RESEARCH PAPER

THE COVID-19 PANDEMIC AND ITS CONSEQUENCES FOR PUBLIC HEALTH: MEDICO-GEOGRAPHICAL ASPECT

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ABSTRACT. The paper consists of a review of the public health consequences of the COVID-19 pandemic. The study focuses on the assessment of the impact of the COVID-19 pandemic on the incidence of the leading disease categories, such as Diseases of the Circulatory System (DCS), Malignant Neoplasms (MN) and External Causes of Morbidity and Mortality (EC) in the Russian Federation. Time series of standardized incidence for each category were examined for the period 2007–2019 (pre-COVID-19), and 2020–2023 (COVID-19 and post-COVID-19). The post-COVID trends were compared to those hypothetically expected with no COVID impact. For the majority of the RF regions, upward trends of DCS and MN incidence were detected both in pre-COVID and post-COVID years. In the first year of the pandemic, a decline in morbidity was observed for all categories. The EC incidence trend was decreasing in pre-COVID years, but it increased in the post-COVID period. The median incidence rates of MN in the post-COVID period were lower than expected in most of the country, while those of DCS demonstrated heterogeneous distribution with no clear spatial patterns. A decline in the incidence of all nosoforms in 2020 may not have been related to the actual decrease of morbidity, but rather to the significant reduction of healthcare and diagnostics accessibility, which led to a reduction in the detection of diseases new cases.

KEYWORDS: COVID-19, Russian Federation, ICD disease categories, time series, incidence trends, trend change point, public health consequences

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INTRODUCTION

Coronavirus infection COVID-19 is a dangerous infectious disease caused by the RNA-containing virus SARS-CoV-2, which often has a multisystemic nature of infection and has a multifaceted impact on public health (Lu et al. 2020; Peng 2020; Richardson et al. 2020). Due to the very high contagiousness of the virus, the disease has spread rapidly throughout the world, affecting millions of people in different countries. Currently, more than 777 million people are infected, of whom more than 7 million people have died (as of December 8, 2024)[1]. Although WHO declared the end of the COVID-19 pandemic in May 2023, coordination of the global response to the pandemic continues[2]. Apart from the profound environmental, economic, and socio-cultural changes in the world (Bedford et al. 2020; Khalifa et al. 2021), such as lockdown measures and a sharp reduction in industrial production have resulted in a decrease in anthropogenic emissions into the atmosphere, resulting in a decrease in the concentration of air pollutants and greenhouse gas levels in many regions, especially in large urban agglomerations (Ginzburg et al. 2020; Baklanov et al. 2021). The COVID-19 pandemic has had many consequences for global health in addition to those caused by the disease itself.

Prolonged exposure to the virus can lead to post-COVID syndrome, which manifests itself in various chronic symptoms. This has been diagnosed and confirmed in most countries with very diverse symptoms, covering neurological complications, cardiovascular symptoms, chronic health outcomes, etc.

[1] WHO. (2020, February 28). Director-General's opening remarks at the media briefing on COVID-19. Retrieved from https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-28-february-2020.
[2]WHO. (n.d.). Coronavirus (COVID-19) Dashboard. Retrieved from https://data.who.int/dashboards/covid19/deaths

(Ong et al. 2023; Filev et al. 2024). The situation is especially complicated in the case of the development of combined pathology in patients under observation for chronic non-communicable diseases.

The high contagiousness of COVID-19 and the variability of clinical manifestations have led to an increase in the number of hospitalizations, which required significant resources from healthcare institutions. There has been a decrease in the number of hospital visits during the pandemic, which has led to an increase in mortality from other causes. In addition, the pandemic has caused significant changes in the lifestyle of the population due to the transition to remote working, the introduction of restrictions on movement and social interaction, and the deterioration of the financial situation, and all these factors have adversely affected the mental health of the population.

The purpose of this article is to analyze the consequences of the COVID-19 pandemic on public health and its impact on the dynamics of morbidity among the leading classes of diseases in the Russian Federation in the COVID and post-COVID periods.

To achieve this goal, the following objectives were formulated:

1) review of the literature on the main consequences of the COVID-19 pandemic for public health;

2) collecting epidemiological information and creating a database on the incidence of the population with leading categories of diseases in the Russian Federation;

3) modeling morbidity trends;

4) creating a series of medico-geographical maps to identify geographic differentiation in the dynamics of morbidity in the pre-COVID, COVID, and post-COVID periods.

MATERIALS AND METHODS

Materials

The review of the literature on the main consequences of the COVID-19 pandemic for public health, as well as the healthcare sector, was prepared on the basis of a significant number of publications according to the eLibrary, Google Scholar, PubMed, Scopus, and Web of Science databases.

Three categories of diseases according to the international classification ICD-10 were considered for analysis in the Russian Federation: II Neoplasms, IX Diseases of the circulatory system, and XX External causes of morbidity and mortality. These categories are the leading causes of death for the period between 2007 and 2023, accounting for more than 70% of all causes of mortality in the population (Fig. 1). Data on relative morbidity (per 100 thousand people) annually for the period 2007-2023 were obtained from official information of the Federal Service for State Statistics (Rosstat)[3].

Methods

To assess changes in the dynamics of incidence in the population before and after the emergence of COVID-19, the median incidence values were considered for two periods: 2007–2019 (pre-COVID-19) and 2020–2023 (COVID-19 and post-COVID). For each of the periods, incidence trends were also determined by fitting a linear regression model using the Least Squares Method. The reliability of the trend was assessed using the determination coefficient R^2 (the proportion of variation explained by regression). A trend was considered reliable if $R^2 \geq 0.5$.

Additionally, the change in incidence in the first year of the pandemic (2020) was assessed compared to the previous year. Furthermore, expected incidence values for the period from 2020 to 2023 were modeled in the absence of COVID-19 and compared with the observed values for this period. The simulation was carried out using a linear trend for the period from 2007 to 2019. A difference between the expected and observed incidence values was mapped. A spatial pattern of their distribution was assessed by Moran's I global spatial autocorrelation test (Getis and Ord 1992). Statistically significant test results (*p-value* ≤ 0.05) indicate the presence of spatial autocorrelation (i.e., high values tend to group together forming clusters), while statistically insignificant *p-value* >0.05 suggests nearly random spatial distribution.

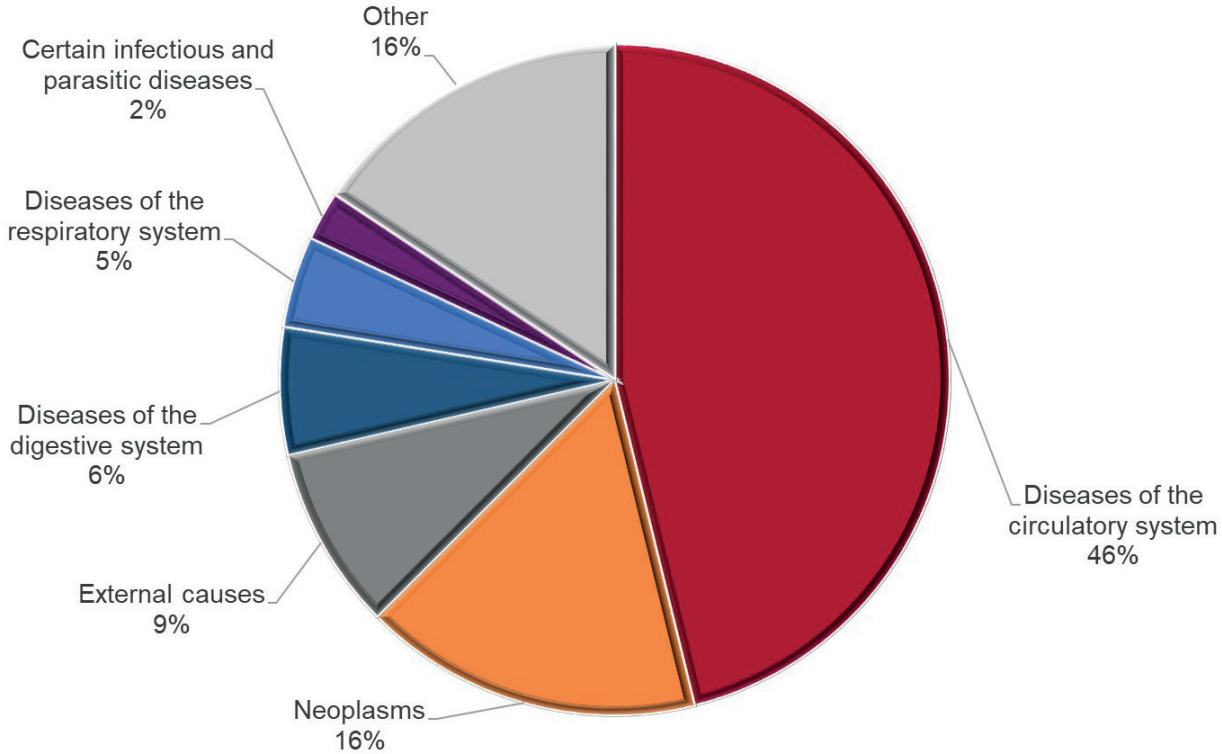

Fig. 1. Mortality structure of the population in the Russian Federation. 2023

[3]Federal State Statistics Service. URL: https://eng.rosstat.gov.ru/. Accessed 09.12.24

Study area

The Russian Federation is a country located in both Europe and Asia, ranking first in the world in terms of area (more than 17 million km^2). The country's population is more than 146 million people with an average density of 8.53 people per km2. Administratively, the country is divided into 89 first-level units (subjects or regions), represented by oblasts, republics, autonomous okrugs, and three cities of federal significance. The research was conducted on the regional level of 85 subjects, for whom incidence data are available for the entire analyzed period.

COVID-19 in Russia

The first cases of COVID-19 were registered in Russia in the first ten days of March 2020. By April 16, COVID-19 had been recorded in all regions of the country, and by the end of the month, the number of cases in Russia exceeded 100,000. A sharp rise occurred in late April - early May when the number of infections increased from 6,000 to 11,000 reaching a maximum on May 11, 2020 (11,656 cases). Then, in the summer months of 2020, the incidence rate began to decline (Malkhazova et al. 2021).

After the number of cases decreased to less than 5,000 per day by the end of August 2020, a new increase in cases ("second wave") emerged in the fall and was considered most intense in the second half of September 2020. In November, more than 20,000 infected people were detected each day. The second wave of the disease peaked in late December 2020 when the number of daily COVID-19 cases was almost 30,000, more than 2.5 times higher than the corresponding figure during the first wave. According to Rosstat, 144,691 people with coronavirus infection died in Russia in 2020, which accounted for 6.8% of the total number of deaths in 2020. Despite significantly higher incidence and mortality rates, the country did not introduce a general lockdown. Essentially, only the universal mask regime and a ban on mass events were maintained on the federal level. The decision to apply additional restrictive measures was made by regional authorities. In December 2020, vaccination against COVID-19 began in Russia amid an increase in the number of infections. From January to June 2021, the number of infections decreased. For example, 27,039 cases of COVID-19 were confirmed on January 1, while the number was only 9,500 on June 1.

A new surge in COVID-19 cases (the "third wave") was recorded in Russia in the last ten days of June 2021. The number of new cases exceeded 20,000 on June 24. Thus, the growth in registered cases of infection since the beginning of the month was 100%. During August, as well as the first and second ten days of September, the daily number of infected people was between 17,813 and 19,905.

Another surge in cases called the "fourth wave" was recorded on September 23, 2021. A new maximum since the beginning of the pandemic was recorded on November 6, 2021, when the daily number of cases reached 41,335.

Thus, despite the measures taken, Russia turned out to be one of the most affected countries.

In the following years, the COVID-19 situation gradually stabilized. The coronavirus has ceased to be a source of anxiety and a serious burden on the healthcare system as it was in the first year of the pandemic, but its strains are still circulating and continuing to mutate.

RESULTS

Consequences of the COVID-19 pandemic. Literature review

Many researchers, analyzing the impact of the SARS-CoV-2 virus on the human body, distinguish between "acute health effects" and long-term health effects (so-called "long COVID") (Yong and Liu 2021; O'Mahoney et al. 2022; Lee et al. 2023).

The main manifestation of COVID-19 is a respiratory disease, ranging from mild symptoms to severe pneumonia and acute respiratory distress syndrome. In addition to the respiratory system, the virus can affect multiple organs, leading to complications such as cardiovascular problems, neurological symptoms, loss of taste and smell, and headaches (McBane 2021; Poyiadji et al. 2021).

A significant proportion of people experience persistent symptoms after the acute phase, called post-COVID syndrome. These symptoms can include fatigue, cognitive impairment (Rodríguez-Rey et al. 2020; Ueda et al. 2021) and negative psychological effects such as depression and anxiety (Nguyen et al. 2020; Zhang and Ma 2020). Even mild cases of the disease can lead to long-term cognitive problems, especially in older adults (Bianchetti et al. 2020; Mendes et al. 2021; Poloni et al. 2021).

Acute symptoms and long-term complications are most common in adult patients, with an average age of 34 to 59 years (Bai et al. 2020; Wang et al. 2020). The highest proportion of severe cases occurs in patients over 60 years old and in people with certain comorbidities, such as cardiovascular disease, cerebrovascular disease, and diabetes (Chen et al. 2020; Fei et al. 2020; Petrilli et al. 2020).

Preconditions such as cardiovascular disease and chronic lung disease, smoking and alcohol consumption are risk factors for long COVID symptoms.

In addition, a cohort study based on 541 pregnant women found that pregnant women who were infected by COVID-19 during pregnancy had a higher level of coagulation disorder, indicating that pregnant women were more likely to have postpartum hemorrhage than those without infection (Zhang and Zhang 2024). Women have a higher incidence of joint or muscle pain. Chest pain and tightness are more common at older ages (45 years old).

The impact of COVID-19 on mortality

Several publications characterizing the situation in Russia during the pandemic are devoted to the high level of excess mortality. This indicator is considered a representation of the impact of the pandemic, including direct (deaths from COVID-19) and indirect (impact on the healthcare system and socio-economic factors) effects. The presence of excess mortality in all regions of the Russian Federation is confirmed by all authors who have studied this topic (Danilova 2020; Kotov et al. 2022; Kvasha 2022, etc.), the differences are only in the quantitative parameters of these estimates. According to some authors, excess mortality in 2020 amounted to 288,000 people, and COVID-19 caused approximately 60% of those deaths (Goroshko et al. 2022). However, another study says that official data on mortality from COVID-19 in Russia are underestimated by more than two times (Livshits and Neklyudova 2020; Druzhinin and Molchanova 2021).

According to the Federal State Statistics Service, the natural population decline exceeded one million people in 2021 (Federal Service..., 2024).

COVID-19 has caused excess mortality in Russia. An assessment of excess mortality in the regions of Russia from April 2020 to February 2021 compared to the five-year average based on regression analysis showed (Kotov et al. 2022) that the most significant factors increasing excess mortality are the share of the elderly population and the employment structure represented by the share of workers in the manufacturing industry (economic activity C, European Skills, Competences and Occupations classification).

An assessment of excess mortality rates for the Russian Federation and its regions, as well as equivalent rates for 36 countries, showed that Russia had the highest excess mortality rate among all the countries considered. Most excess mortality cases were registered in the fourth quarter of 2020, and the level and trajectory of excess mortality in Russia and most Eastern European countries differed from those in Western countries. While the cumulative number of COVID-19 cases and deaths was positively correlated with excess mortality across countries, in Russia an inverse negative relationship was observed between excess mortality and cumulative incidence at the regional level, which may be due to common underreporting of COVID-19 cases (Timonin et al. 2021).

Rosstat published monthly statistics on deaths from coronavirus infection, distinguishing four groups of deaths of patients diagnosed with COVID-19: 1) cases in which coronavirus was the main cause of death; 2) cases requiring additional research, when it is assumed that death occurred due to coronavirus; 3) cases in which coronavirus as a concomitant disease affected the underlying disease that caused death; 4) cases in which coronavirus did not cause complications of the diseases that caused death.

As a result of a comparative analysis of COVID-19-related mortality data, significant territorial heterogeneity was revealed across regions of the Russian Federation (Goldstein 2020).

The impact of COVID-19 on chronic non-communicable diseases

Special attention was paid by the experts to the analysis of the influence of COVID-19 on the occurrence of new cases of chronic non-communicable diseases and the aggravation of their course (Shelgunov et al. 2023). The literature review conducted by the authors is based on the results of 64 papers published between April 1, 2020 and January 31, 2023, exploring the impact of COVID-19 on various organs and systems as well as the aggravation of chronic non-communicable diseases.

The analysis indicated that the infection not only affected various organs and systems and increased the risk of complications in the course of chronic non-communicable diseases but also contributed to the emergence of new cases.

It is understood that COVID-19 is the primary cause of new cases of chronic non-communicable diseases in healthy people and also contributes to the development of combined pathology in patients undergoing dispensary observation for another reason.

At the same time, patients with comorbidities are at higher risk of severe COVID-19 with an unfavorable outcome. Given the scale of the spread of COVID-19 and its consequences, it is important for healthcare workers to have a clearer understanding of the possible consequences for patients, including in terms of the development and exacerbation of chronic non-communicable diseases that this infection can cause. According to the authors of the review (Shelgunov et al. 2023), it is important not only to understand the extent of the impact of COVID-19 on the development of chronic pathology in patients but also to keep in mind the ever-increasing volume of medical care for such patients.

Impact on diseases of the circulatory system

The COVID-19 virus has an adverse effect on the cardiovascular system (Xu et al. 2021; Burn et al. 2022). Manifestations can be varied: myocardial damage, myocarditis, acute heart failure, acute myocardial infarction, cardiac arrhythmia, cardiac arrest, venous thromboembolism, and others (Desai et al. 2020; Driggin et al. 2020; Libby and Luscher 2020; Varga et al. 2020; Gushhina and Lozhkina 2021; McBane 2021; Sugraliev 2021; Romanov 2022; Vorobyeva and Romanova 2022; Huseynov et al. 2023; Pogosova et al. 2023; Yusov and Alpidovskaya 2023).

It has been established that patients with COVID-19 have a high prevalence of cardiovascular manifestations due to a systemic inflammatory response and immune system disorders as the disease progresses (Docherty et al. 2020; Kemerley 2024).

According to the conducted studies, the most common complication from the cardiovascular system is the progression of forms of ischemic disease (41.9%). COVID-19 can also cause both primary cardiac pathology and aggravate existing cardiovascular diseases (Hessami 2021; Kravtsiva et al. 2021; Xie et al. 2022).

Although some studies have suggested a link between cardiovascular diseases and severe COVID-19, the efforts to accurately assess the prevalence of cardiovascular diseases in patients with COVID-19 are complicated by the lack of widespread testing, national surveillance, or standardized data collection in the Russian Federation.

There are concerns that people with cardiovascular diseases do not seek timely treatment during the pandemic and die at home. The shortage of essential medications is also important.

For circulatory system-related studies, a study covering 117 athletes (volleyball, handball, freestyle wrestling, judo, classical wrestling, synchronized swimming, swimming, and diving) who have fully recovered from covid and are back to normal training found that there is a slight increase (52.99% to 53.85%) in resting heart rate, minimum heart rate during sleep, and average heart rate during sleep, but no electrocardiogram (EKG) abnormality is observed among the participants. A study with 59 adult patients (14~60 years old) with post-COVID infection (observation group) and 60 people as a control group found that, when excluding the acute COVID infection (acute and long last impact and 28 days after covid infection), patients after COVID infection often experience a decrease in left ventricular diastolic function and global longitudinal strain, and the above indicators show a gradual improvement trend with recovery time. Apart from these, one study reported a diagnosed case of myocarditis associated with suspected covid infection (Liu et al. 2024).

The impact of COVID-19 on oncologic incidence

Cancer patients are at increased risk of severe COVID-19 outcomes due to immune suppression (Moujaess et al. 2020). The pandemic has also disrupted cancer care, leading to delays in diagnosis and treatment and more advanced disease (Harris 2020; Brest et al. 2021). The overall impact of COVID-19 on cancer patients has been detrimental, with increased mortality and challenges in providing cancer care during the pandemic.

Cancer patients are at higher risk of contracting infectious diseases or developing serious complications caused by the virus due to the immunodeficiency caused by the underlying disease. Many anticancer drugs are known to have an immunosuppressive effect. Surgery is another risk factor for developing infections. Cancer patients are a special group since their treatment cannot be stopped.

The need to find a balance between the risk of cancer patients and healthcare workers becoming infected with coronavirus and the need to continue treatment changes the work of oncology institutions. The high incidence of COVID-19 among healthcare workers significantly reduces the number of personnel to provide specialized care. The global healthcare system is faced with an atypical situation that requires, on the one hand, an urgent revision of the standards of treatment for cancer patients and, on the other hand, maintaining the quality of care provided. The available experience is extremely limited, heterogeneous, and, in most cases, based on isolated observations. Therefore, it is important to organize the provision of care to patients during a pandemic as well as to search for an answer to the question of how coronavirus infection affects the prognosis and methods of treatment of malignant neoplasms.

The leading oncology institute in the Russian Federation, the Hertsen Moscow Oncology Research Institute, conducted a detailed, systematic review of world literature data, including all aspects that reflect the impact of the COVID-19 pandemic on oncological practice (Kaprin et al. 2020). The review reflects the experience of Russian and foreign researchers, presents data on the impact of COVID-19 on cancer patients, the mortality of cancer patients infected with COVID-19, the possibilities of treating COVID-19, etc. It is noted that, despite the pandemic, treatment of cancer patients must be continued since the presence of a tumor process does not allow a delay in therapy. The global oncology community continues to actively develop recommendations for the optimal management of cancer patients during the pandemic. High-risk groups for infection with the new coronavirus have been identified, including patients with cancer.

The impact of COVID-19 on the central nervous system and mental status

COVID-19 is associated with both acute and chronic neurological and psychological symptoms (Ferrando et al. 2021; Rogers et al. 2021). Neurological manifestations may result from direct viral infection, immune responses, or vascular injury (Alnefeesi et al. 2020; Manchia et al. 2022).

Reported nervous system manifestations range from relatively simple symptoms to cerebral hemorrhage and infarction. Postmortem studies of human brains indicate that human coronavirus variants and SARS-CoV-2 can infect neurons and neuroglia. Furthermore, studies have demonstrated increased serum cytokine levels following SARS-CoV-2 infection, consistent with the notion that cytokine overproduction and toxicity may be an important potential mechanism of neurological injury parallel to the known lung injury pathway. Evidence that SARS-CoV-2 may be a vasculotropic and neurotropic virus is discussed. Early reports suggest that COVID-19 may be associated with severe neurological complications, and there are several plausible mechanisms to explain these observations. Detailed information on the potential neurological injury and further exploration of relevant pathophysiological interventions are needed to understand and ultimately mitigate SARS-CoV-2-associated neurological injury.

Psychological consequences include increased rates of depression, anxiety, and posttraumatic stress disorder among patients and the general population (Rodríguez-Rey et al. 2020; Sher 2020; Brown and Schuman 2021; Ueda et al. 2021).

In terms of psychological health, a study based on 161 adults in Hebei province find that, 32.3% have a psychological condition (based on GHQ-12 questionnaire) and 53.4% have poor sleep quality (based on PSQI questionnaire). Among these, female, low education, and being single have a higher risk for psychological conditions, and higher education is a proactive factor for sleeping quality, while worrying about long COVID symptoms is a risk factor for poor sleeping quality (Cai et al. 2022). For very early cognitive impairment, a study covering 311 people who suffered covid during the Wuhan outbreak found that 170 (54.7%) people had very early cognitive impairment and 230 (23.9%) had residual symptoms after discharge from the hospital. Among these, females, elderly, and people with generalized anxiety disorder have a higher risk of very early cognitive impairment after being infected with COVID. People with very early cognitive impairment after covid have much higher chances for other long COVID symptoms, including insomnia, fatigue, chest tightness, shortness of breath, and loss of appetite (Hua et al. 2023).

A recent study covering 68,200 Chinese populations found that fatigue (30.53%), memory decline (27.93%), decreased exercise ability (18.29%), and brain fog (16.87%) are the main long COVID symptoms for the Chinese population. These symptoms were less prevalent among those infected only once: fatigue (24.85%), memory decline (18.11%), and decreased exercise ability (12.52%), etc. (Qin et al. 2024).

As COVID-19 continues to be reported, recent literature on the effects of this new virus on the central nervous system may help guide clinical practice and identify potentially important research directions. In addition, understanding the potential mechanisms of neurological injury may focus efforts on more accurate detection and prevention of these complications (Belopasov et al. 2020; Simonenko et al. 2021; Ekusheva et al. 2022; Parfenov and Kulesh 2022).

The impact of COVID-19 on infectious diseases

Several countries have seen a notable decline in the spread of sexually transmitted infections, including HIV/AIDS, attributed to COVID-19 quarantines, social distancing measures, and advice against casual sex. Similarly, in some places, transmission rates of influenza and other respiratory viruses have dropped significantly during the pandemic. In addition, the influenza B/Yamagata lineage may have disappeared in 2020 or 2021 due to measures to control the COVID-19 pandemic, and no natural cases have been confirmed since March 2020. In 2023, the World Health Organization concluded that protection against the Yamagata lineage is no longer required in the seasonal influenza vaccine, reducing the number of lineages targeted by the vaccine from four to three.

An assessment of the course of the COVID-19 pandemic and its impact on the epidemics of HIV infection, viral hepatitis C (HCV), tuberculosis, influenza, and acute respiratory infections was carried out in the Northwestern Federal District of the Russian Federation over two years of the spread of COVID-19 from the standpoint of the possible formation of a syndemic, or interference between the diseases (Belyakov et al. 2022). The pandemic did not significantly affect the patterns of the epidemic course of HIV, HCV, and tuberculosis, indicating there was no syndemic between these pathogens. Interference with respiratory infections was noted, with a clear predominance of SARS-CoV-2.

The impact of COVID-19 on the category external causes of morbidity and mortality

Experts paid special attention to the analysis of the influence of COVID-19 in terms of stress and anxiety that accompanied the pandemic's course, which can be associated with an increase in mortality rates from injuries, poisoning, and conditions associated with alcohol and drug use (Briko et al. 2020; Nikiforov et al. 2020; Nikitina et al. 2021; Yakovleva et al. 2023).

According to experts, concerns about a possible sharp increase in suicide mortality were not confirmed; on the contrary, at the first stages, during the period with the strictest quarantine measures, the suicide rate decreased (Boyko et al. 2020; Rozanov 2020; Rozanov and Semenova 2022).

Below, a more detailed analysis of the impact of the COVID-19 pandemic on the dynamics of leading classes of diseases in the Russian Federation is carried out.

Impact of the COVID-19 Pandemic on the Incidence Dynamics of Leading Disease Categories in the Russian Federation

Diseases of the circulatory system (DCS)

The annual dynamics of the incidence of DCS on average in the subjects of the Russian Federation are presented in Fig. 2. The point of change in the trend in 2020 is obvious, followed by a continuation of the upward trend. On average, the country's incidence declined by 6.2% ± 7.5% in 2020 compared to 2019. At the same time, an increase in incidence was observed only in some regions in the southern part of the Russian Federation, such as Astrakhan and Kurgan oblasts, and the Republics of Chechnya, Kabardino-Balkaria, Adygea, Altai, and Buryatia.

The average incidence of DCS in the pre-COVID period in all regions of the Russian Federation was 22,177±5,748 cases per 100,000 population. In most (66 out of 85) regions, an increasing trend was observed, and in 44 out of 66 subjects, the trend significance exceeded 0.5. In eight regions, a significant negative trend in the incidence of DCS was observed. These regions included the federal cities of Moscow, St. Petersburg, and Sevastopol, the Republic of Crimea, Astrakhan Oblast, Altai Krai, Vladimir Oblast, and Nenets Autonomous Okrug (Fig. 3). During the COVID-19 period, the average incidence rate in all regions increased and amounted to 24,954±6,382 cases per 100,000 population. At the same time, in 70 out of 85 regions, a stable trend towards increasing incidence continues to form. Only four regions show a significant downward trend in the incidence of DCS during this period; these are the Tomsk and Novgorod oblasts as well as the Republics of Tyva and Khakassia.

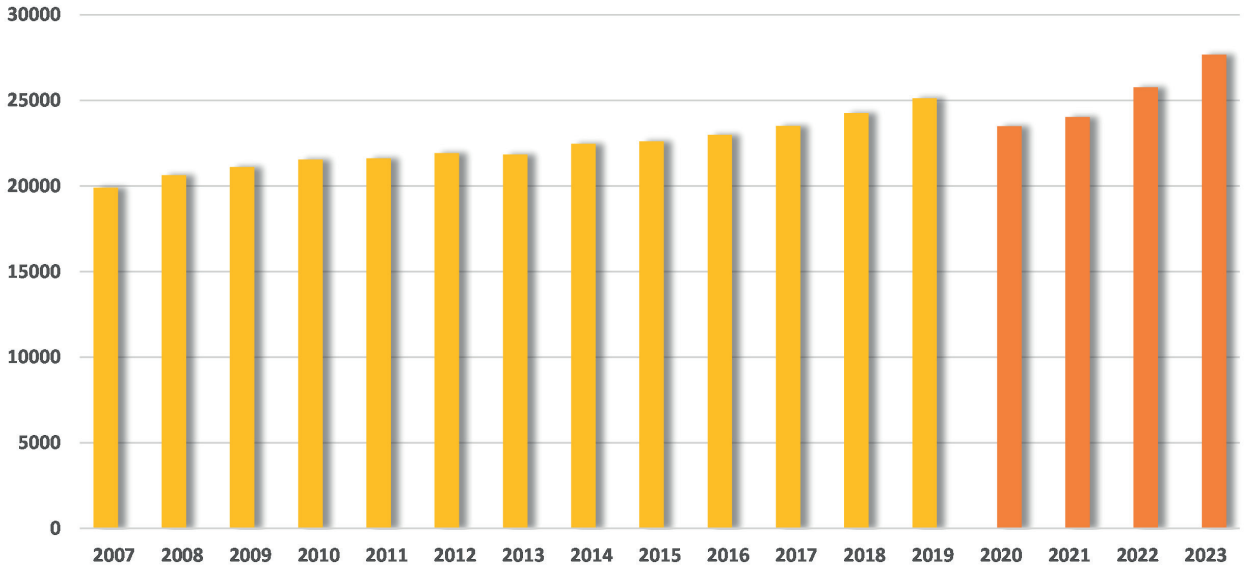

Fig. 2. Annual dynamics of the average incidence of diseases of the circulatory system in the Russian Federation for the period from 2007 to 2023

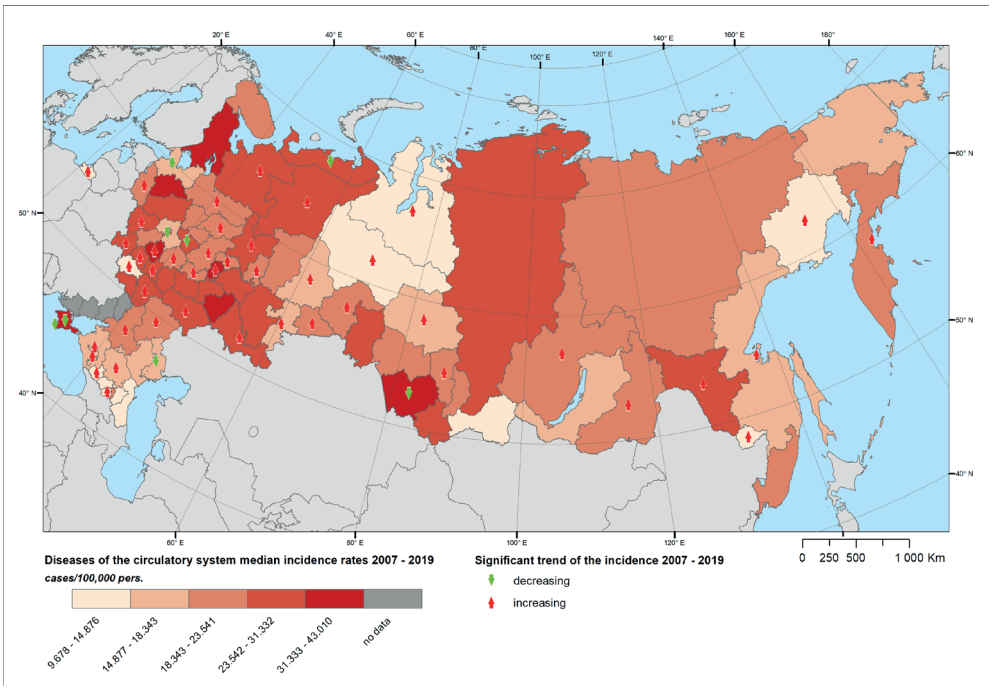

Fig. 3. Distribution of median incidence of diseases of the circulatory system in the Russian Federation in the period 2007–2019 and significant trends in its change

Compared with the hypothetical incidence for 2020–2023 (assuming the continuation of the pre-COVID trend), in 40 of the 85 regions studied, the actual median incidence was higher by up to 35%. In the remaining regions, a lower median incidence of up to 28% is observed. The spatial distribution of regions with an increase and decrease in the incidence of DCS is very heterogeneous and does not reveal any clear patterns ($p = 0.69 > 0.05$) (Fig. 4).

Malignant neoplasms (MN)

The annual dynamics of the incidence of MN on average in the regions of the Russian Federation are presented in Fig. 5. The point of change in the trend in 2020 with the subsequent continuation of the upward trend can be seen. On average, the country's incidence declined by 11.8% ± 7.4% in 2020 compared to 2019. At the same time, an increase in incidence was observed only in two regions, these being the Republic of Ingushetia and the Chukotka Autonomous Okrug.

The average incidence rate of malignant neoplasms in the pre-COVID period in all regions of Russia was 373.5±81.3 cases per 100,000 population. In the overwhelming majority (84 out of 85) of regions, an upward trend was observed, and in 77 out of 84 regions, the trend significance exceeded 0.5. A significant negative incidence trend was observed only in the Chechen Republic (Fig. 6). During the COVID-19 period, the average incidence rate in all regions increased and amounted to 417.8±97.7 cases per 100,000 population. The upward trend in incidence continued in 83 out of 85 regions studied (significant trend in 73 out of 83 regions). An insignificant downward trend is observed in the Leningrad Oblast and the Republic of Ingushetia.

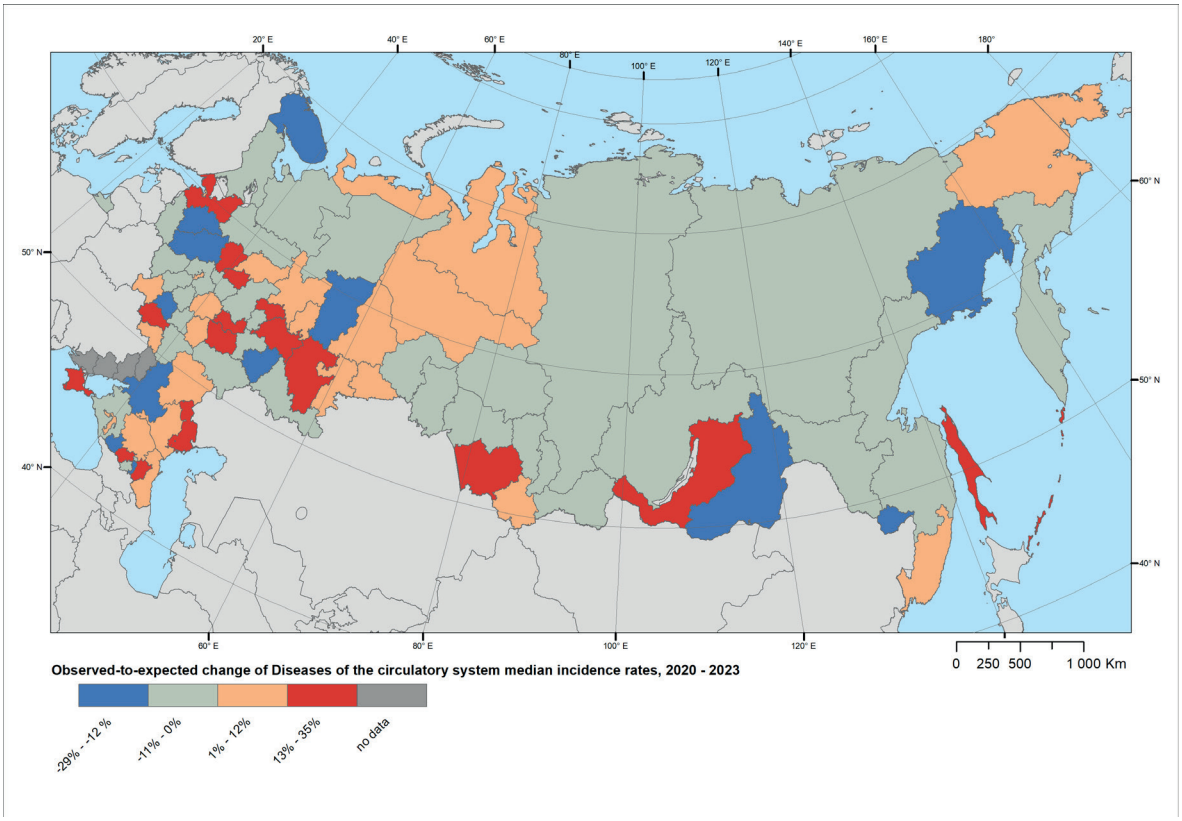

Fig. 4. Change in the actual median incidence of DCS in 2020–2023 compared to the expected hypothetical value without the influence of COVID

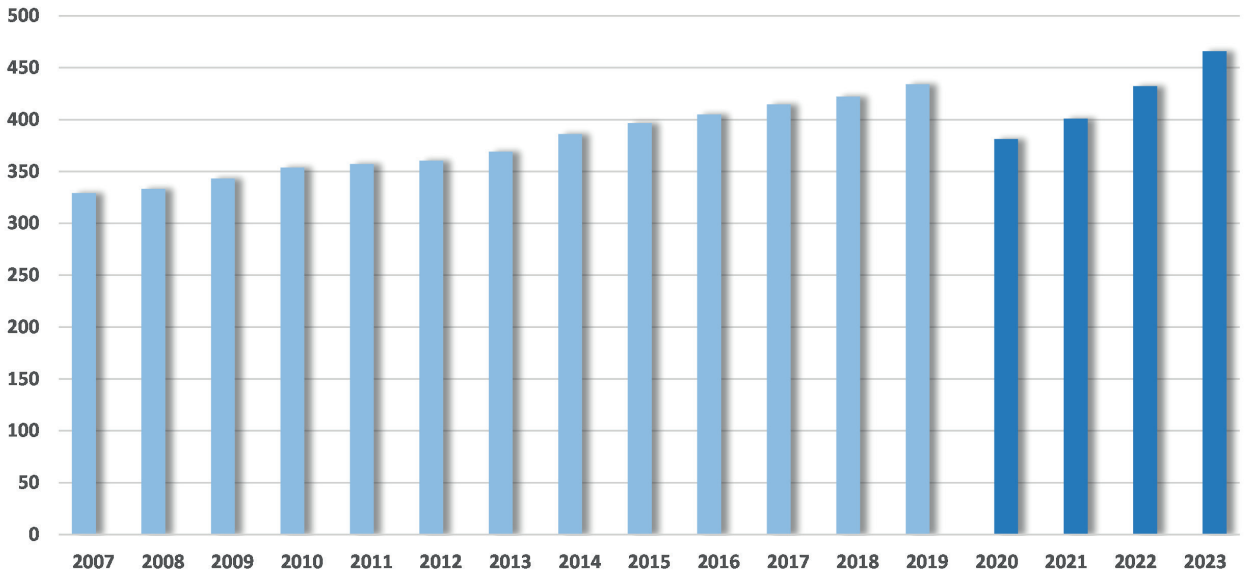

Fig. 5. Annual dynamics of the average incidence of malignant neoplasms in the Russian Federation for the period 2007–2023

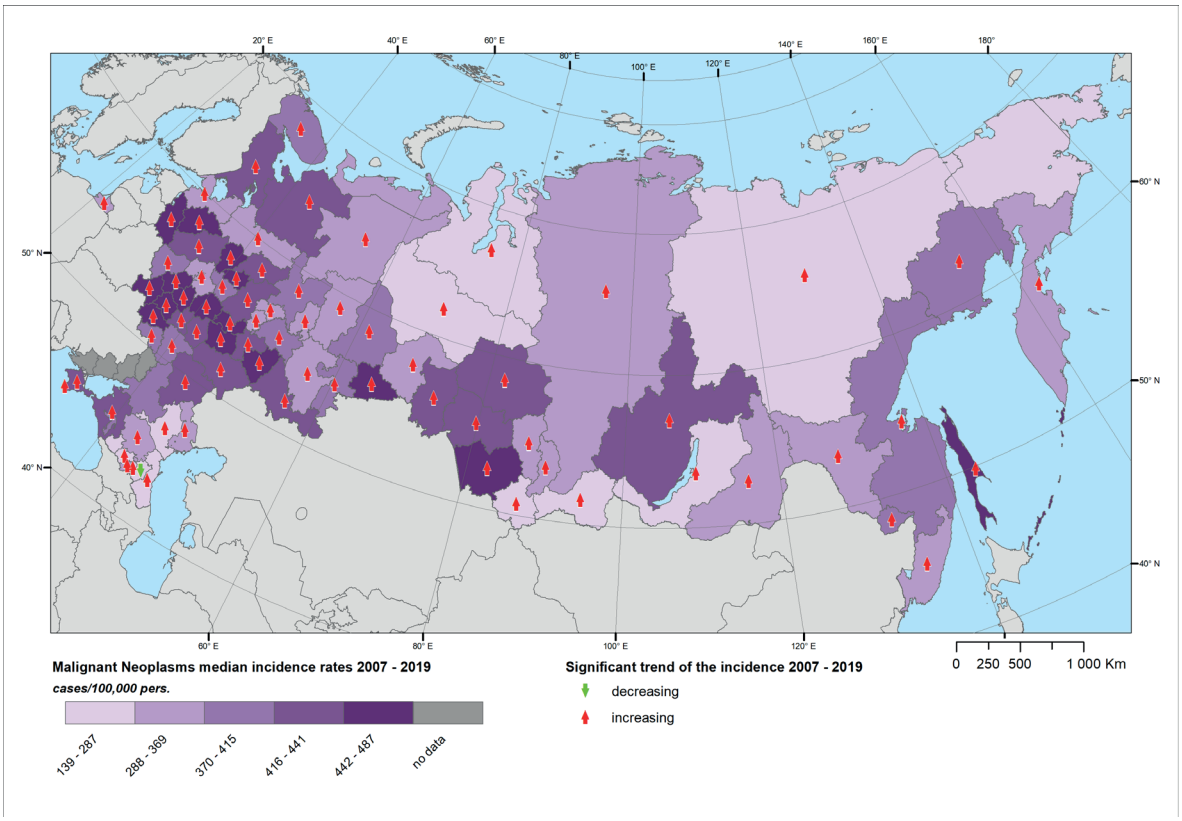

Fig. 6. Distribution of median incidence of malignant neoplasms in the Russian Federation in the period 2007–2019 and significant trends in its change

Compared with the hypothetical incidence rate for 2020–2023 (assuming the pre-COVID trend continues), the actual median incidence rate was higher in only 9 out of 85 regions. Moreover, 8 out of 9 regions demonstrate only a slight excess (up to 8%), while the Chechen Republic shows a 97% excess. Most regions have a lower median incidence rate of up to 30% (Fig. 7). The spatial distribution of regions with an increase and decrease in the incidence of MN is very heterogeneous and does not reveal any clear patterns ($p = 0.44 > 0.05$)

External Causes of Morbidity and Mortality

The annual dynamics of incidence from external causes on average in the subjects of the Russian Federation are presented in Fig. 8. In the period from 2007 to 2019, a

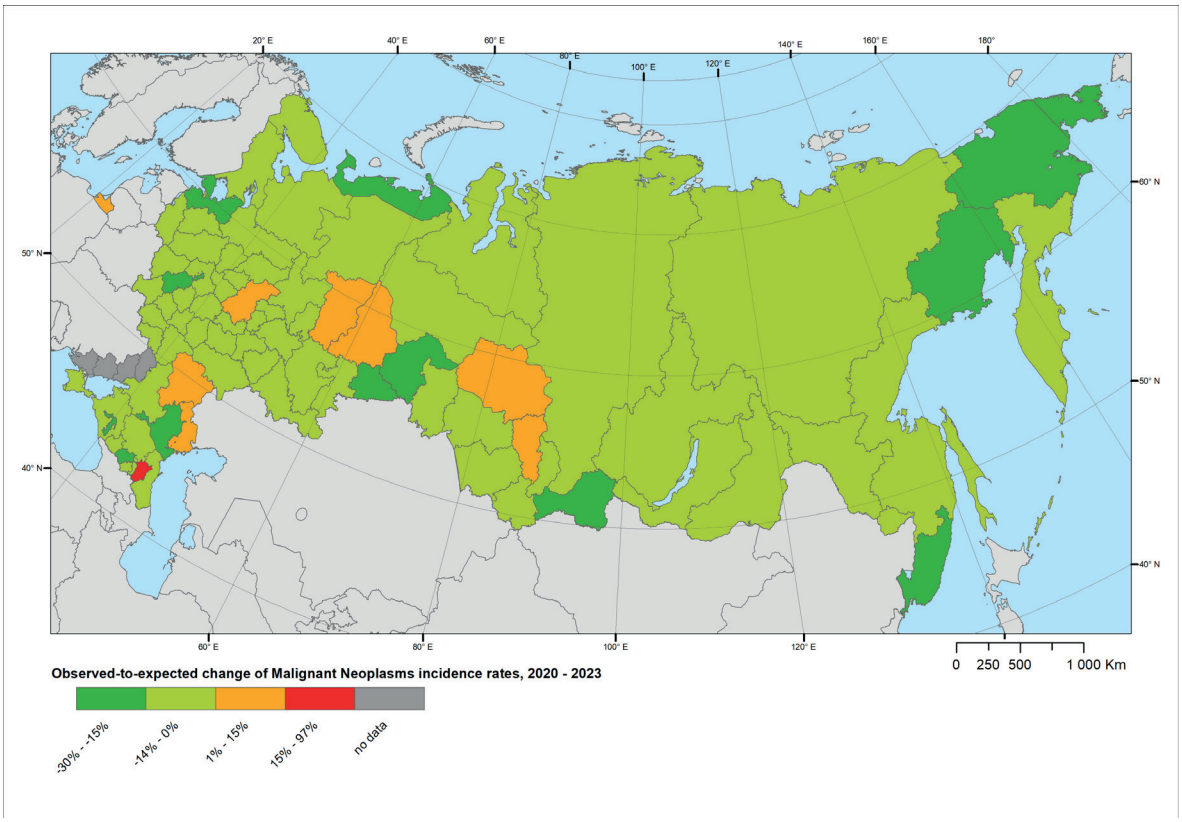

Fig. 7. Change in the actual median incidence of malignant neoplasms in 2020–2023 compared to the expected hypothetical value without the influence of COVID

decreasing trend in morbidity was observed. The point of change in the trend in 2020 with a transition to an increase is visualized. On average in the country, the decline in morbidity in 2020 compared to 2019 was 9.6% ± 6.8%. At the same time, an increase in morbidity was observed only in four subjects: the Leningrad Oblast, the Republics of Altai, Ingushetia, and Kabardino-Balkaria.

The average incidence from external causes for the pre-COVID period in all subjects of the Russian Federation was 8864±2238 cases per 100 thousand population. Only 23 out of 85 subjects showed a significant trend in incidence, with the trend decreasing in 7 out of 23 subjects and increasing in the remaining 16 subjects (Fig. 9). During the COVID-19 period, the average incidence in all subjects slightly decreased and was 8094±2354 cases per 100,000 population. The downward trend in incidence continued in 24 out of 85 subjects (significant for 9 out of 24). The remaining subjects demonstrated a trend towards an increase in incidence due to external causes.

Compared with the hypothetical incidence rate for 2020–2023 (assuming the pre-COVID trend continues), in 53 out of 85 regions, the actual median incidence rate was lower by up to 44%. In the remaining regions, the median incidence rate was exceeded by up to 28% (Fig. 10). The spatial distribution of regions with increases and decreases in incidence from external causes is highly heterogeneous and does not reveal any clear patterns ($p = 0.23 > 0.05$).

Thus, in 2020 (the year the COVID-19 pandemic began), there was a decline in the incidence rate, followed by a resumption of the upward trend in all three classes of diseases (cardiovascular, oncological and external causes of morbidity and mortality). Such a decline in the

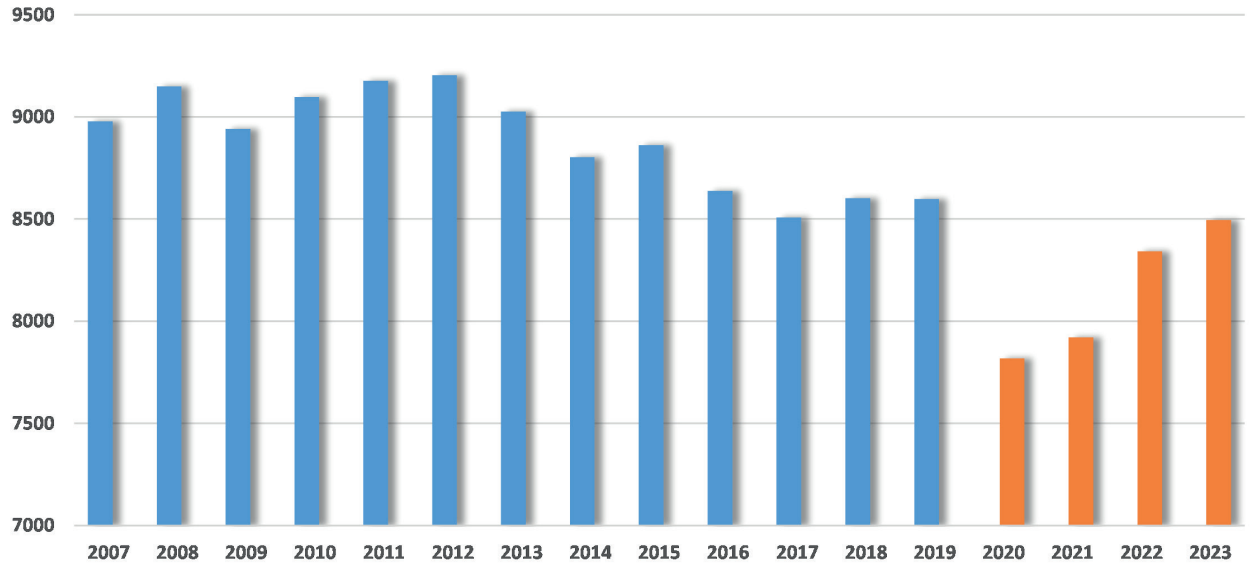

Fig. 8. Annual dynamics of average incidence from external causes in the Russian Federation for the period between 2007 and 2023

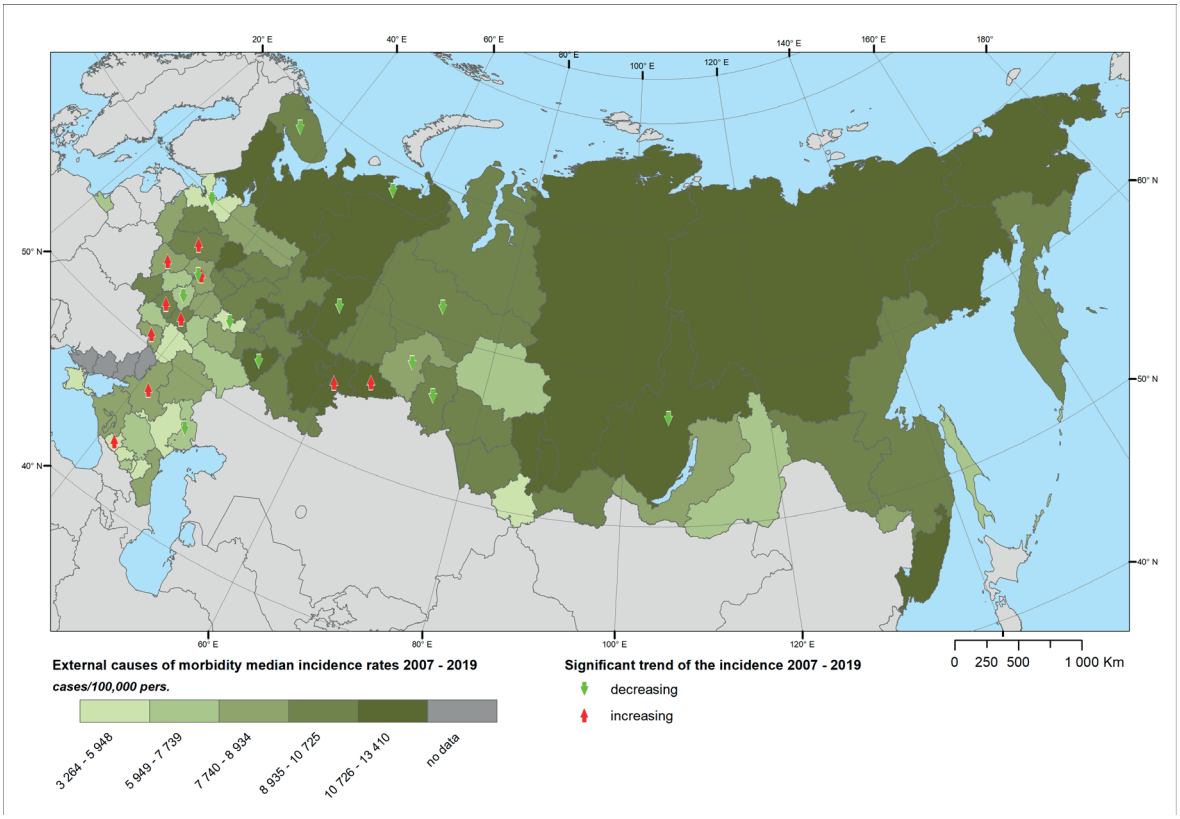

Fig. 9. Distribution of median morbidity caused by external factors in the Russian Federation in the period 2007–2019 and significant trends in its change

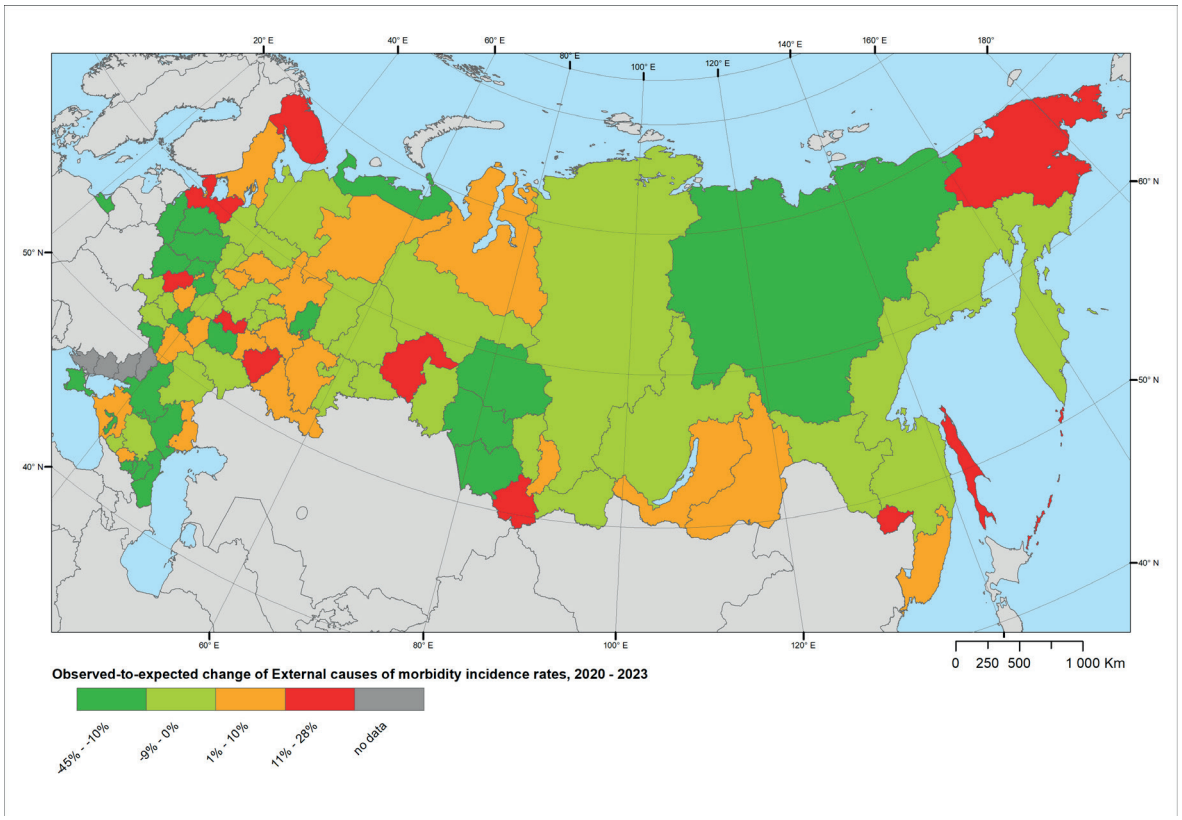

Fig. 10. Change in actual median incidence due to external causes in 2020–2023 compared to the expected hypothetical value without the influence of COVID-19

incidence rate can be explained, obviously, not so much by a decrease in the number of cases but by the peculiarities of the situation in healthcare during the quarantine period.

The quarantine period certainly affected the statistics of COVID-19 cases. The introduction of restrictions on movement and social interaction, during which access to medical institutions was more difficult, led to a reduction in the number of visits to hospitals. Additionally, the behavior of patients with chronic pathologies changed since they often preferred not to have unnecessary contact with anyone outside the home. Of course, the redistribution of medical resources in favor of treating patients with COVID-19 also had an impact. The reduction in government spending on health care before the pandemic and the reduction in the number of infectious disease beds served as prerequisites for the emergence of difficulties during the pandemic. Many medical institutions were forced to adapt to the changed working conditions and redistribute resources. In general, in the context of a massive increase in COVID-19 cases, medical institutions were overloaded, and there was a shortage of personnel, equipment, and medication, which affected the recording of chronic diseases. At the same time, as subsequent analysis showed, with a decrease in the registration of cases during the COVID-19 pandemic, there was no decrease in mortality, particularly from cancer (Medico-geographical Atlas of Russia «Risk Factors for Oncological Diseases» 2024).

DISCUSSION AND CONCLUSIONS

It should be noted that many consequences of the pandemic are not yet fully understood, for example, the level of immunity and immune response, the full spectrum of diseases and long-term effects (Al-Aly et al. 2021, etc.), the consequences of past infection, especially for the child's body (Ranasinghe et al. 2022; Nygaard et al. 2024, etc.).

The COVID-19 pandemic has dealt significant damage to healthcare systems around the world, affecting thousands of people in different countries, and is considered a serious threat to global health. Patients with underlying chronic diseases are at higher risk of a severe COVID-19 case with an unfavorable outcome. Moreover, as research results show, COVID-19 can lead to new cases of chronic non-communicable diseases in healthy people and the development of combined pathology in patients who are getting treatment for another reason.

An analysis of data on the incidence of diseases of the circulatory system, malignant neoplasms, and diseases caused by external causes in the population for the period from 2007 to 2023 showed that for the first two nosological entities in the Russian Federation, before COVID-19, there was a steady increase in incidence, while the incidence from external causes showed a decrease. In the year of the onset of the COVID-19 pandemic (the COVID period), there was a decline in incidence followed by a resumption of the upward trend for all three nosological entities. At the same time, regarding malignant neoplasms, the decline in incidence was more pronounced: most regions of the country demonstrated lower average incidence rates of malignant neoplasms after 2020 than would have been hypothetically expected without the influence of COVID-19.

The decline in the incidence of all nosoforms in 2020 may have been not related to the actual decrease of morbidity, but rather to the significant reduction of healthcare and diagnostics accessibility, which led to a reduction in the detection of new cases. There was a reduction in the number of hospital visits, which led to an increase in mortality from other causes. Patients with other nosological forms did not seek timely treatment during the pandemic and died at home. The overload of medical institutions and the shortage of personnel, equipment, and necessary medications were significant. A similar situation has been noted in other countries.

All this initiatives required significant resources from medical institutions. Many studies note the vulnerability of the healthcare system in the context of a massive increase in COVID-19 cases due to an overload of medical institutions and a shortage of personnel, equipment, and medications (Krivenko 2021; Ulumbekova and Ginoyan 2022).

Journals have been devoting special editions to assessments of the scale of the coronavirus pandemic, analysis of the main mechanisms of its impact on the economy and socio-economic consequences in different geographical conditions, medical and social problems, as well as the impact of the pandemic on the environment and air quality (Geography, Environment, Sustainability 2021).

The assessment of the impact of the pandemic on the health of the population, as well as the healthcare sector, continues, as evidenced by a significant number of publications according to the different databases.

The study of the impact of COVID-19 on public health and the healthcare system in the Russian Federation (Malkhazova et al. 2021) is still highly relevant at present due to the scale of the pandemic, which has had a significant impact on Russian society. These developments led to the need for an in-depth analysis of the consequences of the pandemic for the health of individual population groups, as well as for the healthcare system as a whole (Ulumbekova and Ginoyan 2022; Alov and Pilyasov 2023; Rugol 2023; Tsvetkova et al. 2024).

According to some authors, the so-called optimization of the healthcare system implemented in Russia in recent years has provoked the emergence of several problems that have manifested themselves during the COVID-19 pandemic (Starodubov et al. 2020; Chernyshev et al. 2021). The reduction of infectious disease beds before the pandemic, the mergers of medical institutions, and the reduction of government funds for healthcare served as prerequisites for the emergence of difficulties during the pandemic (Perkhov and Gridnev 2020; Goroshko et al. 2022).

Many medical institutions were forced to adapt to changed working conditions, redistribute resources, and introduce new treatment protocols (Starodubov et al. 2020). There is a need to develop new strategies for resource management and optimization of healthcare delivery processes (Minakir 2020; Pesennikova and Perkhov 2020; Ulumbekova 2020).

The study of the impact of COVID-19 on health and the healthcare system at the local, regional, and global levels, identifying spatiotemporal patterns of infection spread, is highly important since the development of effective solutions to improve public health and increase the resilience of healthcare systems to global challenges is only possible through multi-scale experience (Coronavirus…, 2021).

Given the research data, it is important to have a good understanding of the extent of the impact of COVID-19 on the development of chronic pathology and, accordingly, on the likely increasing volume of medical care for such patients in order to plan medical care rationally within the framework of the free state medical care.

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