EVALUATION OF THE IMPACT OF COVID-19 PANDEMIC ON OVERALL MORTALITY IN OZYORSK URBAN DISTRICT

Osipov MV[1] ✉, Sokolova VA[2], Kushnir AS[2]

[1] Southern Urals Biophysics Institute of the Federal Medical Biological Agency, Ozyorsk, Russia

[2] Clinical Hospital "RZhD-Medicine", Chelyabinsk, Russia

COVID-19 pandemic announced by World Health Organization in March 2020 raised concern on potential demographic losses. This retrospective study was aimed to analyze the pandemic-related changes in the demographic status of the Ozyorsk urban district located close to the nuclear industry facility — the "Mayak" Production Association. Population changes in the Ozyorsk urban district over the last decade were analyzed based on the open-access demographic data. The impact of the COVID-19 pandemic on the demographic status of the Ozyorsk urban district was assessed using the crude overall mortality rates. Comparison of the overall mortality rates has been performed between 2020 and each previous year to assess the deviation of mortality from the forecasted value. The overall mortality rate in 2020 has been found increased significantly by 19%. Excess mortality attributed to the impact of the pandemic was 13.4%. The expected absolute number of excess deaths from COVID-19 being the main cause of death was 60 (4.2%). The COVID-19 pandemic had a significant negative impact on the demographic status of the Ozyorsk urban district; however, the role of COVID-19-associated deaths in overall mortality was not predominant.

Keywords: pandemic, coronavirus infection, COVID-19, SARS-CoV-2, population changes, mortality rate, Ozyorsk

Acknowledgements: the authors would like to express their appreciation to Yulia V. Tzareva, PhD, research fellow at the Department of Epidemiology, Southern Urals Biophysics Institute, for discussing the study results.

Author contribution: Osipov MV — concept, design, research coordination, statistical analysis and data interpretation, drawing conclusions, manuscript writing, and translation; Sokolova VA — analysis, study planning, data interpretation, discussion; Kushnir AS — literature analysis, data interpretation, manuscript writing.

✉ **Correspondence should be addressed:** Mikhail V. Osipov
Ozyorskoe shosse 19/1, k. 108, Ozyorsk, 456780, Russia; osipov@subi.su

Received: 10.03.2022 **Accepted:** 02.04.2022 **Published online:** 21.04.2022

DOI: 10.47183/mes.2022.011

ОЦЕНКА ВЛИЯНИЯ ПАНДЕМИИ COVID-19 НА ОБЩИЙ КОЭФФИЦИЕНТ СМЕРТНОСТИ НАСЕЛЕНИЯ ОЗЕРСКОГО ГОРОДСКОГО ОКРУГА

М. В. Осипов[1] ✉, В. А. Соколова[2], А. С. Кушнир[2]

[1] Южно-Уральский институт биофизики Федерального медико-биологического агентства, Озёрск, Россия
[2] Клиническая больница «РЖД-Медицина», Челябинск, Россия

Пандемия COVID-19, объявленная Всемирной организацией здравоохранения в марте 2020 г., обусловила необходимость оценки потенциального демографического ущерба для населения. Целью работы было провести ретроспективный анализ изменения демографической ситуации в Озерском городском округе, расположенном вблизи предприятия атомной промышленности ПО «Маяк». На основе опубликованных в открытом доступе демографических данных было ретроспективно проанализировано изменение численности населения за десятилетний период. Уровень общей смертности в 2020 г. сравнивался с каждым предыдущим годом в течение исследуемого периода для оценки величины отклонения уровня смертности от его прогнозируемого значения. Оценка влияния пандемии COVID-19 на демографический статус Озерского городского округа выполнялась с использованием грубого показателя общей смертности. Показано статистически значимое повышение уровня общей смертности в 2020 г. по сравнению с его ожидаемой оценкой на 19%. Абсолютный избыток общей смертности, отнесенный к влиянию пандемии, составил 13,4%. Ожидаемое число избыточных случаев смерти в результате заболевания COVID-19 как основной причины смерти составило 60 (4,2%). Пандемия COVID-19 оказала статистически значимое негативное влияние на демографический статус Озерского городского округа, однако ее влияние на общую смертность не было превалирующим.

Ключевые слова: пандемия, коронавирусная инфекция, COVID-19, SARS-CoV-2, показатели общей смертности, Озерск

Благодарность: авторы выражают благодарность научному сотруднику отдела эпидемиологии Южно-Уральского института биофизики, к. м. н. Ю. В. Царевой за помощь в обсуждении результатов исследования.

Вклад авторов: М. В. Осипов — идея, дизайн, координация исследования, статистический анализ и интерпретация результатов, формулирование выводов, подготовка рукописи; В. А. Соколова — анализ, планирование исследования, интерпретация данных, обсуждение результатов; А. С. Кушнир — работа с литературой, анализ и интерпретация данных, подготовка рукописи.

✉ **Для корреспонденции:** Михаил Викторович Осипов
Озерское шоссе, д. 19/1, к. 108, г. Озерск, 456780, Россия; osipov@subi.su

Статья получена: 10.03.2022 **Статья принята к печати:** 02.04.2022 **Опубликована онлайн:** 21.04.2022

DOI: 10.47183/mes.2022.011

On March 11, 2020 the World Health Organization (WHO) announced a new global threat, the outbreak of COVID-19 caused by the novel coronavirus infection SARS-CoV-2, the spread of which had become a pandemic. The COVID-19 associated atypical severe acute respiratory syndrome (SARS) [1], prone to progression towards severe forms in 20% of infected [2] and characterized by high probability of lethal outcome [3], has become a subject of concern for clinicians and epidemiologists all over the world. As of December 31, 2020, the total number of diseased due to infection of novel coronavirus SARS-CoV-2 in the world was about 83,200,000 [4], with over 1,815,000 deaths from various causes among them. Case fatality rate among patients with confirmed cases of COVID-19 varied greatly from country to country within a range of 0.3–5.8% [5].

The global spread of the novel coronavirus infection associated with increased morbidity and mortality is a risk factor potentially affecting the population changes. This could

be particularly important for the sparsely populated areas and small urban districts, such as the closed administrative territory Ozyorsk, located close to the "Mayak" nuclear complex [6]. The sanitary and epidemiologic wellbeing of the Ozyorsk urban district population is an important task of the Federal Target Program "Nuclear and Radiation Safety in 2016–2020, and until 2030" [7], that is why evaluation of possible sanitary losses due to impact of the pandemic becomes especially important.

Since the announcement of the pandemic, a number of research studies has been conducted by Russian and foreign scientists, including those aimed to assess the COVID-19-associated demographic losses [3–5, 8–12]. Specific mortality rates such as *infection fatality ratio* (IFR) and *case fatality ratio* (CFR) based on the number of deaths among infected has been widely used by the epidemiologists to characterize the impact of the pandemic to population. However, these specific indicators used to characterize the prevalence of infection depend on certain demographic and economic conditions which may vary from country to country. According to WHO, the true level of transmission is frequently underestimated because a substantial proportion of people with the infection are undetected either because they are asymptomatic or have only mild symptoms [13]. Therefore, the use of specific fatality rates (IFR and CFR) to assess true level of the pandemic spread could be compromised by underestimation [11, 12].

On the other hand, an in-patient specific mortality indicator used to monitor the infection spread [14] which is calculated for patients seeking medical care, would be obviously higher than among the rest of the population. Thus, the consequences of the SARS-CoV-2 spreading in the population estimated using specific indicators are likely to be overestimated [15]. The fatality rates calculated in different periods of the epidemic process may vary greatly, which could result in erroneous interpretation of the comparison results in various populations at different time [8] and make it difficult to predict the expected sequelae [16]. The use of different methods for fatality rates calculation implemented in different countries serves as a source of bias that led to wide variability (0.1–25% and more) [13], which could mislead researchers when comparing the data reported.

The one of the possible ways to minimize the impact of these uncertainties is the use of the non-specific crude overall mortality rate indicator, which, unlike specific indicators, is insensitive to the use of different calculation methods, since it is a proportion of deaths from all causes in the population. According to that, in this study the pandemic-associated excess mortality in the population of the Ozyorsk urban district has been evaluated using the comparison of the crude overall mortality rates.

METHODS

A retrospective cohort study has been conducted among the population of the Ozyorsk urban district during the period from 2010 to 2020. The statistical analysis has been performed using the data from official statistics [17]. The number of deaths from all causes (M_t) and the population size (P_t) given by the end of the year (t) were used to calculate the overall crude mortality rate (μ_t) per 1000 using equation:

$$\mu_t = \frac{M_t}{P_t} \times 1000. \quad (1)$$

The annual increase in the crude mortality rate was calculated using equation:

$$\Delta\mu = \frac{\mu_t - \mu_{t-1}}{\mu_{t-1}} \times 100\%, \quad (2)$$

where μ_t — crude overall mortality rate in the current year, μ_{t-1} — crude overall mortality rate in the previous year. Excess mortality was calculated as the difference between the 2020 crude mortality rate and the average mortality rate during the decade before the COVID-19 pandemic announcement, assuming the static demographic trend over the years. Trend estimation was performed using the linear correlation coefficient (r) and approximation coefficient R^2 [18].

To characterize the mortality rate per 1000 (‰), a conventional scale was used [19]. According to that scale, the mortality rate in the Ozyorsk urban district was ranged:

$(\mu_t) < 10‰$ — low,
$10‰ \le (\mu_t) < 15‰$ — medium, (3)
$15‰ \le (\mu_t) < 25‰$ — high.

The statistical hypothesis on the existing impact of the COVID-19 pandemic on the mortality rate in the Ozyorsk urban district population was tested against the null hypothesis using the comparison of the overall crude mortality rates given by previous decade. Statistical significance of the differences between the annual mortality rates was assessed by frequency analysis of binary outcomes (presence or absence) in 2 × 2 contingency tables using Pearson Chi-square test implemented in the "WinPepi" statistical software package [20]. The results were considered significant at $p < 0.01$. The probability of replication of the results (P-rep) [21] was considered sufficient reaching 80% with the significance level $\alpha = 0.05$.

RESULTS

The dynamics of population changes in the Ozyorsk urban district during the study period is shown in Fig. 1.

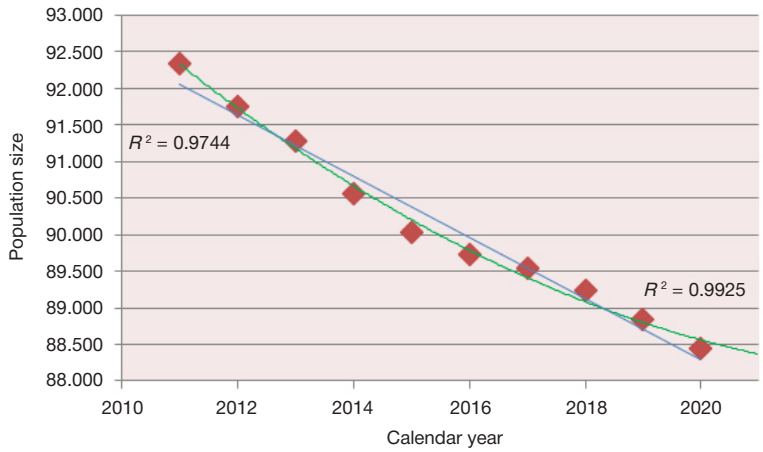

Fig. 1. Dynamics of population changes in the Ozyorsk urban district, 2010–2020

Table 1. Population size and mortality in the Ozyorsk urban district, 2010–2020

Year	Population	Deaths	Deaths increase	Mortality rate (μ_i)	Δ μ, %
2010	97,832	1309	–	13.38	–
2011	92,335	1243	–66	13.46	0.6
2012	91,744	1226	–17	13.36	–0.74
2013	91,285	1181	–45	12.94	–3.14
2014	90,567	1240	59	13.69	5.8
2015	90,029	1237	–3	13.74	0.37
2016	89,724	1279	42	14.25	3.71
2017	89,545	1227	–52	13.7	–3.86
2018	89,230	1241	14	13.91	1.53
2019	88,835	1197	–44	13.47	–3.16
2020	88,399	1430	233	16.18	20.12

The dynamics of population changes in the Ozyorsk urban district over a 10-year period show a clear downward trend which can be approximated using linear quadratic model (R^2 = 0.99). The linear correlation coefficient is 0.84 ($p < 0.05$). The linearity of the trend was within $0.7 < r < 0.9$ (R^2 = 0.97), which points to the distinct linear component.

Annual overall crude mortality rates (μ_i), as well as annual absolute and relative mortality rate increase (Δμ, %) during 2010–2020 are shown in Table 1.

The increase in the absolute number of deaths by 2020 in Ozyorsk urban district population was 233, compared to the previous year, or 192 deaths, compared to the average number of deaths for the previous decade (2010–2019). The expected number of excess deaths that could be related to the first year of the pandemic was 2.17 per 1000, or 13.4% of the overall mortality.

The increase in the overall mortality rate (Δμ) in the Ozyorsk urban district in 2020 was 20.12%, compared to the 2019. The overall mortality ratio, μ_{2020} /$\mu_{2010–2019}$ compared to the previous decade was 1.19 (95% CI: 1.1–1.28; $p = 6.0 \times 10^{-6}$) which corresponds to 19% average excess mortality.

According to the mortality range scale (3), the mortality level observed in the Ozyorsk urban district remained "medium" until 2019, and increased to a "high" level since 2020. The changes in the overall mortality rates in the Ozyorsk urban district compared to similar indicators for Chelyabinsk region in the recent decade (2010–2020) are shown in Fig.2.

During the recent decade, a linear downwardl trend of the overall mortality rate (R^2 = 0.9) in Chelyabinsk region has persisted, compared to the same in the Ozyorsk urban district which fluctuates between 12.5 and 14.5 showing a weak upward trend (linear correlation 0.69). It is noteworthy that in recent years mortality rates in the Ozyorsk urban district exceed that of the region.

According to the official demographic data, the mortality rate in Chelyabinsk region in 2020 reached 15.9, compared to the Ozyorsk urban district (16.2) [22], which showed a substantial deviation from the predicted value calculated based on linear extrapolation. Pairwise comparisons of the annual 2020 mortality with the previous decade were performed in order to test the null hypothesis, using the 2019 mortality as a reference value.

Comparisons of the 2020 overall mortality within the decade, significance testing and reproducibility of the results are shown in Table 2.

Pairwise comparisons of the 2020 mortality with the each mortality rate for the non-pandemic years revealed significant differences in all pairs (p <<0.05) with the high level of reproducibility (> 80%). At the same time, comparison with the reference value (2019) revealed no significant differences in any of the pairs ($p > 0.05$), except for the 2020.

DISCUSSION

Our findings show a significant increase of crude mortality rate by 20.1% in the Ozyorsk urban district compared to the 2019, and by 19.0% compared to the average estimate for the non-

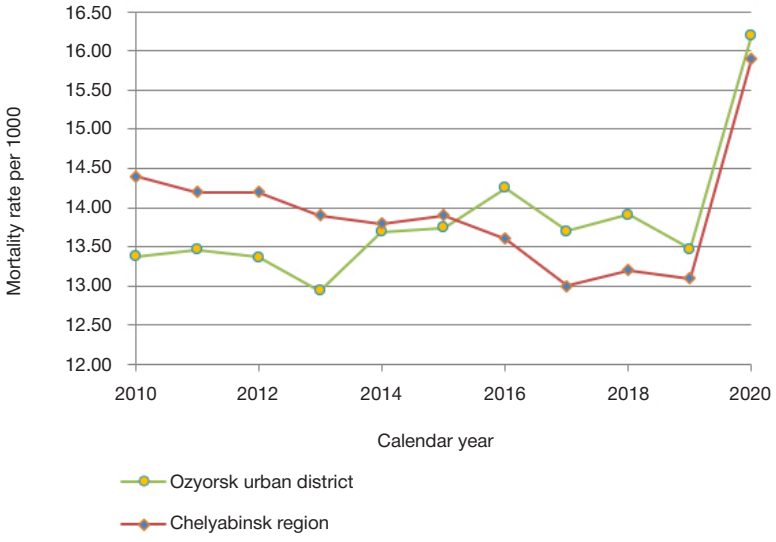

Fig. 2. Annual changes in the crude overall mortality rate per 1000 in the Ozyorsk urban district and Chelyabinsk region, years 2010–2020

Table 2. Comparison of the overall mortality rates in the Ozyorsk urban district within the decade

Year	Pearson χ^2 *p*-value	*P*-rep, %	Year	Pearson χ^2 *p*-value	*P*-rep, %
2010	5.8×10^{-7}	93	2010	0.86	–
2011	1.8×10^{-6}	92	2011	0.98	–
2012	7.6×10^{-7}	93	2012	0.84	–
2013	1.0×10^{-8}	94	2013	0.32	67
2014	1.4×10^{-5}	92	2014	0.69	–
2015	2.3×10^{-5}	91	2015	0.63	–
2016	9.3×10^{-4}	89	2016	0.16	28
2017	1.7×10^{-5}	92	2017	0.68	–
2018	8.7×10^{-5}	91	2018	0.43	89
2019	2.6×10^{-6}	92	2019	–	–
2020	–	–	2020	2.6×10^{-6}	92

pandemic decade (2010–2019). This suggests that in 2020 a new negative factor appeared in the study population which has significantly affected the mortality.

These results are consistent with the national statistics data. According to the Russian Government Statistical Service ("Rosstat") [23], 288,000 more people died in 2020 in the Russian Federation compared to the average number of deaths over the previous 5-year period, and the excess mortality was 18.9% compared to the previous year (2019), which was confirmed by recent studies [10–12]. The estimated proportion of deaths caused by the COVID-19 as the main cause of death in the 2020 in the Russian Federation (excess mortality) was 31%.

In this study we have limited access to the information on the number of fatal cases among infected with SARS-CoV-2 in the Ozyorsk urban district. However, the COVID-19 specific mortality for the Ozyorsk population can be estimated using the "Rosstat" excess mortality coefficient, in the assumption that there are no substantial differences in age and gender structure between the populations of the Ozyorsk urban district and the Russian Federation, and the changes in mortality rate with time at risk, as well. Assuming the aetiological fraction of 31%, the expected number of deaths due to COVID-19 in the Ozyorsk urban district would be 59.5, and the expected annual specific mortality rate per 100,000 would be 67.3.

In comparison with the crude mortality from cardiovascular diseases (CVD) and cancer, as the most socially significant disorders, ranked as the leading causes of death in the Russian Federation, the role of COVID-19 in the overall mortality was not predominant. In case of main cause of death, COVID-19 mortality would be 8.5 lower compared with the CVD-associated mortality rate for 2019 (573.2 deaths per 100,000 population) [24], and 3.0 times lower (203.5 deaths per 100,000 compared to cancer-induced deaths.

According to that, the expected number of related to the pandemic but not induced by the COVID-19 excess deaths in the Ozyorsk urban district in 2020 would be about 132. These excess fatal cases may be associated both with SARS-Cov-2 infection, and the other causes that are not related to COVID-19 itself, but significantly related to the pandemic.

Due to the rapid spread of the pandemic in early 2020, according to WHO recommendations governments of the majority of the countries, including Russia, imposed certain restriction measures aimed to reduce the number of SARS-CoV-2 infected individuals and improve medical care to COVID-19 patients. Despite these mandatory measures, the healthcare system forced real difficulties because the number of in-patient beds for patients with non-communicable diseases in the Chelyabinsk region decreased rapidly in favour of COVID-19 beds (Table 3).

Repurposing of many hospital departments and clinics into the infectious in 2020 has led to insufficiency of healthcare providing to patients with chronic non-communicable diseases, e. g. cardiovascular pathology and cancer, which has the highest prevalence in the population [24]. Such healthcare interventions are particularly sensitive for people older than 60 [12, 25] who shared 29% of the Ozyorsk urban district population at the end of 2020, due to severe chronic diseases and comorbidities [26] which can result in excess mortality. The situation was further complicated by the quarantine measures implemented in many medical hospitals, along with the shortage of specialists engaged in fighting against COVID-19. All this showed that healthcare system experienced serious difficulties when working in a pandemic mode [27] that could result in the increased mortality from non-infectious diseases.

Thus, in the context of the pandemic, along with the specific COVID-19-associated mortality, it is necessary to distinguish the excess mortality not directly related to the SARS-CoV-2 infection, but resulted from the impact of socio-economic factors and preventive measures, the effectiveness of which in reducing the COVID-19 related mortality is widely discussed [28]. Based on the above considerations, planning sanitary anti-epidemic measures during the pandemic requires the assessment complex character of potential sanitary losses.

CONCLUSIONS

Announcement of the global COVID-19 pandemic in 2020 had a distinct negative impact on the demographic status of the Ozyorsk urban district. A significant increase in the overall mortality rate of population has been found compared to the previous non-pandemic decade. The overall mortality rate increase observed during the first pandemic year was

Table 3. Number of in-patient beds in medical hospitals of the Chelyabinsk region, 2016–2020

Hospital bed profile	Number of beds per year					Difference
	2016	2017	2018	2019	2020	2019–2020
Non-infectious	20,064	19,525	19,124	19,035	15,846	–3189
Infectious	1230	1209	1180	1134	6355	5221

19%. Excess overall mortality attributed to the impact of the pandemic was 13.4%, and the expected COVID-19-associated specific mortality rate was 4.2%. The significant impact of COVID-19, however, doesn't play a predominant role in the total demographic losses of the Ozyorsk urban district. Taking into account the prolonged nature of the COVID-19 pandemic, the control of the demographic losses must be implemented pay attention to complex nature of the relationship between the mortality and both direct impact of the COVID-19, and the other pandemic-related socio-economic factors.

References

1. Lotfi M, Hamblin MR, Rezaei N. COVID-19: Transmission, prevention, and potential therapeutic opportunities. Clin Chim Acta. 2020; 508: 254–66. DOI: 10.1016/j.cca.2020.05.044.
2. Müller O, Neuhann F, Razum O. Epidemiologie und Kontrollmaßnahmen bei COVID-19 [Epidemiology and control of COVID-19]. Dtsch Med Wochenschr. 2020; 145 (10): 670–74. DOI: 10.1055/a-1162-1987.
3. Modig K, Ahlbom A, Matthews A. COVID-19 — deaths and analysis. Lakartidningen. 2020; 117: F3XL. PMID: 32365212.
4. Lai CC, Shih TP, Ko WC. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. Int J Antimicrob Agents. 2020; 55 (3): 105924. DOI: 10.1016/j.ijantimicag.2020.105924.
5. Ensheng D, Hongru D, Lauren G. An interactive web-based dashboard to track COVID-19 in real time. The Lancet Infectious Diseases. 2020; 20 (5): 533–34. DOI: 10.1016/S1473-3099(20)30120-1.
6. Novoselov VN, Nosach YuF, Entyakov BN. Atomnoe serdce Rossii. Chelyabinsk: Izd-vo «Avtograf», 2014; 528 s. Russian.
7. Federal'naya celevaya programma «Obespechenie yadernoj i radiacionnoj bezopasnosti na 2016–2020 gody i na period do 2030 goda». Dostupno po ssylke (data obrashheniya 22.02.2022): http://fcp-yarb2030.rf/about/overview/. Russian.
8. Drapkina OM, Samorodskaya IV, Sivceva MG, Kakorina EP, Briko NI, Cherkasov SN, i dr. Metodicheskie aspekty ocenki zabolevaemosti, rasprostranennosti, letal'nosti i smertnosti pri COVID-19. Kardiovaskulyarnaya terapiya i profilaktika. 2020; 19 (3): 302–09. DOI:10.15829/1728-8800-2020-2585. Russian.
9. Weiss P, Murdoch DR. Clinical course and mortality risk of severe COVID-19. The Lancet. 2020; 395: 1014–5.
10. Druzhinin PV, Molchanova EV. Smertnost' naseleniya rossijskix regionov v usloviyax pandemii COVID-19. Regionologiya. 2021; 29 (3): 666–85. DOI: 10.15507/24131407.116.029.202103.666-685. Russian.
11. Lifshits ML, Neklyudova NP. COVID-19 mortality rate in Russian regions: forecasts and reality. R-economy. 2020; 6 (3): 171–82. DOI: 10.15826/recon.2020.6.3.015.
12. Druzhinin PV, Molchanova EV, Podlevskikh YuL. Vliyanie pandemii Covid-19 na smertnost' naseleniya rossijskix regionov. Trudy Karel'skogo nauchnogo centra RAN. 2021; 7: 116–128. DOI: 10.17076/them1421. Russian.
13. Vsemirnaya organizaciya zdravooxraneniya (VOZ). Ocenka pokazatelej smertnosti ot Covid-19. Dostupno po ssylke (data obrashheniya 22.02.2022): https://www.who.int/news-room/commentaries/detail/estimating-mortality-from-covid-19. Russian.
14. Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City Area. JAMA. 2020; 323 (20): 2052–9. DOI: 10.1001/jama.2020.6775.
15. Grasselli G, Zangrillo A, Zanella A, Antonelli M, Cabrini L, Castelli A, et al. COVID-19 Lombardy ICU Network. Baseline Characteristics and Outcomes of 1591 Patients Infected With SARS-CoV-2 Admitted to ICUs of the Lombardy Region, Italy. JAMA. 2020; 323 (16): 1574–81. DOI: 10.1001/jama.2020.5394.
16. Obesnyuk VF. Group health risk parameters in a heterogeneous cohort. Indirect assessment as per events taken in dynamics. Health Risk Analysis. 2021; 2: 17–32. DOI: 10.21668/health.risk/2021.2.02.eng.
17. Pasport Ozyorskogo gorodskogo okruga. Dostupno po ssylke (data obrashheniya 22.02.2022): http://ozerskadm.ru/regulatory/passport/. Russian.
18. Fletcher R, Fletcher S, Vagner Eh. Klinicheskaya ehpidemiologiya. Osnovy dokazatel'noj mediciny. M.: Izd-vo «Media Sfera», 1998; 352 s. Russian.
19. Merkov AM, Suxarebskij LM. Statistika na sluzhbe narodnogo zdorov'ya. M.: Izd-vo «Statistika», 1968; 48 s. Russian.
20. Abramson, JH. WINPEPI updated: computer programs for epidemiologists, and their teaching potential. Epidemiologic Perspectives & Innovations. 2011; 8 (1). DOI: 10.1186/1742-5573-8-1.
21. Reality check on reproducibility. Nature. 2016; 533 (7604): 437. DOI: 10.1038/533437a.
22. Regiony Rossii. Social'no-ehkonomicheskie pokazateli. Statisticheskij sbornik. 2020. Dostupno po ssylke (data obrashheniya 22.02.2022): https://gks.ru/bgd/regl/b20_14p/Main.htm. Russian.
23. Federal'naya sluzhba gosudarstvennoj statistiki «Rosstat». Dostupno po ssylke (data obrashheniya 22.02.2022): https://rosstat.gov.ru/storage/mediabank/TwbjciZH/edn12-2020.html. Russian.
24. Zdravooxranenie v Rossii. Stat. sb. M.: Izd-vo «Rosstat», 2021; 171 s. Russian.
25. Blagosklonny MV. From causes of aging to death from COVID-19. Aging (Albany NY). 2020; 12 (11): 10004–21. DOI: 10.18632/aging.103493.
26. Guan WJ, Liang WH, Zhao Y, Liang HR, Chen ZS, Li YM, et al. China Medical Treatment Expert Group for COVID-19. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. Eur Respir J. 2020; 55 (5): 2000547. DOI: 10.1183/13993003.00547-2020.
27. Bong CL, Brasher C, Chikumba E, McDougall R, Mellin-Olsen J, Enright A. The COVID-19 Pandemic: Effects on Low- and Middle-Income Countries. Anesth Analg. 2020; 131 (1): 86–92. DOI: 10.1213/ANE0000000000004846.
28. Herby J, Joung L, Hanke S. A Literature Review and Meta-Analysis of the Effects of Lockdowns on COVID-19 Mortality. Studies in Applied Economics. 2022; 200: 1–61.

Литература

1. Lotfi M, Hamblin MR, Rezaei N. COVID-19: Transmission, prevention, and potential therapeutic opportunities. Clin Chim Acta. 2020; 508: 254–66. DOI: 10.1016/j.cca.2020.05.044.
2. Müller O, Neuhann F, Razum O. Epidemiologie und Kontrollmaßnahmen bei COVID-19 [Epidemiology and control of COVID-19]. Dtsch Med Wochenschr. 2020; 145 (10): 670–74. DOI: 10.1055/a-1162-1987.
3. Modig K, Ahlbom A, Matthews A. COVID-19 — deaths and analysis. Lakartidningen. 2020; 117: F3XL. PMID: 32365212.
4. Lai CC, Shih TP, Ko WC. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. Int J Antimicrob Agents. 2020; 55 (3): 105924. DOI: 10.1016/j.ijantimicag.2020.105924.
5. Ensheng D, Hongru D, Lauren G. An interactive web-based dashboard to track COVID-19 in real time. The Lancet Infectious

Diseases. 2020; 20 (5): 533–34. DOI: 10.1016/S1473-3099(20)30120-1.
6. Новосёлов В. Н., Носач Ю. Ф., Ентяков Б. Н. Атомное сердце России. Челябинск: Изд-во «Автограф», 2014; 528 с.
7. Федеральная целевая программа «Обеспечение ядерной и радиационной безопасности на 2016–2020 годы и на период до 2030 года». Доступно по ссылке (дата обращения 22.02.2022): http://фцп-ярб2030.рф/about/overview/.
8. Драпкина О. М., Самородская И. В., Сивцева М. Г., Какорина Е. П., Брико Н. И., Черкасов С. Н. и др. Методические аспекты оценки заболеваемости, распространенности, летальности и смертности при COVID-19. Кардиоваскулярная терапия и профилактика. 2020; 19 (3): 302–09. DOI:10.15829/1728-8800-2020-2585.
9. Weiss P, Murdoch DR. Clinical course and mortality risk of severe COVID-19. The Lancet. 2020; 395: 1014–5.
10. Дружинин П. В., Молчанова Е. В. Смертность населения российских регионов в условиях пандемии COVID-19. Регионология. 2021; 29 (3): 666–85. DOI: 10.15507/24131407.116.029.202103.666-685.
11. Lifshits ML, Neklyudova NP. COVID-19 mortality rate in Russian regions: forecasts and reality. R-economy. 2020; 6 (3): 171–82. DOI: 10.15826/recon.2020.6.3.015.
12. Дружинин П. В., Молчанова Е. В., Подлевских Ю. Л. Влияние пандемии Covid-19 на смертность населения российских регионов. Труды Карельского научного центра РАН. 2021; 7: 116–128. DOI: 10.17076/them1421.
13. Всемирная организация здравоохранения (ВОЗ). Оценка показателей смертности от Covid-19. Доступно по ссылке (дата обращения 22.02.2022): https://www.who.int/news-room/commentaries/detail/estimating-mortality-from-covid-19.
14. Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City Area. JAMA. 2020; 323 (20): 2052–9. DOI: 10.1001/jama.2020.6775.
15. Grasselli G, Zangrillo A, Zanella A, Antonelli M, Cabrini L, Castelli A, et al. COVID-19 Lombardy ICU Network. Baseline Characteristics and Outcomes of 1591 Patients Infected With SARS-CoV-2 Admitted to ICUs of the Lombardy Region, Italy. JAMA. 2020; 323 (16): 1574–81. DOI: 10.1001/jama.2020.5394.
16. Obesnyuk VF. Group health risk parameters in a heterogeneous cohort. Indirect assessment as per events taken in dynamics. Health Risk Analysis. 2021; 2: 17–32. DOI: 10.21668/health.risk/2021.2.02.eng.
17. Паспорт Озёрского городского округа. Доступно по ссылке (дата обращения 22.02.2022): http://ozerskadm.ru/regulatory/passport/.
18. Флетчер Р., Флетчер С., Вагнер Э. Клиническая эпидемиология. Основы доказательной медицины. М.: Изд-во «Медиа Сфера», 1998; 352 с.
19. Мерков А. М, Сухаребский Л. М. Статистика на службе народного здоровья. М.: Изд-во «Статистика», 1968; 48 с.
20. Abramson, JH. WINPEPI updated: computer programs for epidemiologists, and their teaching potential. Epidemiologic Perspectives & Innovations. 2011; 8 (1). DOI: 10.1186/1742-5573-8-1.
21. Reality check on reproducibility. Nature. 2016; 533 (7604): 437. DOI: 10.1038/533437a.
22. Регионы России. Социально-экономические показатели. Статистический сборник. 2020. Доступно по ссылке (дата обращения 22.02.2022): https://gks.ru/bgd/regl/b20_14p/Main.htm.
23. Федеральная служба государственной статистики «Росстат». Доступно по ссылке (дата обращения 22.02.2022): https://rosstat.gov.ru/storage/mediabank/TwbjciZH/edn12-2020.html.
24. Здравоохранение в России. Стат. сб. М.: Изд-во «Росстат», 2021; 171 с.
25. Blagosklonny MV. From causes of aging to death from COVID-19. Aging (Albany NY). 2020; 12 (11): 10004–21. DOI: 10.18632/aging.103493.
26. Guan WJ, Liang WH, Zhao Y, Liang HR, Chen ZS, Li YM, et al. China Medical Treatment Expert Group for COVID-19. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. Eur Respir J. 2020; 55 (5): 2000547. DOI: 10.1183/13993003.00547-2020.
27. Bong CL, Brasher C, Chikumba E, McDougall R, Mellin-Olsen J, Enright A. The COVID-19 Pandemic: Effects on Low- and Middle-Income Countries. Anesth Analg. 2020; 131 (1): 86–92. DOI: 10.1213/ANE0000000000004846.
28. Herby J, Joung L, Hanke S. A Literature Review and Meta-Analysis of the Effects of Lockdowns on COVID-19 Mortality. Studies in Applied Economics. 2022; 200: 1–61.