on Rosstat data

Conclusions

The developed geoinformation monitoring system provided for operational processing and visualization of a large array of statistical data, making it possible to conduct a multi-scale spatial analysis of the Covid spread in the world, Russia as a whole and the South of the European part of Russia.

The pandemic has a wave-like character, but its parameters, generally following the global trends, have certain country and regional differences. The epicenter of the pandemic has been gradually moving from East Asia to North America, Europe and other regions due to various factors and their combination – the level of development and inclusion in the world economy, lifestyle and behavior of the population, population age structure, etc.

A significant role in the development of the pandemic was played by the level of development of transport networks, especially presence of transport hubs concentrating large masses of people and becoming a focal point of coronavirus infection.

In Russia, the main center of the spread was the metropolitan regions, followed by a further spread to other territories and formation of local maximum in the core cities of large agglomerations, resort regions, some ethnic republics, northern regions of oil and gas production. The infection spread most rapidly in Moscow and the neighboring urban agglomerations (the Kaluga region, Tula, Ryazan, Vladimir, Ivanovo, etc.).

Analysis of the spread of the pandemic in the South of European Russia has identified a significant spatial-temporal differentiation of its parameters associated with numerous diverse and multidirectional factors. The most important include settlement-related, institutional and socio-cultural factors. However, it should be noted here that the identified factors of the infection spread mainly coincide with the results obtained in other similar studies.

1. The settlement system. In the largest cities and well-developed urban agglomerations, a protracted course of the pandemic prevails. Areas with more sparse settlement are characterized by a rapid and acute development of infection and a similar quick decline (Kalabikhina, Panin 2020; Pilyasov et al. 2021).
2. Spatial mobility of the population. Interregional labor and pendulum migrations and tourist trips were the greatest contributors to the disease dissemination (Pilyasov et al. 2021).
3. Ethno-cultural features of the lifestyle, in particular, traditions of holding and attending crowded events have much contributed to the spread of Covid-19 in ethnic republics (Panin et al. 2021).
4. Peculiar features of the management of regional administrations. Development of epidemiological situation was largely determined by the quality of management decisions made by regional and municipal authorities. For example, tough (perhaps not always popular) measures to some extent helped avoid severe consequences in the Chechen Republic, which has demonstrated the best dynamics in reducing excess mortality among all regions of Southern Russia, that its neighbors (for example, Ingushetia) failed to do.

During the pandemic development, all demographic indicators have deteriorated almost everywhere. Compared to 2019, by 2021, the natural growth decreased by 2.2 promille points worldwide, and by 5 promille points in Russia both due to increased mortality and decreased fertility.

Negative trends have also affected rather favorable in terms of demographics Southern regions of Russia – the North Caucasus Federal District and Southern Federal District. In 2019, the natural increase equaled to 13042 people (0.5 ‰), in 2021 it became negative and decreased to -4.4‰, the population drop equaled to -116126 people. The greatest demographic damage was inflicted to cities with a million-plus population and large well-developed urban agglomerations.

Acknowledgements

The study was implemented within the framework of RFBR grants No. 20-05-00386 A "Spatial and temporal disproportions of demographic development of urban agglomerations of various types in the European part of Russia", No. 20-35-90069 "Graduate students". "Trans-

formation of the population ethnodemographic structure in the regional capitals of the South of European Russia" and within the framework of the state budget topics "Development of the world economic system in the conditions of changing technological patterns" and "Study of dynamics in socio-natural systems through geoinformation mapping and digital technologies".

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