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Assessment of the COVID-19 epidemiological situation in St. Petersburg

Vasily G. Akimkin[1], Stanislav N. Kuzin[1✉], Elena N. Kolosovskaya[1], Elena N. Kudryavtceva[1], Tatyana A. Semenenko[2], Antonina A. Ploskireva[1], Dmitry V. Dubodelov[1], Elena V. Tivanova[1], Natalia Yu. Pshenichnaya[1], Anna V. Kalenskaya[1], Svetlana B. Yatcishina[1], Olga Yu. Shipulina[1], Elena N. Rodionova[1], Natalia S. Petrova[1], Irina V. Solov'eva[1], Olga A. Kvasova[1], Marina A. Vershinina[1], Marina V. Mamoshina[1], Vitalina V. Klushkina[1], Marina I. Korabel'nikova[1], Nadezhda S. Churilova[1], Yarina V. Panasyuk[1], Natalia V. Vlasenko[1], Alexey A. Ostroushko[1], Evgeniy S. Balmasov[1], Artem V. Mosunov[1]

[1]Central Research Institute for Epidemiology, Moscow, Russia;
[2]National Research Centre for Epidemiology and Microbiology named after the honorary academician N.F. Gamaleya, Moscow, Russia

Abstract

Aim. Identification of epidemiological patterns of the SARS-CoV-2 spread among the population of St. Petersburg during the one-year COVID-19 pandemic period.

Materials and methods. The performed analysis focused on the dynamics of COVID-19 cases in St. Petersburg from 2/3/2020 to 4/4/2021 and on the gender-age profile of patients. The information about patients (age, gender, type of the disease, hospitalization, social, and occupational status) was obtained from the database containing the materials from statistical data form No. 058/u.

Results. After one year, the dynamics of reported cases of COVID-19 in St. Petersburg shows two cycles of seasonal surge (spring and autumn-winter) and 8 epidemic periods. It has been found that there are no gender-age differences among COVID-19 patients, which can be seen from the relatively similar number of cases among men and women per 100,000 people in each age group during specific epidemic periods. The strong association between clinical manifestations of COVID-19 and the patients' age was detected: Severe cases were more frequently diagnosed in patients over 70 years, regardless of their gender identity. Based on the social and occupational status, the people who were most exposed to the COVID-19 epidemic process were retirees and people whose occupation was associated with health and safety of St. Petersburg. Among the COVID-19 patients, retirees accounted for 13.69% (men) and 17.67% (women). The proportion of healthcare workers was 3.67% (men) and 9.41% (women).

Conclusion. It has been assumed that COVID-19 tends to be a seasonal disease featuring annual autumn-winter epidemic cycles. The study addressed prospects of preventive vaccination against COVID-19 in Russia and the importance of tracking the complications pathogenetically associated with the acute phase of the disease in the system of epidemiological surveillance.

Keywords: *COVID-19, SARS-CoV-2, incidence, epidemic process, epidemiological patterns, gender-age proportion, St. Petersburg*

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Характеристика эпидемиологической ситуации по COVID-19 в Санкт-Петербурге

Акимкин В.Г.[1], Кузин С.Н.[1]✉, Колосовская Е.Н.[1], Кудрявцева Е.Н.[1], Семененко Т.А.[2], Плоскирева А.А.[1], Дубоделов Д.В.[1], Тиванова Е.В.[1], Пшеничная Н.Ю.[1], Каленская А.В.[1], Яцышина С.Б.[1], Шипулина О.Ю.[1], Родионова Е.Н.[1], Петрова Н.С.[1], Соловьева И.В.[1], Квасова О.А.[1], Вершинина М.А.[1], Мамошина М.В.[1], Клушкина В.В.[1], Корабельникова М.И.[1], Чурилова Н.С.[1], Панасюк Я.В.[1], Власенко Н.В.[1], Остроушко А.А.[1], Балмасов Е.С.[1], Мосунов А.В.[1]

[1]Центральный научно-исследовательский институт эпидемиологии Роспотребнадзора, Москва, Россия;
[2]Национальный исследовательский центр эпидемиологии и микробиологии имени почётного академика Н.Ф. Гамалеи, Москва, Россия

Аннотация
Цель. Определить эпидемиологические закономерности распространения SARS-CoV-2 среди населения Санкт-Петербурга за годовой период пандемии COVID-19.
Материалы и методы. Проведён анализ динамики случаев заболеваний COVID-19 в Санкт-Петербурге в период с 02.03.2020 по 04.04.2021 и гендерно-возрастной характеристики пациентов. Информация о пациентах (возраст, пол, форма заболевания, госпитализация, социально-профессиональная принадлежность) извлечена из базы данных, сформированной на основе материалов формы статистического учёта № 058/у.
Результаты. По прошествии года в динамике выявления случаев COVID-19 в Санкт-Петербурге можно выделить два цикла сезонного подъёма заболеваемости (весенний и осенне-зимний) и 8 периодов эпидемии. Установлено, что в структуре заболевших COVD-19 отсутствует гендерно-возрастная избирательность, о чём свидетельствуют относительно равномерные показатели заболеваемости мужчин и женщин на 100 тыс. населения в каждой возрастной группе в отдельные периоды эпидемии. Отчётливо выражена зависимость клинических проявлений COVID-19 от возраста пациентов: тяжёлые формы заболевания чаще диагностированы у пациентов старше 70 лет независимо от гендерной принадлежности. Наиболее вовлечёнными в эпидемический процесс COVID-19 по социально-профессиональному статусу были пенсионеры и лица, связанные по роду деятельности с обеспечением жизнедеятельности Санкт-Петербурга. Удельный вес пенсионеров среди заболевших COVID-19 составил 13,69% (мужчины) и 17,67% (женщины). Доля медицинских работников составила 3,67% (мужчины) и 9,41% (женщины).
Заключение. Высказано предположение, что COVID-19 формируется как сезонное заболевание с ежегодными осенне-зимними эпидемическими циклами. Обсуждаются перспективы вакцинопрофилактики COVID-19 в России и необходимость учёта в системе эпидемиологического надзора за COVID-19 случаев осложнений, патогенетически связанных с острой фазой заболевания

Ключевые слова: *COVID-19, SARS-CoV-2, заболеваемость, эпидемический процесс, эпидемиологические закономерности, гендерно-возрастная пропорция, Санкт-Петербург*

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 COVID-19 pandemic caused by the betacoronavirus formally named as SARS-CoV-2 remains a serious challenge in the 21st century, giving rise to numerous problems. As of April 4, 2021, more than 131 million COVID-19 cases had been reported worldwide, including 2.84 million deaths. In European countries, the seasonal surge of COVID-19, which is also known as "the second wave", was quite strong and prompted most governments to toughen the epidemic control measures or even to close the borders. The seasonal surge is characterized not only by high intensity, but

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also by new variants of SARS-CoV-2 detected in patients in many countries. During early 2021, the genetic variant of SARS-CoV2 known as the UK variant came under notice of specialists. It differs from the wild-type virus by 2 nucleotide substitutions and 2 nucleotide deletions: N501Y, A570D, del HV 69-70, del Y144 [1–4]. Furthermore, the spread of another variant of SARS-CoV-2 gene mutations has been reported in Europe; the variant, known as South African [5–8], is able, according to some researchers, to evade the immune responses triggered by the existing vaccines.

Amidst the challenging epidemiological situation, since early 2021, many countries, including Russia, have started vaccinating their population against COVID-19 to establish herd immunity against SARS-CoV-2. At the same time, further studies in the COVID-19 epidemic process and its specific features still require special attention to pinpoint the underlying principles of the epidemiological surveillance of the disease and to develop measures, which can temper the intensity of the SARS-CoV-2 spread.

The general characteristics of the COVID-19 epidemic process in Russia have been identified. During the early stage of the epidemic (late February – early March 2020), SARS-CoV-2 penetrated the country through its main transportation hubs — Moscow and St. Petersburg. By that time the COVID-19 epidemic had reached high intensity levels in European countries, though it had not hit Russia yet. Coming back from business and holiday trips, infected people acted as a trigger of the COVID-19 epidemic process, first of all, in Moscow and St. Petersburg. The studies of the SARS-CoV-2 spread at the beginning of the epidemic in Moscow revealed some of the general patterns: The virus has no gender-age selectivity and can infect people of any age and gender; the most severe forms of the disease are observed in people over 70 years; a significant number of people with COVID-19 remain asymptomatic [9, 10].

The seasonal upswing of COVID-19 started in Russia at the end of September in 2020, being more massive and long-lasting than the spring surge. Its main distinction was that the COVID-19 epidemic process affected different regions in Russia, while in spring, most of the COVID-19 cases were recorded in Moscow. Special attention should be given to the analysis of epidemiological patterns of the SARS-CoV-2 spread in St. Petersburg, the second largest city in Russia.

The **purpose** of the work is to study patterns of the SARS-CoV-2 spread and epidemiological characteristics of the COVID-19 pandemic in St. Petersburg during the 2/3/2020-4/4/2021 period.

Materials and methods

The study was performed at the Central Research Institute of Epidemiology of the Russian Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing. The COVID-19 incidence in St. Petersburg from 2/3/2020 to 4/4/2021 was analyzed. The information about patients (age, gender, type of the disease) was obtained from the database containing the materials from statistical data form No. 058/u "The special announcement about an infectious, parasitic, and any other disease, occupational poisoning, any adverse response associated with immunization, an impact of living mechanical forces". The above materials were used to study the main features of the COVID-19 epidemic process, including the incidence dynamics, gender ratios and age distribution of the patients, proportion of the hospitalized patients, proportions of different types of infection, social and occupational status of patients.

The materials for the analysis of the age-gender distribution of the population were obtained using the Data Marts of the Federal State Statistics Service. The study included patients with COVID-19, who were divided into the following groups: aged 0–18 years (*n* = 30,928; men/women 15,821/15,107), aged 19–29 years (*n* = 39,405; men/women 17,337/22,068), aged 30–49 years (*n* = 116,674; men/women 51,631/65,043), aged 50–69 years (*n* = 87,579; men/women 33,958/53,621), aged 70–79 years (*n* = 18,501; men/women 6,967/11,534), aged 80 years and older (*n* = 12,014; men/women 3,714/8,300).

The proportions of the hospitalized and non-hospitalized patients with COVID-19 during different pandemic periods and in different age groups were estimated in the patient cohort (*n* = 307,104; men/women 130,262/176,842).

The statistical processing was performed with standard descriptive statistics tools - Microsoft Excel and Statistica 12.0 (StatSoft). The mean values were based on the 95% confidence interval (95% CI) calculated with the Clopper-Pearson (exact) method.

Results

The dynamics of reported new cases of COVID-19 in St. Petersburg during the 2/3/2020-4/4/2021 period is shown in **Fig. 1**.

The curve of new COVID-19 cases demonstrates several periods in the evolution of the epidemic in St. Petersburg.

During the first period (2/3-31/3/2020), which can be characterized as the "importation" period, cases of novel coronavirus infection were generally detected among people coming from other countries and their contacts. The general population remained unexposed to SARS-CoV-2; only isolated and unrelated cases of COVID-19 were recorded. Within 30 days during that period, only 98 cases were detected in St. Petersburg.

From 1/4/2020, the number of new cases of COVID-19 started steadily increasing, implying the beginning of the epidemic process in St. Petersburg. The epidemic growth continued for 45 days

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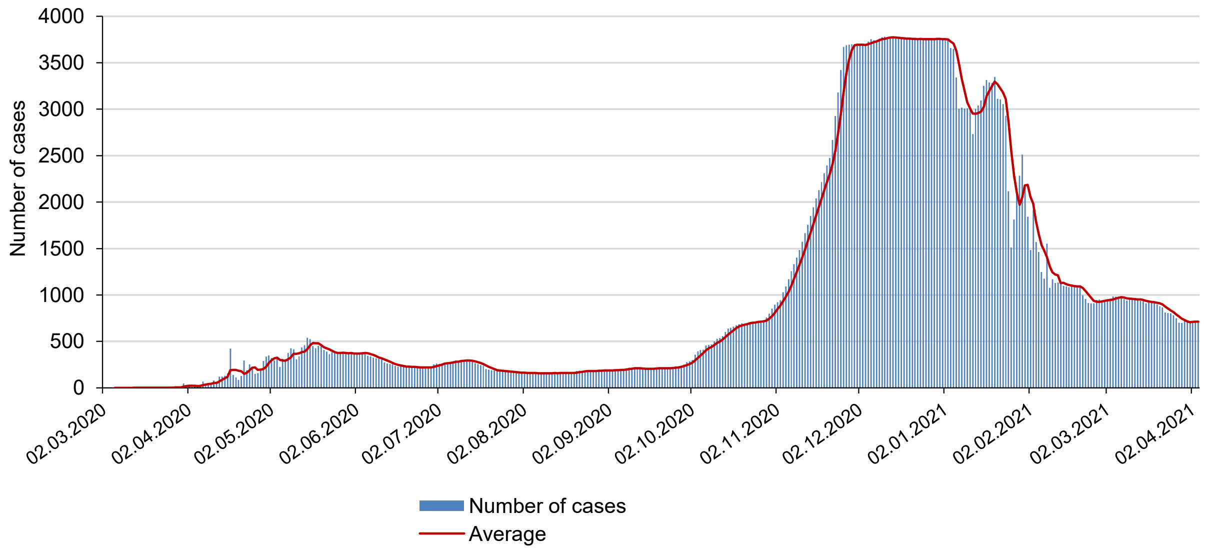

Fig. 1. The dynamics of reported new cases (abs.) among the population of St. Petersburg.

(1/4/2020-16/5/2020) and was characterized by a moderate increase in the number of new cases per day (+4.6%). During that period, the number of detected cases of COVID-19 in St. Petersburg increased from 27 (1/4/2020) to 525 (16/5/2020). Note that there was no stabilization at the highest numbers of new COVID-19 cases during that period, and the next day was marked by a gradual decrease in the number of cases, i.e. the period of growth gave way to a long period of a slow decrease followed by stabilization at minimum numbers. During the period of decline, which lasted for 76 days (from 17/5/2020 to 31/7/2020), the daily number of new COVID-19 cases went down to 159. The dynamics of COVID-19 cases was characterized by a downward turn at a daily rate of 1.1%. Over the growth and decline periods, the average number of COVID-19 cases, not including the "importation" period, was 255 cases per day.

The period of the epidemic slowdown (from 1/8/2020 to 27/9/2020) lasted for 57 days, during which the maximum number of COVID-19 cases reported daily ranged from 155 (8/8/2020) to 232 (26/9/2020). The epidemiological situation during that period remained stable (the growth rate was +0.7% per day). The average number of daily reported cases of COVID-19 was 189.4.

Starting from 28/9/2020, the seasonal factors and the end of holiday season aggravated the COVID-19 epidemiological situation in St. Petersburg. The seasonal upswing in COVID-19 incidence lasted for 62 days till 29/11/2020. During that period, the minimum/maximum number of COVID-19 cases was 227/3,701 (27/9/2020)/(29/11/2020). Based on the growth rates recorded for COVID-19 cases during the seasonal surge, 2 intervals can be singled out: from 28/9/2020 to 3/11/2020 and from 4/11/2020 to 29/11/2020. During the first interval, the growth rate of cases was +3.0% a day; during the second interval — +4.8%. Considering the high base effect, such rates of growth of COVID-19 cases should be seen as quite significant.

During the next pandemic period (30/11/2020–5/1/2021), which can be defined as a period of epidemic maximum (the plateau), the number of daily detected COVID-19 cases remained stable (the growth rate of +0.018% per day), ranging from 3,649 to 3,779 cases per day.

From 6/1/2021 to 8/2/2021, the number of daily detected cases of COVID-19 went down at a moderate rate of 2.8% per day. The period included 2 short-term intervals (16/1/2021–20/1/2021 and 27/1/2021–31/1/2021) characterized by an increase in the number of reported cases of COVID-19.

The final period (9/2/2021–4/4/2021) referred to as the period of epidemic stability was characterized by steady numbers of daily detected new cases of COVID-19, ranging from 697 to 1,169 at a growth rate of +0.78% per day. During that period, the average number of COVID-19 cases per day was 1,001.7.

Over the entire observation period, the overall gender proportion of COVID-19 patients in St. Petersburg is characterized by overrepresentation of women (57.6%), which, in our opinion, has a strong association with the present-day structure of the population of St. Petersburg. It also predetermined the men/women ratio among the COVID-19 patients in different age groups in St. Petersburg (**Fig. 2**).

The gender-age distribution of COVID-19 cases in St. Petersburg shows a markedly high proportion of patients aged 30–49 and 50–69 years. For example, in the cohort of men with COVID-19, patients of these age groups accounted for 39.89% (95% CI; 39.63–40.16) and 26.24% (95% CI; 26.00–26.48); in the cohort of women with COVID-19, they accounted for 37.03% (95% CI; 36.80–37.25) and 30.52% (95% CI; 30.31–30.74). The other age groups of patients with COVID-19 were much less represented. The children who were under 18 years and had COVID-19 accounted for 12.22% (95% CI; 12.05–12.40) of boys and 8.60% (95% CI; 8.47–8.73) of girls. The patients aged 70–79 and over 80 years were least represented in the cohort of patients. In the cohort of men with COVID-19, the patients belonging to these age groups accounted for 5.38% (95% CI; 5.26–5.51) and 2.87% (95% CI; 2.78–2.96); in the cohort of women, they accounted for 6.57% (95% CI; 6.45–6.68) and 4.72% (95% CI; 4.63–4.82). Note that among COVID-19 patients aged under 50 years, the proportion of men was slightly higher in each age group, while women prevailed among the patients aged over 50 years.

The COVID-19 case rates calculated as cases per 100,000 people differed significantly in each age group. The patterns typical of the cohorts of men and women with COVID-19 are presented in **Table 1**.

As can be seen from Table 1, among men, the COVID-19 incidence ratestend to increase from younger to older age groups, demonstrating a slight decrease in groups of patients aged 70–79 and over 80 years.

The lowest case rate is recorded for children in the age group under 18 years — 3,109.6$^{0}/_{0000}$. Note the wide spread of the case rates among children, depending on their age — from 1,475.6$^{0}/_{0000}$ (2 years) to 6,684.8$^{0}/_{0000}$ (17 years). The highest case rate among men was demonstrated by the age groups of patients aged 30-49 and 50–69 years, reaching 5,979.1 and 6,071.8$^{0}/_{0000}$, respectively. The highest COVID-19 case rates were demonstrated by men aged 29, 60 and 71 years — 7,401.6, 7,053.8, and 8,008.6$^{0}/_{0000}$, respectively.

The pattern of age distribution of COVID-19 cases in the cohort of women correlated with the above tendency; however, the highest COVID-19 case rate was recorded in the 30–49-year-old age group — 7,137.7$^{0}/_{0000}$. The case rates among women aged 70–79 and over 80 years were slightly lower than among men, totaling 4,804.3 and 4,285.0$^{0}/_{0000}$, respectively. Unlike men, women aged 29 and 59 years demonstrated the highest COVID-19 case rates — 9,507.6 and 7,911.5$^{0}/_{0000}$, respectively.

Proportions of different types of COVID-19 and their ratios were among the main parameters used for assessment of the severity of the epidemiological situation. During all the epidemic periods, asymptomatic and mild COVID-19 cases prevailed both among men and women. During the entire observation period (exclusive of the "importation" period), they accounted for 83.77% (95% CI; 83.51–84.02) among men and for 83.95% (95% CI; 83.72–84.16) among women. Mild COVID-19 cases prevailed both among men and among women, accounting for 66.26% (95% CI; 65.93–66.58) and 68.66% (95% CI; 68.39–68.93) of the total number of cases, respectively.

The maximum values for the combined proportions of asymptomatic and mild COVID-19 cases were recorded during the period of epidemiological maximum (30/11/2020–5/1/2021): among men — 86.64% (95% CI; 86.35–86.93), among women — 88.08% (87.84–88.31). During the other periods, the combined proportion of these cases was slightly lower. The lowest proportion was recorded during the period of decline (17/5–31/7/2020): 55.29% (95% CI; 56.60–59.30) — among men and 55.29% (95% CI; 53.80–56.77) — among women. Note that mild cases generally prevailed among St. Petersburg patients with COVID-19, regardless of their gender identity.

Table 2 presents the data on the COVID-19 structure by the severity of the disease and by the proportion of hospitalized patients during different epidemic periods in St. Petersburg.

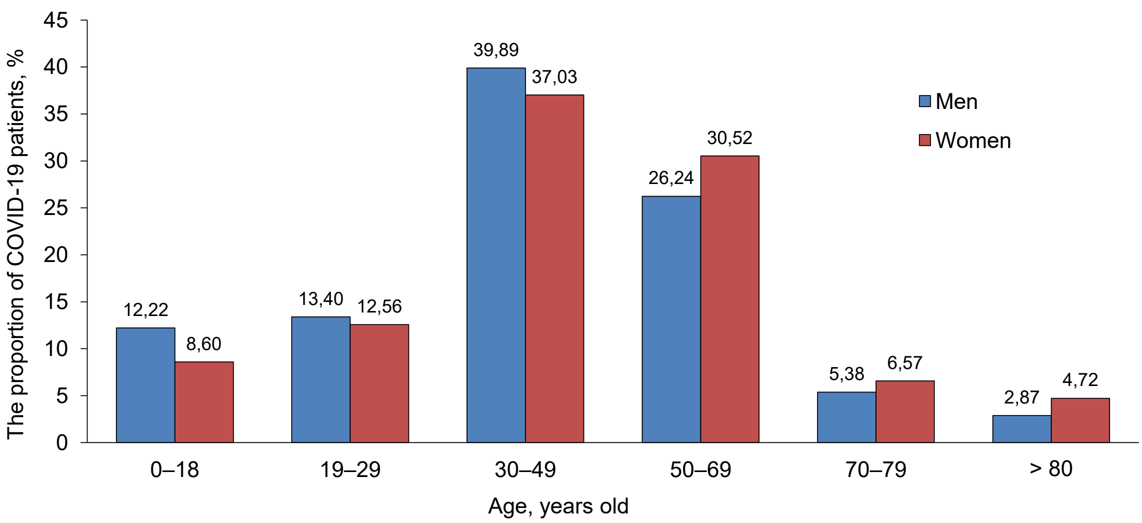

Рис. 2. Возрастная структура заболевших (мужчин и женщин) в период эпидемии COVID-19 в г. Санкт-Петербурге.

Fig. 2. The age distribution (men and women) during the COVID-19 epidemic in St. Petersburg.

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Table 1. COVID-19 incidence in different age groups of population (men/women) in St. Petersburg (cases per 100,000 people of the age group, $^{0}/_{0000}$)

Age, years	Incidence in age groups	Minimum rate		Maximum rate		Standard deviation
		$^{0}/_{0000}$	age, years old	$^{0}/_{0000}$	age, years old	
Men						
0–18	3109,6	1475,6	2	6684,8	17	1703,4
19–29	5385,3	3686,6	19	7401,6	29	1282,7
30–49	5979,1	5016,6	49	6585,8	33	381,6
50–69	6071,8	5252,8	69	7053,8	60	369,5
70–79	5813,4	3620,8	77	8008,6	71	1418,9
> 80	5330,2	219,5	≥ 100	6851,9	82	1796,4
Women						
0–18	3126,4	1246,6	3	6711,5	17	1830,6
19–29	6655,7	4111,6	19	9507,6	29	1777,8
30–49	7137,7	5788,4	47	7762,6	33	513,0
50–69	6742,9	5372,9	69	7911,5	59	754,3
70–79	4804,3	2992,5	77	6268,9	71	1074,8
> 80	4285,0	430,4	≥ 100	6194,4	81	1260,0

Note that while the epidemic was evolving in St. Petersburg, the proportion of mild COVID-19 cases, both among men and among women, tended to increase. During the epidemic upswing (1/4/2020–16/5/2020), the mild COVID-19 cases accounted for 39.08% (95% CI; 37.92–40.25) of men and 46.06% (95% CI; 44.89–47.27) of women. At the peak of the seasonal surge (30/11/2020–5/1/2021), the proportion of such patients increased significantly, reaching 71.36% (70.97–71.75) of men and 73.92% (73.61–74.24) of women. During the two final periods (decline and epidemic stability), the proportion of mild COVID-19 cases continued to increase, reaching 73.60% (73.06–74.14) and 73.24% (72.37–74.09) among men, and 76.26% (75.82–76.70) and 75.29% (74.59–75.98) among women, respectively.

During different epidemic periods, the proportions of severe cases differed significantly; at the beginning of the epidemic, severe COVID-19 cases were reported significantly more frequently. The highest proportion of severe cases was observed during the periods of epidemic decline (17/5/2020–31/7/2020) and slowdown (1/8/2020–27/9/2020), reaching 16.28% (15.20–17.41) and 15.17% (13.84–16.57) among men and 13.72% (12.79–14.68) and 13.85% (12.74–15.03) among women, respectively. During the periods of epidemic maximum, decline and stability, the proportion of severe COVID-19 cases decreased significantly, reaching 0.03–1.27% among men and 0.03–0.86% among women.

The changes are well seen in the proportions of hospitalized patients with COVID-19 during different stages of the epidemic, being primarily associated with the adaptation of St. Petersburg's health service to the new working conditions during the pandemic. At the beginning of the COVID-19 epidemic, with lacking experience of treatment of such patients and high media pressure, the maximum possible number of patients was hospitalized: among men, the hospitalized patients accounted for 87.11% (95% CI; 82.67–90.76) and among women, such patients accounted for 83.84% (95% CI; 79.15–87.84). At the very beginning of the epidemic, the RF Government adopted the strategy of combating the novel disease, giving the priority to the maximum possible protection of people's health and to minimization of the fatal outcomes. The intensive research conducted worldwide and in Russia made it possible to optimize the disease management for patients with COVID-19, to substantiate the possibility and advisability of medically supervised, at-home treatment of patients with mild and moderate COVID-19. As a result, during the seasonal surge (28/9/2020–29/11/2020) and epidemic maximum (30/11/2020–5/1/2021), the proportion of hospitalized patients decreased significantly. During the above periods, hospitalized patients accounted for 9.85% (9.52–10.18) and 13.50% (12.56–14.49) among men and 9.09% (8.81–9.36) and 13.15% (12.30–14.03) among women of all detected cases of COVID-19.

The analysis of the proportions of COVID-19 cases of different severity in the age groups showed that patients over 70 years, regardless of their gender identity, suffer from moderate and severe COVID-19 much more frequently than younger patients (**Table 3**).

In the 0–18 and 19–29 year old age groups, severe COVID-19 cases were detected at the lowest rate — 0.01% (0.00–0.06) and 0.14% (0.08–0.23) among

Table 2. The COVID-19 breakdown by the severity of the disease and the proportion of hospitalized patients during different epidemic periods in St. Petersburg (%)

Epidemic periods		Severity of COVID-19				Proportion of hospitalized patients
		asymptomatic form	mild form	moderate form	severe form	
Men						
"Importation" period	02.03.2020–30.03.2020	5,23% (2,95–8,47)	25,09% (20,18–30,52)	53,66% (47,70–59,54)	16,03% (11,98–20,79)	87,11% (82,67–90,76)
Period of epidemic upswing	01.04.2020–16.05.2020	33,63% (32,51–34,76)	39,08% (37,92–40,25)	21,51% (20,54–22,50)	5,78% (5,24–6,36)	29,21% (28,15–30,29)
Period of epidemic decline	17.05.2020–31.07.2020	7,41% (6,65–8,22)	47,88% (46,39–49,37)	28,43% (27,10–29,80)	16,28% (15,20–17,41)	45,39% (43,97–46,82)
Epidemic slowdown	01.08.2020–27.09.2020	20,10% (18,61–21,66)	50,29% (48,40–52,19)	14,43% (13,13–15,81)	15,17% (13,84–16,57)	27,40% (26,19–28,64)
Seasonal surge	28.09.2020–29.11.2020	19,24% (18,48–20,01)	60,22% (59,27–61,17)	17,82% (17,08–18,57)	2,72% (2,41–3,05)	9,85% (9,52–10,18)
Epidemic maximum	30.11.2020–05.01.2021	15,28% (14,98–15,59)	71,36% (70,97–71,75)	12,90% (12,61–13,19)	0,46% (0,41–0,53)	13,50% (12,56–14,49))
Period of decline	06.01.2021–08.02.2021	12,65% (12,24–13,06)	73,60% (73,06–74,14)	12,48% (12,07–12,89)	1,27% (1,14–1,42)	6,83% (6,22–7,48)
Period of epidemic stability	09.02.2020–04.04.2021	12,10% (11,48–12,74)	73,24% (72,37–74,09)	14,63% (13,96–15,33)	0,03% (0,01–0,08)	10,54% (8,56–12,79)
Women						
"Importation" period	02.03.2020–30.03.2020	13,47% (9,80–17,89)	24,92% (20,10–30,24)	48,82% (43,00–54,66)	12,79% (9,22–17,14)	83,84% (79,15–87,84)
Period of epidemic upswing	01.04.2020–16.05.2020	22,66% (21,67–23,69)	46,06% (44,86–47,27)	25,51% (24,47–26,57)	5,76% (5,22–6,35)	32,24% (31,14–33,35)
Period of epidemic decline	17.05.2020–31.07.2020	7,92% (7,20–8,69)	49,65% (48,28–51,01)	28,72% (27,49–29,97)	13,72% (12,79–14,68)	42,84% (41,56–44,13)
Epidemic slowdown	01.08.2020–27.09.2020	21,01% (19,69–22,38)	50,67% (49,02–52,32)	14,46% (13,33–15,66)	13,85% (12,74–15,03)	24,17% (23,18–25,18)
Seasonal surge	28.09.2020–29.11.2020	18,28% (17,66-18,91)	61,96% (61,17-62,74)	17,71% (17,09-18,33)	2,06% (1,83-2,30)	9,09% (8,81-9,36)
Epidemic maximum	30.11.2020–05.01.2021	14,15% (13,90–14,40)	73,92% (73,61–74,24)	11,59% (11,36–11,82)	0,34% (0,30–0,38)	13,15% (12,30–14,03)
Period of decline	06.01.2021–08.02.2021	11,66% (11,33–12,00)	76,26% (75,82–76,70)	11,22% (10,89–11,55)	0,86% (0,77–0,96)	6,93% (6,42–7,47)
Period of epidemic stability	09.02.2020–04.04.2021	11,17% (10,67–11,69)	75,29% (74,59–75,98)	13,51% (12,97–14,07)	0,03% (0,01–0,07)	8,36% (6,82–10,11)

men, and 0.01% (0.00–0.06) and 0.05% (0.02–0.11%) among women, respectively. In the cohort of men, the sharp increase of 13.60% (95% CI: 13.16–14.06) in the proportion of severe COVID-19 cases was recorded in the 50–69 year old age group. In the age groups of patients aged 70–79 and over 80 years, severe COVID-19 cases accounted for 10.94% (10.08–11.86) and 23.60% (22.00–25.25) respectively.

In the cohort of female COVID-19 patients aged under 50 years, the proportion of severe cases was not high; in the 30–49 year old age group, the above cases accounted for 0.25% (95% CI; 0.20–0.30). In comparison with men, among 50–69 year-old women with COVID-19, severe cases were diagnosed only in 1.42% (1.30–1.54) of all cases. The proportion of severe COVID-19 cases increased significantly among patients aged 70–79 and over 80 years, accounting for 6.34% (5.81–6.90) and 18.54% (17.54–19.57). With age, the proportion of moderate COVID-19 cases increased both among men and among women. In the cohort of men, among 0–18 year-old children, moderate COVID-19 cases were diagnosed in 5.65% (5.18–6.15) of all cases, while among men aged 70–79 and over 80 years, such cases were diagnosed in 32.09% (30.77–33.43) and 34.56% (32.76–36.39) of all cases, respectively. The cohort of female COVID-19 patients demonstrated the similar pattern. Among 0–18 year-old girls, moderate cases were diagnosed in 4.93% (4.49–5.41%) of all cases; among women aged 70–79 and over 80 years – in 28.44% (27.45–29.45) and 33.21% (32.00–34.44) of all cases, respectively.

Asymptomatic and mild cases of COVID-19 were diagnosed much more frequently among 0–18 and 19–29 year-old patients than among elderly people. In the

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0–18 and 19–29 year old age groups, the proportions of asymptomatic COVID-19 cases were as follows: among men — 25.29% (24.39–26.20) and 22.31% (21.54–23.14), among women — 25.57% (24.66–26.50) and 17.76% (17.13–18.42), respectively. Among patients aged 70–79 and over 80 years, asymptomatic COVID-19 cases accounted for 10.55% (9.70–11.45) and 8.36% (7.36–11.45) of male patients, and 10.64% (9.97–11.34) and 9.30% (8.56–10.07) of female patients, respectively.

The analysis of the target groups of population by social-occupational status and their active involvement in the COVID-19 epidemic process showed that SARS-CoV-2 was common almost in all strata of society, similar to any other pathogens transmitted by an airborne route. Meanwhile, the analysis of the proportions of COVID-19 patients belonging to different social and occupational groups of the St. Petersburg population showed that some groups can be singled out as groups of high risk of infection (**Table 4**).

Based on the data shown in Table 4, the highest proportions of COVID-19 cases were found in several groups of the population. Among patients with COVID-19, retirees accounted for 13.69% (13.43–13.96) of male patients and 17.67% (17.43–17.92) of female patients. The proportion of blue-collar workers was also high, reaching 20.04% (19.73–20.35) among male COVID-19 patients and being significantly lower among female patients, amounting to 9.99% (9.79–10.18). The proportion of children in the cohort of patients with COVID-19 was quite high, being in conflict with the opinion popular during the early stages of the pandemic and asserting that children were involved insignificantly into the epidemic process. In the cohort of men, the proportion of boys was 21.23% (20.92–21.54); in the cohort of women, the proportion of girls was 14.57% (13.94–14.39).

The high-risk group includes healthcare workers, especially those working in the red zone. Male healthcare workers accounted for 3.67% (95% CI; 3.57–3.82) of COVID-19 patients, while the proportion of female healthcare workers was significantly higher — 9.41% (95% CI; 14.04–14.23). People who were not working temporarily can be also included in the risk group of COVID-19 patients. The proportion of men was 17.53% (95% CI; 14.04–14.23); the proportion of women was 17.25% (95% CI; 14.04–14.23). Education sector employees, law enforcement, transport and municipal workers whose work responsibilities involve close contact with population are also included in high-risk infection groups and are characterized by high proportions among patients with COVID-19. A significant

Table 3. Proportions of different COVID-19 cases in the age groups of patients in St. Petersburg (%)

Age, years	Severity of COVID-19				Proportion of hospitalized patients
	asymptomatic form	mild form	moderate form	severe form	
			Men		
0–18	25,29 (24,39–26,20)	69,05 (68,08–70,01)	5,65 (5,18–6,15)	0,01 (0,00–0,06)	8,85 (8,26–9,46)
19–29	22,31 (21,54–23,14)	71,11 (70,25–71,95)	6,44 (5,99–6,92)	0,14 (0,08–0,23)	8,83 (8,26–9,43)
30–49	17,43 (17,02–17,85)	70,46 (69,96–70,95)	11,54 (11,20–11,89)	0,57 (0,49–0,65)	14,58 (14,16–15,01)
50–69	13,60 (13,16–14,06)	60,41 (59,76–61,04)	22,75 (22,21–23,31)	13,60 (13,16–14,06)	34,91 (34,22–35,60)
70–79	10,55 (9,70–11,45)	46,42 (45,00–47,84)	32,09 (30,77–33,43)	10,94 (10,08–11,86)	56,91 (55,45–58,45)
> 80	8,36 (7,36–9,47)	33,48 (31,70–35,30)	34,56 (32,76–36,39)	23,60 (22,00–25,25)	70,25 (68,45–72,00)
			Women		
0–18	25,57 (24,66–26,50)	69,49 (68,51–70,45)	4,93 (4,49–5,41)	0,01 (0,00–0,06)	7,65 (7,08–8,26)
19–29	17,76 (17,13–18,42)	75,13 (74,39–75,85)	7,02 (6,63–7,50)	0,05 (0,02–0,11)	9,66 (9,12–10,21)
30–49	16,2 (15,85–16,56)	74,33 (73,90–74,75)	9,22 (8,94–9,50)	0,25 (0,20–0,30)	11,49 (11,14–11,84)
50–69	12,73 (12,38–13,02)	67,14 (66,65–67,63)	18,72 (18,31–19,12)	1,42 (1,30–1,54)	26,17 (25,65–26,70)
70–79	10,64 (9,97–11,34)	54,58 (53,47–55,68)	28,44 (27,45–29,45)	6,34 (5,81–6,90)	48,36 (47,14–49,58)
> 80	9,3 (8,56–10,07)	38,95 (37,69–40,23)	33,21 (32,00–34,44)	18,54 (17,54–19,57)	66,10 (64,85–67,34)

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part of the patients — 17.53% (17.24–17.83) among men and 17.25% (17.01–17.50) among women – identified themselves as temporarily not working, without disclosing their affiliation to any group of population (Table 4).

Discussion

The COVID-19 epidemiological situation in St. Petersburg from 2/3/2020 to 4/4/2021 has been analyzed. During that period in St. Petersburg, a total of 397,477 COVID-19 cases and 12,394 deaths were reported. By the beginning of the outbreak, before the first cases of COVID-19 were reported in St. Petersburg, the city government had issued a number of regulatory documents governing the preventive and epidemic control measures, thus providing the efficient tools for prevention of an explosive increase in the incidence rates and for having the city's medical infrastructure ready ahead of time.

After one year, in the dynamics of confirmed COVID-19 cases in St. Petersburg, two epidemic cycles (spring and autumn–winter) of the evolution and 8 epidemic periods can be singled out: the "importation" period (2/3/2020–31/3/2020), epidemic upswing (1/4/2020–16/5/2020), decline (17/5/2020–31/7/2020), epidemic slowdown (1/8/2020–27/9/2020), seasonal surge (28/9/2020–29/11/2020), epidemic maximum (30/11/2020–5/1/2021), decline (6/1/2021–8/2/2021) and epidemic stability (9/2/2021–4/4/2021). The dynamics of detected COVID-19 cases in St. Petersburg is characterized by a significant difference in the intensity of two surges in COVID-19 incidence. At the beginning of the epidemic, including periods of "importation", epidemic upswing and decline (the spring cycle of rise/decline), considering the complete absence of herd immunity against SARS-CoV-2, the detection rate for COVID-19 cases was +4.6% a day; the maximum number of patients (*n* = 540) was recorded on 15/5/2020. The total duration of that COVID-19 epidemic period in St. Petersburg was 140 days, during which a total of 31,461 cases were reported.

The seasonal surge in COVID-19 incidence, the period of epidemic maximum and decline, comprising the autumn-winter cycle of rise/decline, lasted for 133 days, and the total number of patients was 304,109 people, demonstrating a 9.7-fold increase compared to the spring cycle. In the meantime, the buildup of herd immunity had already started in St. Petersburg by the beginning of the autumn-winter cycle of the COVID-19 epidemic, though, apparently, it was still not sufficient to have an impact on the spread of SARS-CoV-2. According to the data from A. Popova et al., during the intensive spread of COVID-19 infection, the detection rate for antibodies to SARS-CoV-2 among the St. Petersburg population was 26% [12]. The spring cycle of COVID-19 epidemic was characterized by much lower intensity and by the absence of the consistently high incidence rates (the plateau period), while during the autumn-winter cycle, this period was quite long (37 days).

The gender-age distribution of COVID-19 patients in St. Petersburg correlated with the patterns out-

Table 4. Proportions of COVID-19 patients representing different strata of the St. Petersburg population, %

Social and occupational status	Men, % (95% CI)	Women, % (95% CI)
Retirees	13,69 (13,43–13,96)	17,67 (17,43–17,92)
Blue-collar workers	20,04 (19,73–20,35)	9,99 (9,79–10,18)
Healthcare workers	3,67 (3,57–3,82)	9,41 (9,22–9,60)
Children aged 0–18 years	21,23 (20,92–21,54)	14,57 (13,94–14,39)
Office employees	9,38 (9,16–,61)	7,88 (7,71–8,05)
Temporarily not working	17,53 (17,24–17,83)	17,25 (17,01–17,50)
Education sector employees	1,92 (1,81–2,03)	6,32 (6,16–6,47)
Law enforcement	1,31 (1,22–1,40)	0,63 (0,58–0,68)
Transport workers	1,64 (1,55–1,74)	0,60 (0,55–0,65)
Residents of long-term care facilities	0,12 (0,10–0,15)	0,17 (0,15–0,20)
Municipal workers	3,57 (2,43–3,71)	3,41 (3,29–3,53)

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lined in the analysis of the epidemiological situation in Moscow [10, 11]. In the age distribution of COVID-19 patients in St. Petersburg, patients of two age groups prevailed: 30–49 and 50–69 year-olds. Their combined proportion in the age distribution of COVID-19 patients over the observation period was 66.95% (66.78–67.11). Among COVID-19 patients, young people aged 19–29 years accounted for 13.40% (13.21–13.58) and 12.56% (12.41–12.72), respectively. Note that men prevailed among the COVID-19 patients aged under 50, while in senior age groups, the proportion of women was higher. These differences in the proportions are apparently associated with the specific features of the gender-age composition of the St. Petersburg population.

In the meantime, the actual level of involvement in the epidemic process is shown by the case rates. Over the studied period, in St. Petersburg, the case rates (calculated per 100,000 people for each age group) estimated for cohorts of men and women made it possible to identify the most affected age groups, regardless of the age distribution in the St. Petersburg population. In the cohort of men who had COVID-19 during the observation period, the case rates in different age groups ranged from 3,109.6$^0/_{0000}$ (0–18 year-olds) to 6,071.8$^0/_{0000}$ (50–69 year-olds). In the cohort of women, the difference between the lowest and highest rates was more significant, demonstrating a range from 3,126.4$^0/_{0000}$ (0–18 year-olds) to 7,137.7$^0/_{0000}$ (30–49 year-olds). The highest COVID-19 case rates in men and women were recorded in different age groups. In the cohort of men, the COVID-19 case rates in all age groups, except for 0–18 year-olds, differed insignificantly, while in the cohort of women, their spread was more significant. For example, the case rate in the age groups of female patients aged 30–49 was 1.7 times lower than the rate in the age group of female patients over 80. It was found that in St. Petersburg, the COVID-19 case rate could not be used as a criterion to identify the age group of men who were most involved in the epidemic process. At the same time, among women, the highest COVID-19 case rates were recorded in the 19–29, 30–49, and 50–69 year old age groups. Note that among women, the COVID-19 case rates in the 0–18, 19–29, 39–49, and 50–69 year old age groups were higher than the rates among men, though the groups of patients over 70 demonstrated the opposite situation.

It should be noted that children were also actively involved in the COVID-19 epidemic process. In the age groups of COVID-19 patients in St. Petersburg, 0–18 year-old children accounted for 12.22% (12.05–12.40) of male patients and 8.60% (8.47–8.73) of female patients. Although the COVID-19 case rate was lower in this group compared to the other, it was still high. This age group of COVID-19 patients is characterized by the highest proportion of asymptomatic COVID-19 both among boys and among girls — 25.29% (24.39–26.20) and 25.57% (24.66–26.50), respectively. This feature of COVID-19 specified the epidemiological significance of patients in this age group.

Asymptomatic COVID-19 cases are difficult to diagnose, and it can be reasonably assumed that quite a few cases of this type remain undetected. Staying out of sight of the healthcare workers, asymptomatic COVID-19 patients have no restrictions prescribed for other COVID-19 patients, and can become an active source of SARS-CoV-2 transmission, contributing to stability of the epidemic process. Note that the proportions of asymptomatic COVID-19 cases vary significantly in different countries, according to the published data. For example, the data from Oran et al. [13] show that in Italy, the asymptomatic disease was registered in 42% of COVID-19 patients, while in the United States, the asymptomatic cases accounted for 44–96% of COVID-19 patients. N.A. Patel [14] summarized the findings of researchers from different countries (USA, Spain, China, Iran) and found that among 0-17 year-old children, asymptomatic COVID-19 cases were detected at different rates, ranging from 0% to 53%. In their review, Yanes-Lane et al. [15] show that asymptomatic cases among COVID-19 patients accounted for 75% of patients in Italy, 50% in Germany, and 8.2% in South Korea. Gandhi et al. [16] examined all the patients who had contact with the doctor infected with COVID-19 at a large hospital in California (USA) and found that 53% of all the infected patients had asymptomatic COVID-19.

An important parameter of the COVID-19 epidemic in Russia is the distribution of cases by their severity. Over the entire observation period, in St. Petersburg, the highest detection rate was demonstrated by mild and moderate COVID-19 cases. During different periods of the COVID-19 epidemic, mild cases diagnosed in men ranged from 25.09% (20.18–30.52) during the "importation" period to 73.60% (73.06–74.14) during the period of decline (6/1/2021–8/2/2021); the similar cases diagnosed in women ranged from 23.92% (20.10–30.24) during the "importation" period to 76.26% (75.82–76.70) during the period of decline (6/1/2021–8/2/2021). The general pattern should be noted: The number of mild cases increased throughout the epidemic period. Moderate cases of COVID-19 varied in their proportion during different epidemic periods; such variance, in our opinion, can be explained by improved diagnostics. During the periods comprising the spring cycle of the COVID-19 epidemic in St. Petersburg, moderate cases among men accounted for 21.51% (20.54–22.50) during the epidemic upswing; such cases accounted for 53.66% (47.70–59.54) during the "importation" period. During the other epidemic periods, the proportion of moderate cases was significantly lower, ranging from 12.48% (12,07–12.89) during the period of decline (6/1/2021) to 17.82% (17.08–18.57) during the seasonal surge (28/9/2020–29/11/2020). The cohort of women with COVID-19 demonstrated the similar pattern of COVID-19 cases of different severity (Table 2).

The proportions of cases differed significantly by their severity in different age groups of patients, regardless of their gender identity. There was a marked decrease in the proportion of asymptomatic and mild COVID-19 cases. While among patients aged 0–18 and 19–29, asymptomatic cases diagnosed in men accounted for 25.29% (24.39–26.20) and for 22.31% (21.54–23.14) and in women, they accounted for 25.57% (24.66–26.50) and 12.76% (17.13–18.42) of patients, the proportions observed among patients over 80 years were 8.36% (7.36–9.47) and 9.3% (8.56–10.07), respectively. The inverse relationship is demonstrated by moderate and severe COVID-19 cases; their proportions increased significantly with the age of patients. The conclusion is that the pattern demonstrated by COVID-19 types in St. Petersburg correlates with the pattern that was previously identified in Russia and other countries [9, 17–19]. Analyzing the factors that could be associated with severe COVID-19 cases in the cohort of patients of an average age of 69, Jiménez et al. [20] found the direct association with the elderly age, neurological diseases, chronic kidney diseases, and cancer.

The epidemiological analysis of the COVID-19 epidemic in St. Petersburg covered a relatively long period (more than one year), which includes two epidemic cycles and the interim period of epidemic slowdown. The analysis leads to conclusions based on the multiple actual data:

1. It can be assumed that COVID-19 develops as a seasonal disease with annual autumn-winter epidemic cycles.

2. COVD-19 cases do not give any proof of gender-age selectivity, demonstrating relatively similar case rates calculated per 100,000 people in each age group of the population.

3. There are no gender-age differences among COVID-19 patients in different epidemic periods in St. Petersburg.

4. The severity of COVID-19 is clearly associated with the age of patients: severe cases were more frequently diagnosed among patients aged over 70, regardless of their gender identity.

5. Retirees and workers of different categories, mostly those who were employed in the municipal service sector, were most involved in the COVID-19 epidemic process among the groups of St. Petersburg population.

At present, there are still many unresolved and unanswered questions. It is important to study the specific features of the course and consequences of COVID-19, especially its asymptomatic types, as there is no clear picture of the intensity and the time of SARS-CoV-2 seeding, the likelihood of re-infection, for example, with another genetic variant of the virus, and the characteristics of the post-COVID-19, etc. The efficient system of epidemiological surveillance cannot be built without accurate information about these characteristics of COVID-19.

Specific features of COVID-19 include severe post-acute complications, which are detected at high frequency rates. Most of the post-COVID-19 patients (up to 80%) were diagnosed with long-term complications or frequently with a range of them. Based on the data from L.T. McDonald, pulmonary fibrosis is a common complication (accounting for 62%) [21]. Sinanović et al. detected frequent neuropsychiatric disorders: depression (20.1%), anxiety (35.1%), and insomnia (18.2%) [22]. High detection rates are demonstrated by neurological disorders [23] and renal disorders [24]. It has been found that patients with COVID-19 are prone to high risk of arterial and venous thrombosis, which may result in myocardial infarction and strokes [25].

The mass vaccination against COVID-19, which started in Russia, is an affordable anti-epidemic measure; its epidemiological significance will be obvious after the beginning of the next autumn-winter seasonal surge.

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Information about the authors

Vasily G. Akimkin — D. Sci. (Med.), Prof., Full Member of RAS, Director, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-4228-9044

Stanislav N. Kuzin✉ — D. Sci. (Med.), Professor, Head, Laboratory of viral hepatitis, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, drkuzin@list.ru, https://orcid.org/0000-0002-0616-9777

Elena N. Kolosovskaya — D. Sci. (Med.), Associate Professor, consultant, Organizational and methodological department, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0001-6667-2377

Elena N. Kudryavtceva — D. Sci. (Biol.), consultant, Organizational and methodological department, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0002-7325-8577

Tatyana A. Semenenko — D. Sci. (Med.), Professor, Head, Department of epidemiology, National Research Centre for Epidemiology and Microbiology named after the honorary academician N.F. Gamaleya, Moscow, Russia, https://orcid.org/0000-0002-6686-9011

Antonina A. Ploskireva — D. Sci. (Med.), Deputy director, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0002-3612-1889

Dmitry V. Dubodelov — Cand. Sci. (Med.), senior researcher, Laboratory of viral hepatitis, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-3093-5731

Elena V. Tivanova — Head, Directions of laboratory medicine and promotion of laboratory services, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-1286-2612

Natalia Yu. Pshenichnaya — D. Sci. (Med.), Deputy director, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-2570-711X

Anna V. Kalenskaya — Deputy head, Directions of laboratory medicine and promotion of laboratory services, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0002-9126-1155

Svetlana B. Yatcishina — Cand. Sci. (Biol.), senior researcher, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-4737-941X

Olga Yu. Shipulina — Cand. Sci. (Med.), Head, Division of laboratory medicine and promotion of laboratory services, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-4679-6772

Elena N. Rodionova — Cand. Sci. (Med.), Head, Laboratory for the development and production of drugs for the diagnosis of infectious diseases in humans and animals, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-0192-1832

Natalia S. Petrova — Cand. Sci. (Biol.), chief technologist, Research and production laboratory, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-0166-555X

Irina V. Solov'eva — Head, Quality assurance group, Clinical diagnostic laboratory, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0002-3136-9500

Olga A. Kvasova — doctor-epidemiologist, Laboratory of infections associated with the provision of medical care, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0002-4545-1804

Marina A. Vershinina — leading consultant in laboratory medicine, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0001-8582-5199

Marina V. Mamoshina — junior researcher, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0002-1419-7807

Vitalina V. Klushkina — Cand. Sci. (Med.), doctor-epidemiologist, Laboratory of viral hepatitis, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0001-8311-8204

Информация об авторах

Акимкин Василий Геннадиевич — д.м.н., проф., академик РАН, директор ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-4228-9044

Кузин Станислав Николаевич✉ — д.м.н., проф., зав. лаб. вирусных гепатитов отдела молекулярной диагностики и эпидемиологии ЦНИИ Эпидемиологии, Москва, Россия, drkuzin@list.ru, https://orcid.org/0000-0002-0616-9777

Колосовская Елена Николаевна — д.м.н., доцент, консультант организационно-методического отдела ЦНИИ эпидемиологии Москва, Россия, https://orcid.org/0000-0001-6667-2377

Кудрявцева Елена Николаевна — д.б.н., консультант организационно-методического отдела ЦНИИ эпидемиологии Москва, Россия, https://orcid.org/0000-0002-7325-8577

Семененко Татьяна Анатольевна — д.м.н., проф., рук. отдела эпидемиологии НИЦЭМ им. Н.Ф. Гамалеи, Москва, Россия, https://orcid.org/0000-0002-6686-9011

Плоскирева Антонина Александровна — д.м.н., зам. директора ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0002-3612-1889

Дубоделов Дмитрий Васильевич — к.м.н., с.н.с. лаб. вирусных гепатитов отдела молекулярной диагностики и эпидемиологии ЦНИИ эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-3093-5731

Тиванова Елена Валерьевна — рук. направления лабораторной медицины и продвижения лабораторных услуг отдела молекулярной диагностики и эпидемиологии ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-1286-2612

Пшеничная Наталья Юрьевна — д.м.н., зам. директора ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-2570-711X

Каленская Анна Валентиновна — зам. рук. направления лабораторной медицины и продвижения лабораторных услуг по клиентскому сервису отдела молекулярной диагностики и эпидемиологии ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0002-9126-1155

Яцышина Светлана Борисовна — к.б.н., с.н.с. отдела молекулярной диагностики и эпидемиологии ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-4737-941X

Шипулина Ольга Юрьевна — к.м.н., рук. подразделения лабораторной медицины и продвижения лабораторных услуг отдела молекулярной диагностики и эпидемиологии ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-4679-6772

Родионова Елена Николаевна — к.м.н., зав. лаб. по разработке и производству препаратов для диагностики инфекционных заболеваний человека и животных ЦНИИ эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-0192-1832

Петрова Наталья Сергеевна — к.б.н., главный технолог научно-производственной лаборатории ЦНИИ эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-0166-555X

Соловьева Ирина Владимировна — рук. группы обеспечения качества Клинико-диагностической лаборатории ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0002-3136-9500

Квасова Ольга Андреевна — врач-эпидемиолог лаборатории инфекций, связанных с оказанием медицинской помощи, ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0002-4545-1804

Вершинина Марина Анатольевна — ведущий консультант по лабораторной медицине отдела молекулярной диагностики и эпидемиологии ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0001-8582-5199

Мамошина Марина Васильевна — м.н.с. отдела молекулярной диагностики и эпидемиологии ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0002-1419-7807

Клушкина Виталина Владимировна — к.м.н., врач-эпидемиолог лаборатории вирусных гепатитов отдела молекулярной диагностики и эпидемиологии ЦНИИ эпидемиологии, Москва, Россия, https://orcid.org/0000-0001-8311-8204

Marina I. Korabel'nikova — consultant, Organizational and methodological department, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0002-2575-8569

Nadezhda S. Churilova — research laboratory assistant, Laboratory of viral hepatitis, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0001-5344-5829

Yarina V. Panasyuk — doctor-epidemiologist, Laboratory of viral hepatitis, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0002-9335-4953

Natalia V. Vlasenko — research laboratory assistant, Laboratory of viral hepatitis, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0002-2388-1483

Alexey A. Ostroushko — Head, Information and analytical service, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-0803-5630

Evgeniy S. Balmasov — systems analyst, Information and analytical service, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0003-3382-2441

Artem V. Mosunov — leading analyst, Department of molecular diagnostics and epidemiology, Central Research Institute for Epidemiology, Moscow, Russia, https://orcid.org/0000-0001-6743-3650

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Корабельникова Марина Игоревна — консультант организационно-методического отдела ЦНИИ Эпидемиологии, Москва, Россия, https://orcid.org/0000-0002-2575-8569

Чурилова Надежда Сергеевна — лаборант-исследователь лаборатории вирусных гепатитов отдела молекулярной диагностики и эпидемиологии ЦНИИ эпидемиологии Москва, Россия, https://orcid.org/0000-0001-5344-5829

Панасюк Ярина Васильевна — врач-эпидемиолог лаборатории вирусных гепатитов отдела молекулярной диагностики и эпидемиологии ЦНИИ эпидемиологии, Москва, Россия, https://orcid.org/0000-0002-9335-4953

Власенко Наталья Викторовна — лаборант-исследователь лаборатории вирусных гепатитов отдела молекулярной диагностики и эпидемиологии ЦНИИ эпидемиологии, Москва, Россия, https://orcid.org/0000-0002-2388-1483

Остроушко Алексей Александрович — руководитель информационно-аналитической службы отдела молекулярной диагностики и эпидемиологии ЦНИИ эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-0803-5630

Балмасов Евгений Сергеевич — системный аналитик информационно-аналитической службы отдела молекулярной диагностики и эпидемиологии ЦНИИ эпидемиологии, Москва, Россия, https://orcid.org/0000-0003-3382-2441

Мосунов Артем Васильевич — ведущий аналитик отдела молекулярной диагностики и эпидемиологии ЦНИИ эпидемиологии, Москва, Россия,
https://orcid.org/0000-0001-6743-3650

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