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COVID-19: the evolution of the pandemic in Russia. Report I: manifestations of the COVID-19 epidemic process

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Abstract

Background. The ongoing pandemic of a new coronavirus infection (COVID-19) determines the relevance of the analysis of epidemiological patterns of SARS-CoV-2 spread among the population of the Russian Federation.

Aim — study of the manifestations of the epidemic process of COVID-19 in the Russian Federation in 2020–2022.

Materials and methods. A retrospective epidemiological analysis of the incidence of COVID-19 in the Russian Federation was carried out from 03/30/2020 to 04/24/2022. The data from the Rospotrebnadzor report No. 970 "Information on cases of infectious diseases in persons with suspected new coronavirus infection", information portal Stopcoronavirus.rf, etc. were used. The presence of SARS-CoV-2 RNA was confirmed by real-time RT-PCR.

Results and discussion. The analysis of the manifestations of the epidemic process of COVID-19 in the Russian Federation in 2020–2022 showed the presence of two stages which differed depending on the influence of the

biological factor and the ongoing anti-epidemic measures. There was a pronounced trend in the development of the epidemic process, starting from megacities (Moscow, Moscow region and St. Petersburg), which are major transport hubs and centers of migration activity of the population, to the regions of the Russian Federation. The SARS-CoV-2 pathogenicity has been shown to decrease with each subsequent cycle of the rise in the incidence of COVID-19 against the background of the increased contagiousness of the virus.
Conclusion. As a result of the study, risk areas (megacities) and risk groups were identified.

Keywords: *COVID-19, incidence, epidemic process, SARS-CoV-2*

Ethics approval. The study was conducted with the informed consent of the patients. The research protocol was approved by the Ethics Committee of the Central Research Institute for Epidemiology (protocol No. 3, March 27, 2020).

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Научная статья
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COVID-19: эволюция пандемии в России. Сообщение I: проявления эпидемического процесса COVID-19

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Аннотация

Актуальность. Продолжающаяся пандемия новой коронавирусной инфекции (COVID-19) определяет актуальность анализа эпидемиологических закономерностей распространения SARS-CoV-2 среди населения России.

Цель данной статьи — изучение проявлений эпидемического процесса COVID-19 на территории РФ за 2020–2022 гг.

Материалы и методы. Проведён ретроспективный эпидемиологический анализ заболеваемости COVID-19 с 30.03.2020 по 24.04.2022 на территории РФ. Использованы материалы отчёта Роспотребнадзора № 970 «Информация о случаях инфекционных заболеваний у лиц с подозрением на новую коронавирусную инфекцию», информационного портала Стопкоронавирус.рф и др. Наличие РНК SARS-CoV-2 было подтверждено методом полимеразной цепной реакции в реальном времени с обратной транскрипцией.

Результаты и обсуждение. При анализе проявлений эпидемического процесса COVID-19 на территории РФ за 2020–2022 гг. выделены два этапа, различавшиеся влиянием биологического фактора и проводимыми противоэпидемическими мероприятиями. Прослеживается выраженная тенденция развития эпидемического процесса, начиная от мегаполисов (Москва, Московская область и Санкт-Петербург), являющихся крупными транспортными узлами и центрами миграционной активности населения, до регионов РФ. Установлено, что с каждым последующим циклом подъёма заболеваемости COVID-19 на фоне усиления контагиозности SARS-CoV-2 снижается его патогенность.

Заключение. Выявлены территории риска (города-мегаполисы), группы риска, факторы, влияющие на развитие эпидемического процесса. Определены закономерности распространения SARS-CoV-2 и оценена эффективность противоэпидемических мероприятий, направленных на разрыв механизма передачи возбудителя.

Ключевые слова: *COVID-19, заболеваемость, эпидемический процесс, SARS-CoV-2*

Этическое утверждение. Исследование проводилось при добровольном информированном согласии пациентов. Протокол исследования одобрен Этическими комитетами ФБУН ЦНИИ Эпидемиологии Роспотребнадзора (протокол № 3 от 27.03.2020).

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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Introduction

The epidemic, which first broke out in China in late 2019 – early 2020 and then spread to other countries worldwide, and which was etiologically related to SARS-CoV-2 (severe acute respiratory syndrome-related coronavirus 2), has propelled research covering the entire range of the infection-associated problems [1, 2].

Coronaviruses belong to the family *Coronaviridae*, the order *Nidovirales*; the first of them — HCoV-B814 — was isolated in 1965 and to date has not been preserved in virological collections. By the beginning of the 21st century, coronaviruses had not been seen as dangerous viruses for human health; rather they had been considered pathogens of relevance in veterinary medicine. This view had to be revised after people had been infected by SARS-CoV (severe acute respiratory syndrome-related coronavirus) of bat origin in Southeast Asia in 2002 and by MERS-CoV (Middle East respiratory syndrome-related coronavirus) in the Arabian Peninsula in 2012. Having a pronounced zoo-

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notic potential, coronaviruses were able to cross the interspecies barrier, thus urging scientists to revise the taxonomic structure of the *Coronaviridae* family [3].

The studies have shown that the novel SARS-CoV-2 virus emerged through natural mechanisms in China in October-November 2019 and used angiotensin-converting enzyme 2 (ACE2) receptors to facilitate its entry into human lung cells. The first case of infection associated with the novel coronavirus was reported in Wuhan (China) on November 17, 2019; then, the authorities identified at least 266 people with the respiratory condition that could be associated with the new variant of coronavirus. At the end of December 2019, the World Health Organization (WHO) was informed about an outbreak of pneumonia of unknown etiology. At the beginning of 2020, cases of the new disease subsequently named COVID-19 (coronavirus disease 2019) were reported in many countries, primarily in Europe and the United States [4–7]. With numerous fatal outcomes, damage to people's health, which was caused by COVID-19, its rapid global spread, WHO had every reason to declare the novel coronavirus infection outbreak a global pandemic on March 11, 2020[1]. COVID-19 remains a public health concern worldwide, having a tremendous epidemiological, social and economic impact.

The COVID-19 epidemic process has distinctive patterns in different countries. Such diversity can be caused by multiple factors, including the level of economic development, effectiveness of the healthcare system, ethnic composition of population, promptness and scale of the containment measures imposed by the government, population health and mentality, environmental conditions, and other factors. Since the first cases of COVID-19 were reported, many countries have developed and introduced statistical reporting forms to collect epidemiological and clinical information to be further used for building databases not only to analyze the country-specific patterns of the epidemic process and disease course, but also to assess the effectiveness of the containment measures and to plan further measures aimed to control and prevent outbreaks of acute respiratory infections of pandemic potential [8–15].

Note that all the epidemic control measures implemented in the Russian Federation (RF) were based on the scientific rationale and the experience accumulated by the Russian epidemiology. Therefore, from the outset, the measures adopted by the Federal Service for Surveillance on Consumer Rights and Human Well-being (Rospotrebnadzor) were focused on monitoring of the epidemiological situation (from December 31, 2019) and strict sanitary and quarantine control at RF border crossing points. Yet, as the COVID-19-causing pathogen can be transmitted by asymptomatic carriers, the risk of infection being imported to the country still existed. During the early stage of the COVID-19 pandemic, the main efforts were focused on prevention of importation and spread of infection across the RF state border. Subsequently, once SARS-CoV-2 had spread throughout the world and reached pandemic proportions, the focus on control and prevention measures shifted from the cross-border sanitary measures toward testing and screening, tracing contacts, their quarantine and isolation inside the country.

The effectiveness of the response to the SARS-CoV-2 spread in RF is rooted in the systemic approach and prompt implementation of strict containment measures based on the results of the large-scale laboratory screening and prediction for development of the epidemic situation. The response to the COVID-19 spread in Russia is unique, as research institutions closely collaborate with sanitary and epidemiological services. Science has become a secure foothold for development of diagnostic tools, means of prevention and treatment of COVID-19, monitoring the dynamics of the epidemic process across regions and country-wide, thus providing the ground for further adoption of executive decisions. The epidemiological analysis and well-defined criteria set for assessment of the epidemic situation lay behind the decisions on restriction of air travel, operation of business offices, manufacturing facilities, educational and cultural institutions [16–24].

The **aim** of the article was to study the COVID-19 epidemic process features in Russia during 2020-2022.

Materials and methods

The study was performed at the Central Research Institute of Epidemiology of Rospotrebnadzor. The retrospective epidemiological analysis of the COVID-19 incidence in RF was conducted for the period from March 30, 2020 to April 24, 2022. The information about patients (age, gender, case severity, and the onset date) was retrieved from the database containing data of Rospotrebnadzor reports, form 970 "Information about Cases of Infectious Diseases in Individuals with Suspected Novel Coronavirus Infection". The ICD-10 U07.1, COVID-19, virus identified, code was assigned to the above patients: COVID-19 was confirmed by laboratory tests, regardless of the severity of the clinical signs or symptoms. We also used the data from WHO, the Russian information portal stopcoronavirus.rf[2], and the Yandex DataLens data visualization and analysis service[3]. The above materials were used to study main features of the COVID-19 epidemic process during the period from the beginning of the pandemic to the present day, including incidence dynamics, gender ratios

[1] WHO. Coronavirus disease 2019 (COVID-19) Situation Report — 51; 2020. Available at: https://apps.who.int/iris/handle/10665/331475

[2] The public Internet resource for information of population on coronavirus (COVID-19). URL: https://стопкоронавирус.рф

[3] URL: https://datalens.yandex

and age distribution of patients, seasonal patterns, the effect of the imposed containment measures. We also used materials from VGARus (Virus Genome Aggregator of Russia), the national platform for aggregated data on SARS-CoV-2 genomes[4].

The laboratory studies were conducted in compliance with Guidelines MR 3.1.0169-20, Laboratory Diagnostics of COVID-19, etc. The biological material for the study included nasal, nasopharyngeal, and/or throat swabs, bronchial washings collected during fibrobronchoscopy (bronchoalveolar lavage), (endo) tracheal and nasopharyngeal aspirate, sputum, biopsy or autopsy material of the respiratory tract.

The laboratory techniques used in the study are developed by specialists of the Central Research Institute of Epidemiology of Rospotrebnadzor. The presence of SARS-CoV-2 RNA was confirmed by using the real-time reverse transcription polymerase chain reaction (real-time RT-PCR) test system AmpliSens® Cov-Bat-FL[5] and LAMP-based assay AmpliSens® SARS-CoV-2. To quantify SARS-CoV-2 RNA with RT-PCR, we used the AmpliSens® COVID-19-FL reagent kit[6]. For the amplification of genomic fragments and subsequent sequencing, we used the primer panels designed at the Central Research Institute of Epidemiology of Rospotrebnadzor. The real-time PCR-based technique was developed to detect 2 mutations in the S protein of the delta genetic variant (B.1.617.2) – *L452R* and *P681R*, and 4 mutations in the S protein of the omicron genetic variant (B.1.1.529) – the *N501Y* mutation, the *delHV69-70* deletion, the *delVYY143-145* deletion, and the *Ins214EPE* insertion.

The statistical analysis was conducted using standard methods of descriptive statistics in Microsoft Excel and Statistica 12.0 (StatSoft). The confidence interval (95% CI) was calculated using the Clopper-Pearson method (the exact method).

Results

The analysis of the COVID-19 epidemic process in Russia during 2020–2022 was based on the dynamic assessment of the epidemic situation and its trends.

In Russia, the first cases of COVID-19 were reported in areas bordering China 31/1/2020; the first case of imported infection in the European part of the country was recorded on 2/3/2020. From 30/3/2020, the infection started spreading swiftly in megacities and megaregions, and, later, on 16/4/2020, COVID-19 cases were reported in all regions of Russia. During the entire period of monitoring (30/3/2020–24/4/2022) in Russia, a total of 18,137,137 cases of infection were reported. The average COVID-19 incidence rate in Russia during 2021–2022 was ***155.3 per 100,000 population***. The dynamic assessment of the COVID-19 epidemic situation and its trends in Russia during 2020–2022 showed that there were 5 surges in the incidence. The highest number of cases was recorded during the 5th surge (10/1/2021–27/2/2022), being 905.37 per 100,000 population (**Fig. 1**).

The most intensive spread of SARS-CoV-2 was recorded in three megalopolises of Russia (Moscow, the Moscow Region, St. Petersburg) where the cumulative number of COVID-19 cases during the importation period (2/3/2020–30/3/2020) accounted for 84% (95% CI, 83.08–85.20) of the total number of reported cases (**Fig. 2**).

Later, the proportion changed dramatically, and the number of COVID-19 cases in Moscow, the Moscow Region, and St. Petersburg during the entire period (30/3/2020–24/4/2022) accounted for 31% of the total cases (95% CI, 30.8–32.2) (Moscow – 16%, the Moscow Region – 6%, St. Petersburg – 9%), while the number of recorded cases in other RF regions accounted for 69% (95% CI, 68.5–70.95) (Fig. 2).

The epidemic process in Russia started from the first case of COVID-19 imported to the European part of the country (Moscow) from Italy on 2/3/2020. Starting from 30/3/2020, cases of COVID-19 began surging (30/3/2020–30/8/2020 — 22 calendar weeks). During that period, a total of ***987,989*** cases of COVID-19 were recorded; the average incidence rate in Russia was 30.72 per 100,000 population (**Fig. 3**).

When the epidemic was escalating during the first surge in the incidence, the rate of increase in new cases ranged from 39.6% to 161.3% (from 10,370 to 75,001 cases weekly). Starting from 16/5/2020, the number of recorded new cases declined sharply, having demonstrated a 20.5% drop by 31/5/2020, and having further decreased by 42.6% by 30/6/2020, compared to the previous highest level. The incidence reached its peak during 4/5/2020–11/5/2020, with 51.31 cases per 100,000 population. In Moscow, the incidence rates were 6.4-fold higher than the rates across Russia ($p < 0.001$). The period of escalation was followed by a slow decline and then, finally, the rates plateaued at their lowest levels — 22.97 per 100,000 population (Fig. 3). In regions, the stabilization of incidence rates (21st–39th week) took much longer time and the highest rate was recorded 15 days later than in Moscow, the Moscow Region, and St. Petersburg.

The aggravation of the epidemiological situation was recorded from 31/8/2020 through May 09, 2021

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[4] VGARus (Virus Genome Aggregator of Russia). URL: https://genome.crie.ru/app/index

[5] Registration Certificate No. RZN 2014/1987 dated 7/4/2020; The reagent kit for detection of RNA of coronaviruses causing severe respiratory infection: MERS-Cov (Middle East respiratory syndrome coronavirus) and SARS-Cov (severe acute respiratory syndrome coronavirus) in biological materials by using polymerase chain reaction (PCR) with the AmpliSens® Cov-Bat-FL kit for hybridization and fluorescence detection in compliance with TU 9398-224-01897593-2013 specifications.

[6] Registration Certificate No. 2021/14026, 9/4/2021; The reagent kit for detection and quantification of SARS-CoV-2 RNA by using RT-PCR and AmpliSens® COVID-19-FL.

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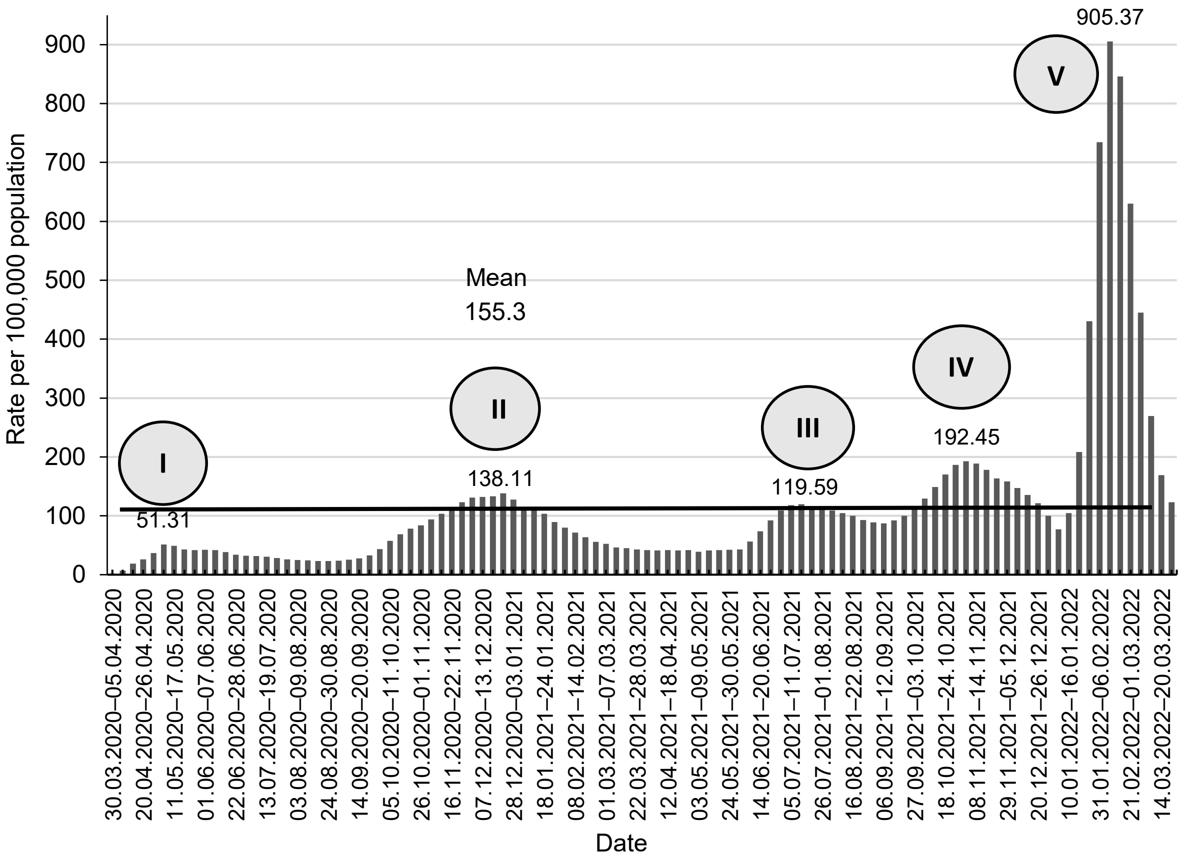

Fig. 1. Dynamics of COVID-19 incidence in the Russian Federation in 2020–2022.
I–V — periods of rise.

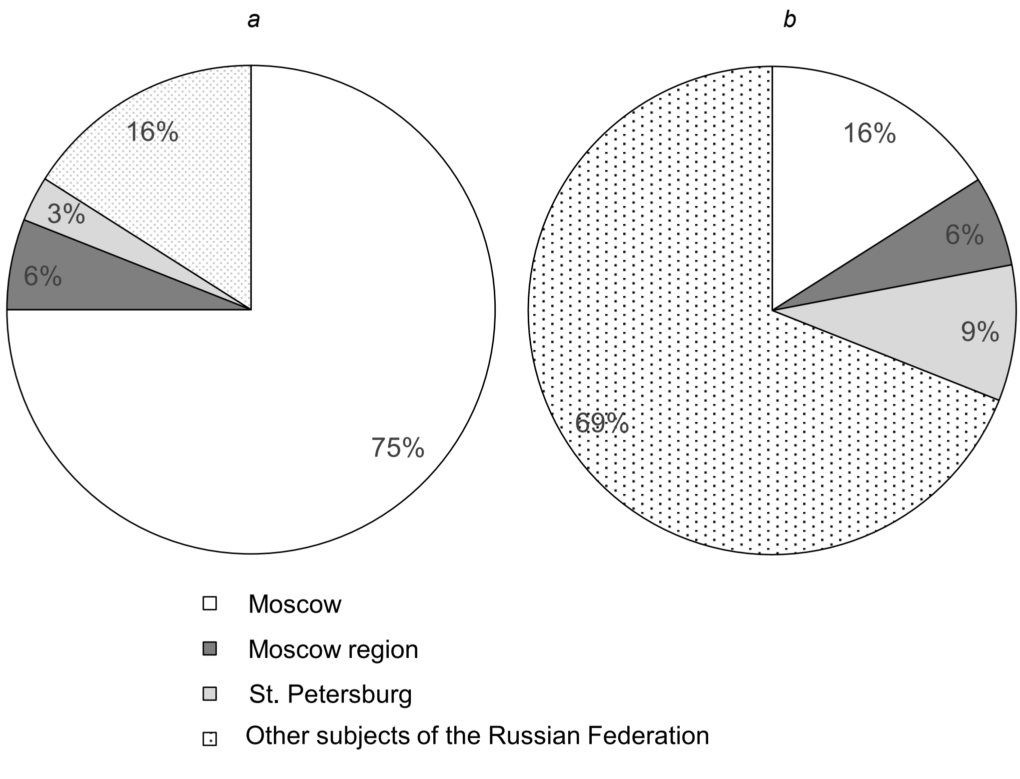

Fig. 2. The proportion of SARS-CoV-2 infection in large megacities (Moscow, Moscow Region, St. Petersburg) among all COVID-19 cases registered in the Russian Federation during the period of SARS-CoV-2 "importation" in 2020 (March, 02, 2020 – March 30, 2020) (*a*) and during the period from March 30, 2020 to April 24, 2022 (*b*).

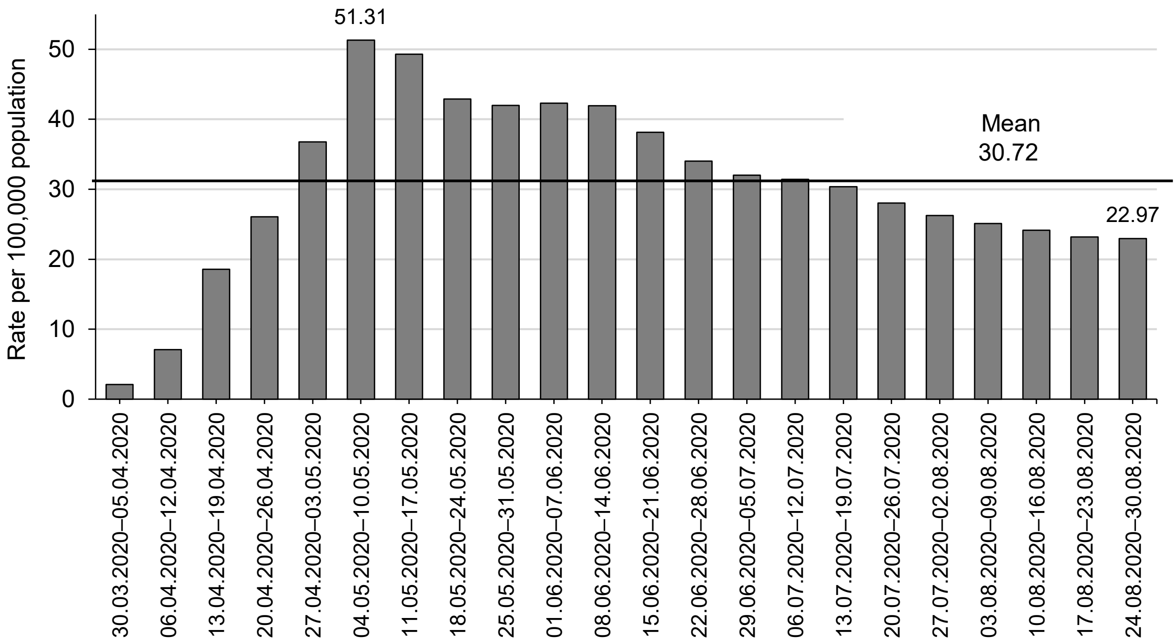

Fig. 3. Dynamics of COVID-19 incidence in the Russian Federation during its I period from March 30, 2020 to August 30, 2020.

(36 calendar weeks) and was caused by the 2nd surge in the COVID-19 incidence in Russia. The incidence rate was 2,661.23 **per** 100,000 population. A total of 3,889,936 cases were recorded. The average rate of COVID-19 incidence in Russia during that period was 73.92 per 100,000 population (**Fig. 4**).

During the 2nd surge in the COVID-19 incidence in Russia, the rate of increase was characterized by high absolute numbers and varied during September-December 2020, ranging from 0.7% to 32.3% (from 35,179 to 201,871 cases weekly). The rate of newly reported cases reached its peak, spiking to 29,935 new cases of infection on 24/12/2020, and was followed by a steep decline, having dropped by 38.7% by 31/1/2021 and by 62.1% by 28/2/2021 compared to the highest rate. The peak of incidence was recorded during 21/12/2020–27/12/2020, reaching 138.11 per 100,000 population. The average incidence rate was 93.0 per 100,000 population.

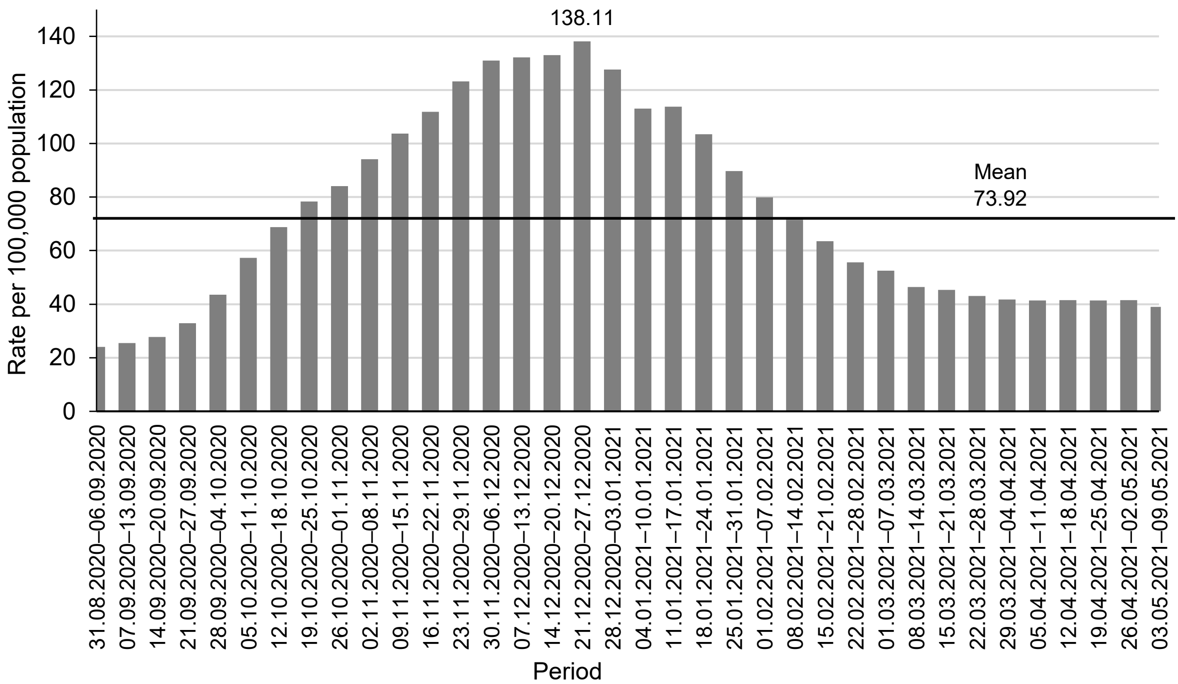

Fig. 4. Dynamics of COVID-19 incidence in the Russian Federation during its II period from August 31, 2020 to May 9, 2021.

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During the 3rd surge (10/5/2021–12/9/2021, 18 calendar weeks), a total of 2,259,808 cases were recorded in Russia with the average COVID-19 incidence rate of 85.89 per 100,000 population (**Fig. 5**).

During that period, the rate of increase was characterized by high numbers and ranged from 1.1% to 31.5% weekly (from 59,983 to 174,800 cases). The peak level of 25,766 new cases of infection was recorded during 12/7/2021–18/7/2021, with 119.59 per 100,000 population. Later, the number of newly reported cases went down, having decreased by 7.6% by 31/7/2021 and by 30.9% by 31/8/2021 compared to the highest level (Fig. 5).

The fourth surge in the incidence lasted from 13/9/2021 to 9/1/2022 (17 calendar weeks); a total of 3,510,779 cases were reported with the average incidence rate being 141.28 per 100,000 population (**Fig. 6**). The rate of increase varied during September 2021, ranging from 3.4% to 15.1% (from 112,883 to 281,305 cases weekly). The peak of incidence was recorded during 1/11/2021–7/11/2021, the incidence rate being 192.45 per 100,000 population and going downward by 21.0% by 30/11/2021 and by 50.1% by 31/12/2021 compared to the highest level.

The 5th surge (10/1/2021–27/3/2022, 11 calendar weeks) brought 5,640,267 cases. The average COVID-19 incidence rate in Russia during that period was 442.31 per 100,000 population (**Fig. 7**).

The above period of the pandemic demonstrated high rates of increase ranging during January–February 2022 from 23.3% to 106.4% (from 15,830 to 203,949 cases daily). The peak of 203,949 new cases of infection was recorded on 11/2/2022. Then, the number of newly reported cases dwindled, having decreased by 16.2% by 20/2/2022 compared to the highest level. The fifth surge was recorded on 3/1/2022, with the incidence peak reached on 7/2/2022–13/2/2022. The highest rate of COVID-19 incidence in Russia during that period was 905.37 per 100,000 population.

The comparative analysis of the epidemic process rates in different regions of Russia showed that the epidemic started escalating in megacities and megaregions before it hit other regions. For example, in Moscow, the increase in the incidence was reported from 30/3/2020 through 5/4/2020 with the peak rates reached during 4/5/2020–10/5/2020 — 325.04 per 100,000 population, while the other RF regions reported the increasing incidence rates during 20/4/2020–26/4/2020 with the highest incidence rates recorded during 8/6/2020–14/6/2020 — 37.75 per 100,000 population (**Fig. 8**). The trend persisted during the next 4 surges in the COVID-19 incidence in Russia (**Table**).

One of the priorities of the epidemiological surveillance over COVID-19 is identification of target groups of population at high risk of infection. The retrospective epidemiological analysis of the data collected at different points of the epidemic during 2020–2022 showed that the gender-age structure of COVID-19 cases was mostly represented by women and men aged 50–64 years (24.2 and 21.8%, respectively) and female and male patients over 65 years (20.8 and 15.7%, respectively). The lowest proportion among the COVID-19 cases was reported for individuals aged 18–29 years (with women accounting for 10.9% and

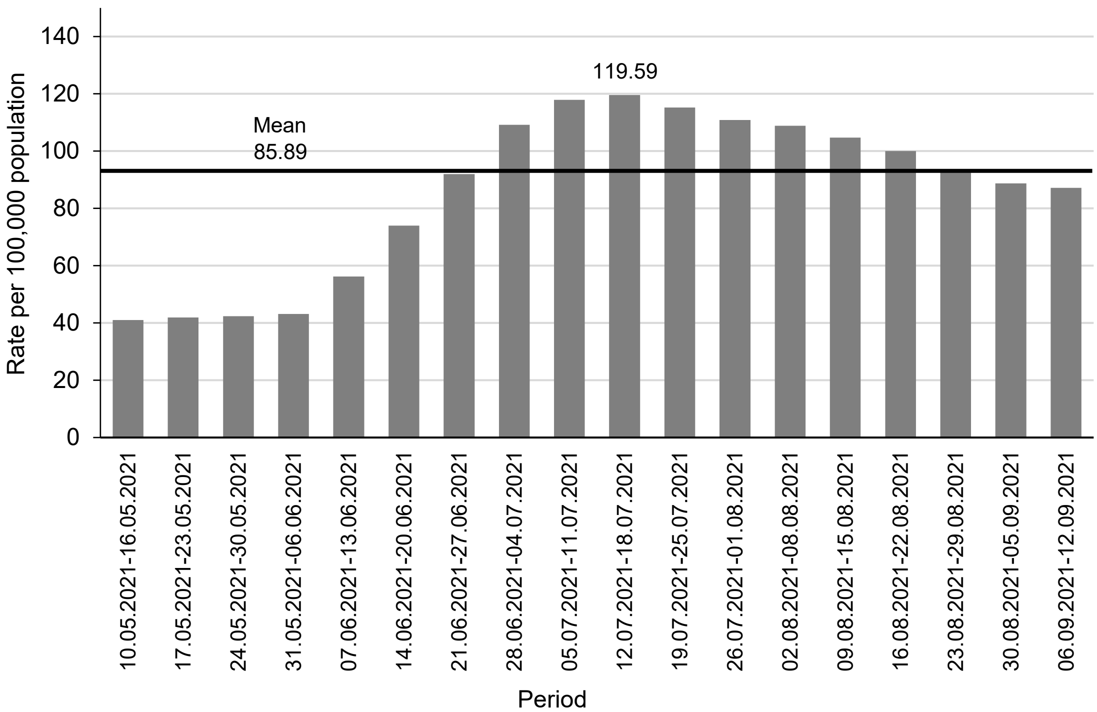

Fig. 5. Dynamics of COVID-19 incidence in the Russian Federation during the third period from May 10, 2021 to September 12, 2021.

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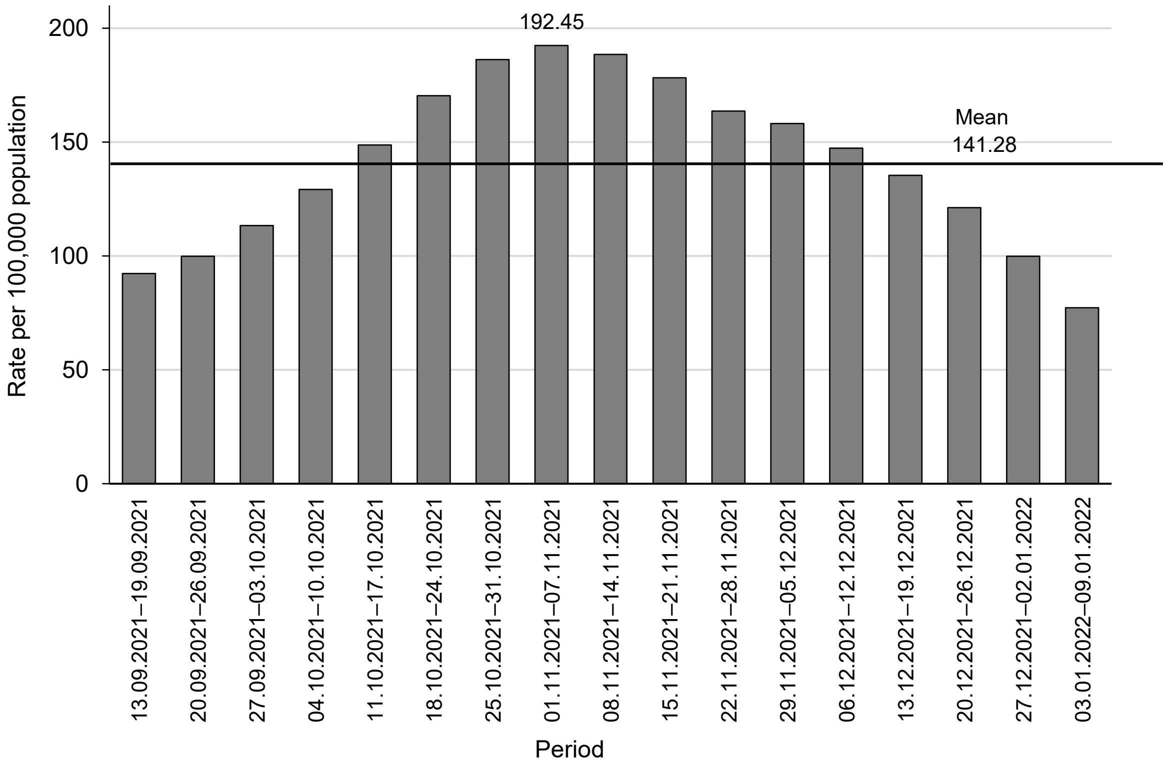

Fig. 6. Dynamics of COVID-19 incidence in the Russian Federation during the fourth period from September 13, 2021 to January 9, 2022.

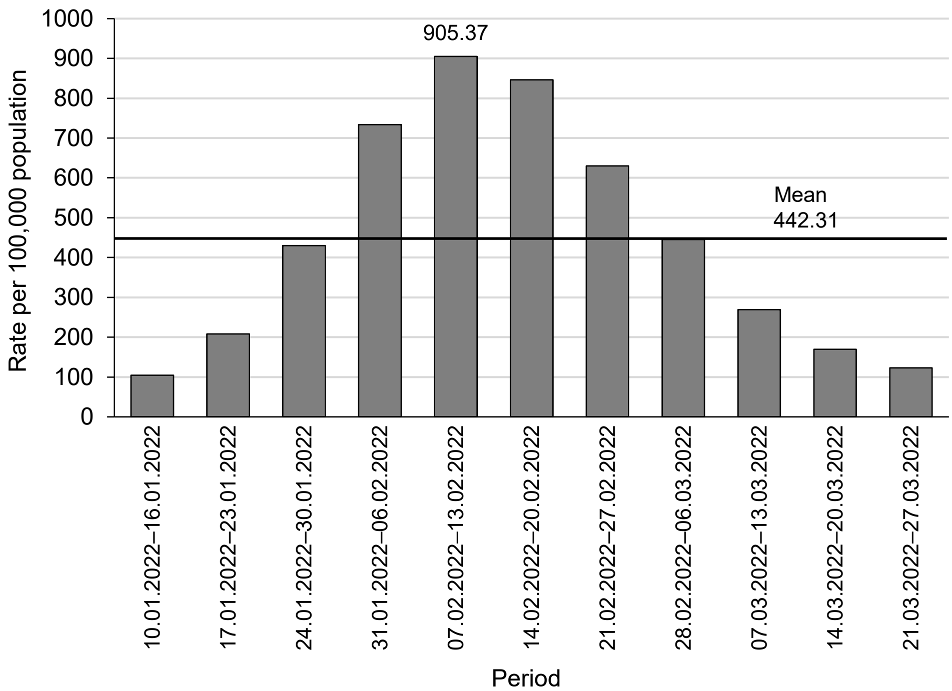

Fig. 7. Dynamics of COVID-19 incidence in the Russian Federation during the V period from January 10, 2022 to March 27, 2022.

men – for 11.9%), which can be explained by the prevalence of asymptomatic cases due to active functioning of the immune system providing effective protection of the host against infectious agents (**Fig. 9**). The above data are consistent with the results obtained by Russian researchers in 2020 and demonstrating that COVID-19 is the disease affecting primarily middle-aged and older adults [24].

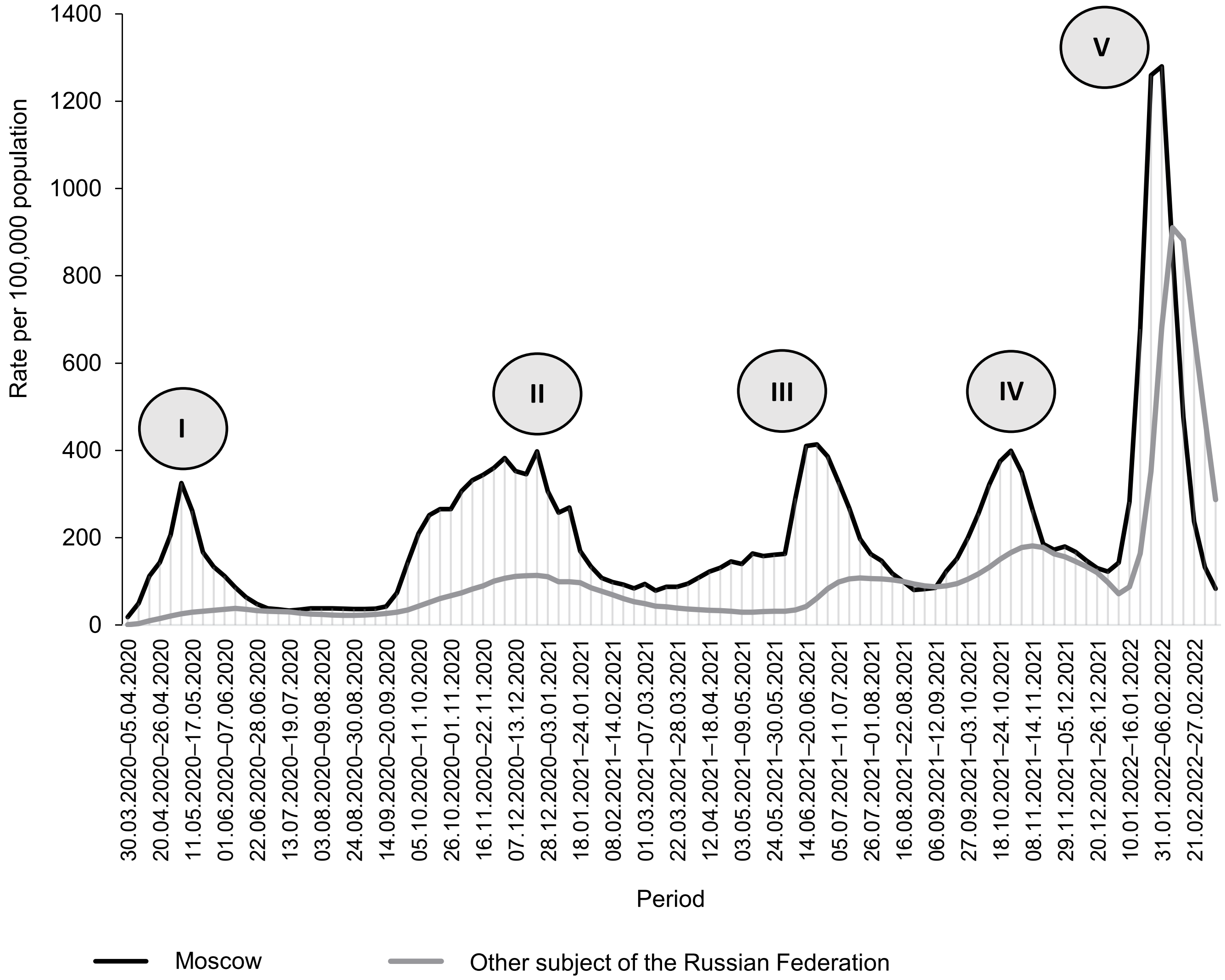

Fig. 8. Comparative dynamics of COVID-19 incidence in Moscow and in the Russian Federation (2020–2022).
I –V — periods of rise (dates see in the Table).

Comparison of COVID-19 incidence rates at the different stages of epidemic in Moscow and other regions of the Russia

Rise	Start date of the increase in incidence **Incidence rate (per 100 thousand population)**		Date of maximum incidence **Maximum incidence rate (per 100 thousand population)**	
	Moscow	regions of the Russian Federation	Moscow	regions of the Russian Federation
I	14th week, 2020 (30.03.2020–05.04.2020) **18,02**	17th week, 2020 (20.04.2020–26.04.2020) **14,93**	19th week, 2020 (04.05.2020–10.05.2020) **325,04**	24th week, 2020 (08.06.2020–14.06.2020) **37,75**
II	37th week, 2020 (07.09.2020–13.09.2020) **37,46**	40th week, 2020 (28.09.2020–04.10.2020) **34,00**	49th week, 2020 (30.11.2020–06.12.2020) **382,05**	52nd week, 2020 (21.12.2020–27.12.2020) **113,52**
III	23rd week, 2021 (07.06.2021–13.06.2021) **290,08**	25th week, 2021 (21.06.2021–27.06.2021) **61,49**	25th week, 2021 (21.06.2021–27.06.2021) **413,80**	29th week, 2021 (19.07.2021–25.07.2021) **107,45**
IV	37th week, 2021 (13.09.2021–19.09.2021) **123,33**	39th week, 2021 (27.09.2021–03.10.2021) **105,14**	43rd week, 2021 (25.10.2021–31.10.2021) **398,75**	45th week, 2021 (08.11.2021–14.11.2021) **181,28**
V	1st week, 2022 (03.01.2022–09.01.2022) **142,28**	3rd week, 2022 (17.01.2022–23.01.2022) **163,89**	5th week, 2022 (31.01.2022–06.02.2022) **398,75**	6th week, 2022 (07.02.2022–13.02.2022) **181,28**

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Although the gender distribution was relatively uniform in different age groups, men prevailed among the COVID-19 patients under 40 years old, while women prevailed among the patients over 40 years old (Fig. 9). Thus, the demographic profiles of COVID-19 patients remained almost unchanged during the pandemic, thus implying a relative stability of the gender-age distribution. This stability makes it possible to identify the target groups of population at high risk of infection as well as monitoring parameters to have sufficient information for making targeted and effective executive decisions.

The proportion of children aged 0–17 years increased from 10% in 2020 to 18% of the total number of cases in 2022 (**Fig. 10**).

The analysis of clinical manifestations of COVID-19 in Russia during the monitoring period (March 30, 2020 – April 24, 2022) showed that mild cases (54.19%; 95% CI, 53.13–55.24) and moderate cases (42.73%; 95% CI, 41.86–43.60) prevailed. The severe cases accounted for 3.08% (95% CI, 2.86–3.30) of the total cases.

The analysis of the COVID-19 incidence in Russia during the surge in the incidence showed that the COVID-19 cases were distributed by their severity as follows: During the first period, mild cases accounted for 47.8%, moderate cases — for 47.7%, severe cases — for 4.5% of the total cases; during the second surge, they accounted for 55.3%, 41.6%, and 3.1%,

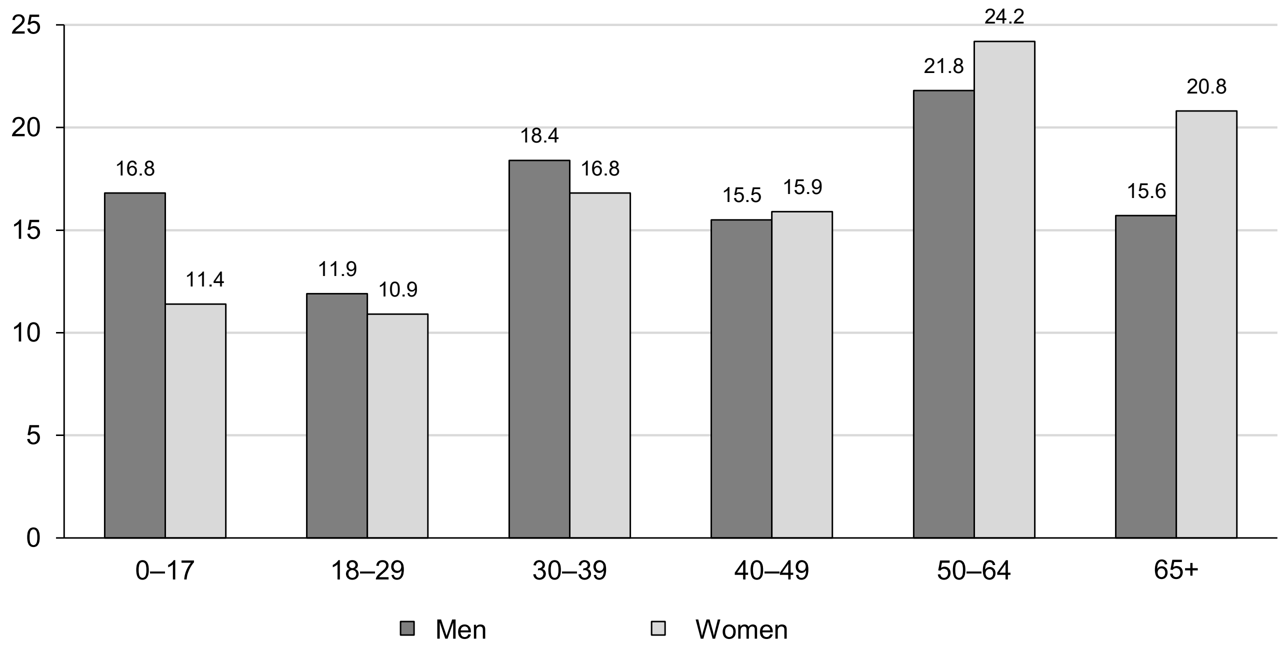

Fig. 9. Age distribution of COVID-19 cases (male and female) in the Russian Federation in 2020–2022.

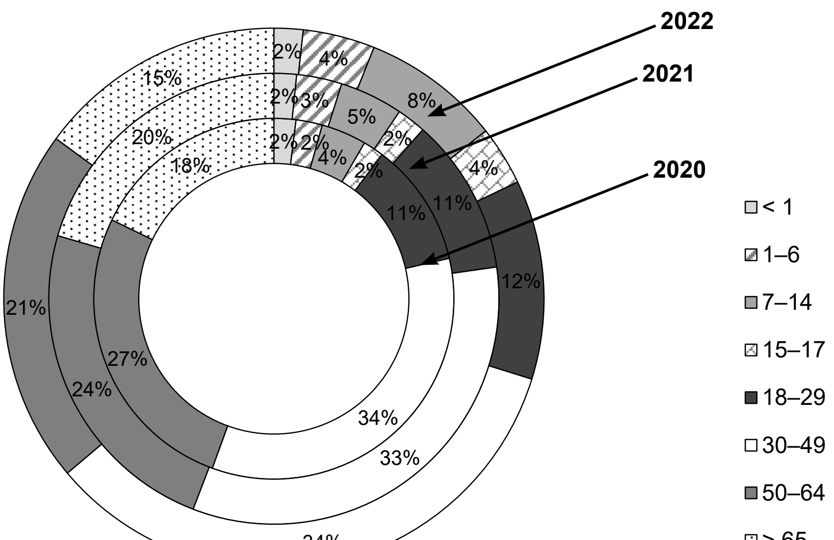

Fig. 10. Age distribution of COVID-19 cases in the Russian Federation in 2020–2022.

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respectively; during the third surge, they accounted for 56.3%, 41.1%, and 2.6%, respectively; during the fourth surge, they accounted for 56.8%, 40.9%, and 2.2%; during the firth surge period, they accounted for 66.6%, 33.0%, and 0.4% of the total cases, respectively (**Fig. 11**).

As can be seen, during five periods of surge in the COVID-19 incidence, the proportion of severe cases of infection was shrinking, and during the first period, they accounted for 4.5% of the total cases of different severity, going gradually down to 3.1%, 2.6%, 2.2%, and 0.4% during the 2nd, 3rd, 4th, and 5th periods, respectively. It can be assumed that this downward trend was caused by the improved treatment practices for COVID-19 patients and by weakening of the pathogenic properties of the virus due to mutation processes.

Among the COVID-19 cases reported in Russia during the studied period (30/3/2020–24/4/2022), the proportion of pneumonia cases among hospitalized patients with diagnosed COVID-19 was 80.68% (95%

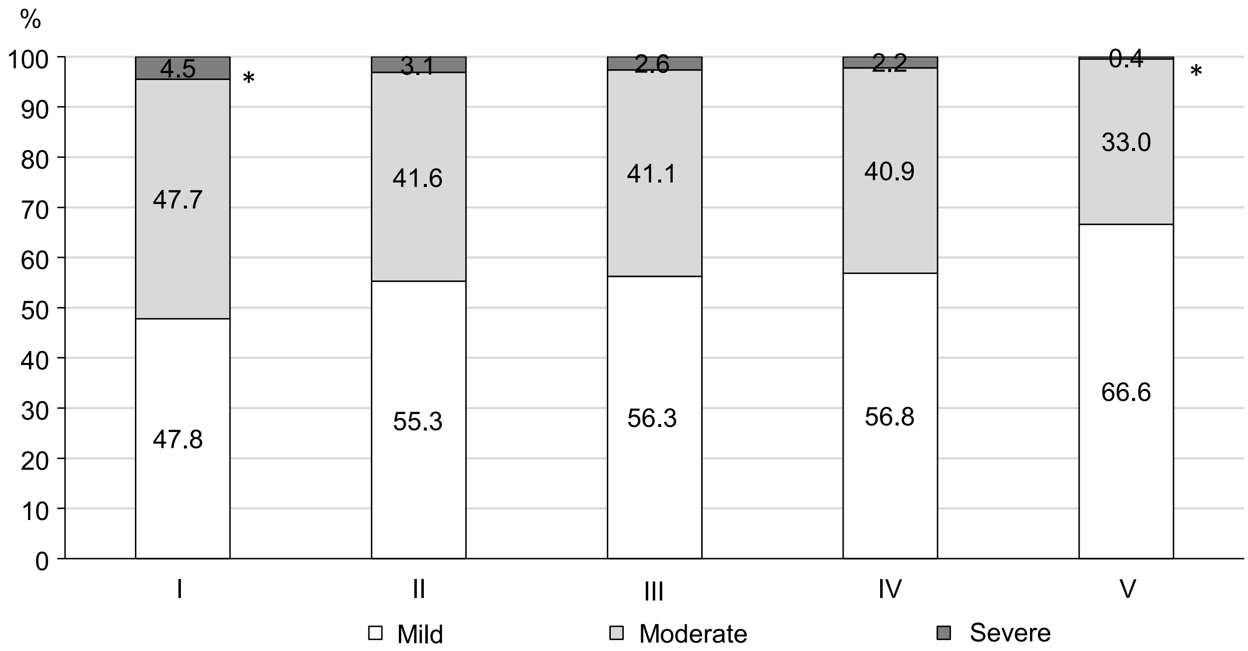

Fig. 11. The distribution of COVID-19 cases by the disease severity in the Russian Federation at the I–V stages of the epidemic. * $p < 0,05$.

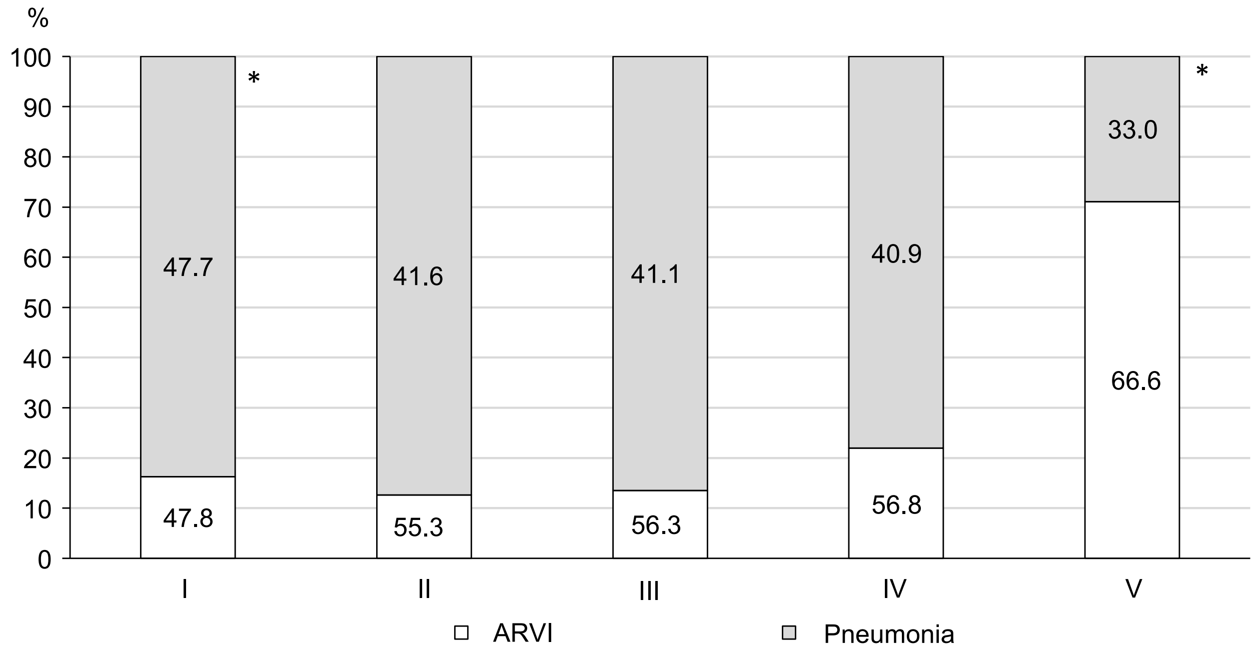

Fig. 12. Distribution of the clinical variants of registered cases of COVID-19 in the Russian Federation during the I–V stages of the epidemic. * $p < 0,05$.

CI, 77.75–83.61), and the proportion of clinical variants of respiratory viral infection was 19.32 (95% CI, 16.39–22.25).

The distribution of COVID-19 clinical forms in Russia by periods of surge in the incidence is shown in **Fig. 12**. As the COVID-19 pandemic kept spreading in Russia, the cases diagnosed with pneumonia were reported 4.5–5.2 times more frequently than the cases diagnosed with acute respiratory viral infection; however, the ratio changed dramatically during the fifth surge in the incidence.

Discussion

The analysis of the features of the COVID-19 epidemic process in Russia during 2020–2022 showed that the process could be broken into two stages.

The first stage (March 2020 – January 2021) is intrinsically connected with the epidemic control and containment measures put in place across the country and incorporating non-specific prevention practices. From the epidemiological perspective, it was characterized by inhomogeneity (heterogeneity) of the interacting pathogen and human populations. During the first stage of the COVID-19 epidemic in Russia, two surges in the incidence were recorded, both driven by social and natural factors.

The second stage (January 2021–the present day) evolved due to changes in the biological properties of SARS-CoV-2 and launching of mass vaccination against COVID-19; during that stage, three surges in the incidence among the population were recorded.

The analysis of the SARS-CoV-2 spread helped identify the pattern of the COVID-19 epidemic process in Russia: The initial rapid surge in the incidence during the virus importation period (2/3/2020–30/3/2020) in megacities and megaregions due to high density of population and social activity, high-density domestic and international traffic flows, poor social distancing and subsequent gradual spread of the epidemic process to other RF regions from west to east.

During the first stage of increasing incidence among the population, from March to May 2020, the timely implemented epidemic control measures incorporating mandatory restriction policies and sanitary-epidemiological measures (the lockdown policies) had a significant impact on the development of the COVID-19 epidemic process in all regions of Russia [17]. As the COVID-19 pandemic was escalating worldwide, the RF Government consistently imposed stringent protective measures: from bans on entry of foreign citizens from the most affected countries to border closures and international air travel bans. A total of 15 orders were issued by the RF Government in January-March 2020 to impose restrictions on travel. Following the Decrees of RF President (No. 206, No. 239, No. 2294), the period of stay-at-home days ended on 12/5/2020.

The imposition of restriction orders and containment measures reduced the activity of the pathogen transmission from the source of infection to a susceptible person. The epidemic control measures prevented an explosive increase in the incidence in Russia and gave time required for providing medical infrastructure for effective professional assistance to affected people.

It should be noted that the time interval, after which the social distancing and self-isolation measures can take effect in megacities and megaregions, is equal to 3.0–3.5 incubation periods with maximum duration of 14 days [22]. During the mandatory self-isolation, the watershed moment in the COVID-19 epidemic in Moscow was reached on 16/5/2020, when the number of new cases dropped dramatically from 4,748 to 3,505, stabilizing at new levels and going further down.

Mandatory containment measures, despite their impact on the intensity of the epidemic process, are limited not only in their scale, but also in their duration. In Russia, the complex of containment measures and stay-at-home orders produced a positive epidemiological effect.

The second stage of the COVID-19 pandemic in Russia (from January 2021 to date) started with changes in the biological properties of SARS-CoV-2, the subsequent swapping of prevailing (alpha, delta, and omicron) genetic variants and the launch of large-scale specific preventive immunization. During the second stage, surges in the COVID-19 incidence (the 3rd through the 5th) took place amid the mass vaccination and, apparently, were linked with the evolution of the virus and development of its epidemic variant (the phasic development of the epidemic process fitting into the theory of self-regulation by academician V.D. Belyakov), along with the natural changes in the immunological structure of the human population in the circulation of the pathogen [25, 26].

The second surge in the COVID-19 incidence was assumedly catalyzed by seasonal factors typical of spikes in incidence of respiratory infections with airborne transmission of the pathogen. The available data can hardly be used for retrospective multi-year analysis of COVID-19 incidence. It can be assumed that the coronavirus is becoming seasonal with annual peaks in the incidence in September-October; however, these data require further research and substantiation.

Conclusion

The analysis of features of the COVID-19 epidemic process and the circulation of SARS-CoV-2 genetic variants in Russia during 2020-2022 helped us identify 2 stages of the pandemic and 5 surges in the COVID-19 incidence, each of them having its specific characteristics. The first stage (March 2020 – January 2021) starts with the new pathogen in the human population, which, with the support of social and natural factors, triggered the COVID-19 epidemic process. During the second stage of the COVID-19 pandemic in Russia (January 2021 – the present day), there were changes in the biological properties of SARS-CoV-2 and the subsequent swapping of prevailing genetic variants, their genetic transformation and the beginning of specific large-scale immunization.

The new genetic variants of SARS-CoV-2 are less pathogenic, but more contagious for humans. It can be seen from the increased incidence rates in the population and the decreased percentage of severe cases of infection.

The study demonstrated a clear trend in development of the COVID-19 epidemic process in Russia, including megacities and megaregions (Moscow, the Moscow Region, and St. Petersburg), which are large commuting hubs and centers of migration activity of the population, and regions connected through transportation flows.

One of the priorities in epidemiological surveillance over COVID-19 is identification of target groups of population at high risk of infection. The epidemiological analysis shows that risk increases for people aged 50–64 years. The proportion of children aged 0–17 is gradually increasing in the total affected population in 2022, thus suggesting that the pathogen has adapted to the new vulnerable group of population.

The analysis of COVID-19 incidence rates, monitoring of biological, natural, and social factors, identification of high-risk groups and regions are essential for mapping out further routes and focus areas of epidemiological surveillance, which lies at the core of planning and implementation of preventive and epidemic control measures.

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