The COVID-19 pandemic in the Arctic: An overview of dynamics from 2020 to 2022

Andrey N. Petrov, Sweta Tiwari, Michele Devlin, Mark Welford, Nikolay Golosov, John DeGroote, Tatiana Degai & Stanislav Ksenofontov

Since February 2020, the COVID-19 pandemic has been unfolding in the Arctic, placing many communities at risk due to their remoteness, limited healthcare options, underlying health issues, and other compounding factors. This paper assimilates diverse sources of COVID-19 data in the Arctic from 2020-2022 and provides a preliminary analysis at the regional (subnational) level. The results suggest that the COVID-19 pandemic outcomes to date (infections, mortality, and case-fatality ratios) were highly variable, but mortality generally remained below respective national levels. The Arctic has persevered through COVID-19 with less dire consequences despite the region's pre-existing vulnerabilities. Based on the varying trends and magnitude of the pandemic, we classify Arctic regions into several groups.

As of October 1, 2022, the Arctic has experienced about 2.4 million confirmed cases and over 29,000 deaths from COVID-19. These outcomes are not uniform across the Arctic region and are greatly influenced by Northern Russia, given its sizable

Andrey N. Petrov, ARCTICenter and Department of Geography, University of Northern Iowa, USA; Sweta Tiwari, ARCTICenter and Department of Geography, University of Northern Iowa, USA; Michele Devlin, ARCTICenter, University of Northern Iowa and United States Army War College, USA; Mark Welford, Department of Geography, University of Northern Iowa, USA; Nikolay Golosov, Department of Geography, Pennsylvania State University, USA; John DeGroote, Department of Geography, University of Northern Iowa, USA; Tatiana Degai, ARCTICenter, University of Northern Iowa, USA and Department of Anthropology, University of Victoria, Canada; Stanislav Ksenofontov, ARCTICenter and Department of Geography, University of Northern Iowa, USA.

Arctic populations. Greenland, the Faroe Islands, Iceland, Northern Canada, and Northern Norway reported just under 60 cumulative deaths per 100,000 population, while Alaska, Northern Russia, and Northern Sweden had over 180 deaths per 100,000. This study summarizes the COVID-19 epidemiological outcomes in the Arctic by its regions from February 2020 to October 2022, with a goal of shedding more light on the factors that determine the pandemic's spatiotemporal dynamics in the Arctic. The COVID-19 epidemiological variability across the Arctic, to a large extent, is explained by geographical isolation, the effectiveness of COVID-19 public health prevention measures, the nature of the health care system, and varying vaccination rates, among other reasons.

Lessons learned by examining the patterns of COVID-19 spread and pandemic outcomes, such as mortality and morbidity their relationships with underlying public health conditions and healthcare resources, as well as socioeconomic characteristics, prevention and mitigation policies, and experiences of the Indigenous Peoples can inform responses to current and future pandemics.

Introduction

COVID-19 (or formally SARS-CoV-2) has, since December 1, 2019, advanced rapidly around the world (Ciotti et al., 2020; Kapitisinis, 2020; MacIntyre, 2020). In fact, SARS-CoV-2 is the fifth pandemic to affect the world since the 1918 flu outbreak, known as "Spanish flu." The others are the 1957 Asian flu, 1968 Hong Kong flu, and 2009 Swine flu. The February 1918 to April 1920 pandemic infected ~500 million and killed between 17-50 million including large numbers of Arctic inhabitants. The 1957-1958 flu infected in-excess of 100 million and killed ~1.1 million, the 1968 flu killed 1 million, and the 2009 flu killed in-excess of 200,000 (Barro et al., 2020; Kilbourne, 2006; Simonsen et al., 2013).

Although pandemic morbidities have declined over the last 100 years, intense globalization has accelerated the spread of these pandemics. Over the course of the COVID-19 pandemic to date (2020-2022) positive cases totalled over 660 million and 6.7 million people perished due to the disease (JHCRC, 2023) and many were left permanently compromised. In other cases, infected individuals barely noticed their infection yet were infectious (JHCRC, 2023; Liu et al., 2020). Research from China, Italy, and Singapore suggested that early morbidity from SARS-CoV-2 was elevated among those individuals suffering from hypertension, diabetes, heart disease, cancer, dementia, or with a medical record of strokes (Singh et al., 2020). Past evidence from China and Italy suggests ~20% of all COVID-19 sufferers who visited hospitals or were hospitalized will suffer subsequent heart disease, while 40-60% of those individuals infected with SARS-CoV between 2002-2004 and who survived continue to suffer heart problems (Bansal 2020). Stringent public health policies and subsequent mass vaccination campaigns conducted in 2021-2022 around the world have slowed down the pandemic (Watson et al., 2022), although the outbreaks continue to persist (JHCRC, 2023).

The Arctic is considered particularly vulnerable to pandemics due to factors such as limited infrastructure and healthcare options, remoteness, difficult socioeconomic conditions, and painful histories of colonization and neglect from central governments in the past (Huot et al., 2019; Petrov et. al, 2021a; Adams & Dorough, 2022). Arctic populations are characterized by high rates of comorbidities including hypertension, diabetes, and heart disease (Erber et al. 2010; Murphy et al. 1997, Arctic Council, 2020) as well as health disparities (Chatwood et al., 2012). In turn, many observers have pointed out that the COVID-19 pandemic has also exacerbated the existing socioeconomic and health vulnerabilities of Arctic residents (Markova et al., 2021, Lemieux et al., 2020, Jaakko et al., 2021, Cook & Johannsdottir, 2021, Men & Tarasuk, 2021 and Golubeva et al., 2022). At the same time, Arctic communities possess capacities that contribute to their resilience to the pandemic, most notably through control over implementing anti-pandemic measures and Indigenous knowledge and practices. In particular, reliance on Indigenous knowledge, generational wisdom, leadership, self-determination, and rapid vaccination have been instrumental in reducing the potential impacts of the COVID-19 pandemic in some Arctic jurisdictions, including Alaska, Northern Canada, and Greenland (Petrov et. al, 2021a; Richardson and Crawford, 2020; Fleury & Chatwood 2022).

COVID-19 was first recorded in the Arctic in February of 2020, and by January 1, 2023 there have been 2,677,457 positive COVID-19 cases and 29,492 deaths. Past analysis indicates that the pandemic's dynamics varied among Arctic regions, with some areas more affected than others (Petrov et al., 2020, 2021b; Tiwari et al;., 2022). There are some indications that while infections, mortality, and case-fatality ratios were highly variable, mortality generally remained below respective national levels (Petrov et al., 2021a).

This paper examines COVID-19 data in the Arctic from February 2020 to September 2022 and provides a preliminary analysis at the regional (subnational) level with a goal to shed more light on the pandemic's spatiotemporal dynamics and outcomes in the Arctic. We used the ARCTICCOVID (ARCTICenter, 2023) dataset for COVID-19 cases and deaths for 52 subnational political units within ten Arctic regions: Alaska, Faroe Islands, Iceland, Greenland, Northern Canada, Northern Norway, Northern Russia, and Northern Sweden.

Dataset and methods

This study utilized data on COVID-19 positive cases and fatalities collected at the subnational (regional, county) level for 52 regions in eight Arctic countries (Figure 1). This follows the Arctic boundaries used in the Arctic Human Development Report (Einarsson et al., 2004) that were revised by Jungsberg et al. (2019).

The data was collected by the project team through the pandemic (Petrov et al., 2020, 2021a) by acquiring daily case and death information from a variety of global, national and regional sources (John Hopkins University Coronavirus Resource Center (https://coronavirus.jhu.edu/map.html), the Public Health Agency of Sweden (https://www.folkhalsomyndigheten.se/), the National Institute for Health and Welfare of Finland (https://thl.fi), the Government of the Russian Federation (https://стопкоронавирус.рф), and Verdens Gang (Norway) - https://vg.no). The data were extracted at 17:00 GMT each day, stored, and published daily on the Arctic COVID-19 dashboard (https://arctic.uni.edu/arctic-covid-19). The temporal coverage extends from February 21, 2020 (the first documented case in the Arctic) to the present. However, for the purposes of this study, we focused on COVID-19 dynamics between February 2020 and September 2022. The data after October 1, 2022 were not included due to changes in data availability as some jurisdictions discontinued regular COVID-19 reporting. We used the ArcticVAX (2021) tracker to obtain information on vaccination trends for the same period.

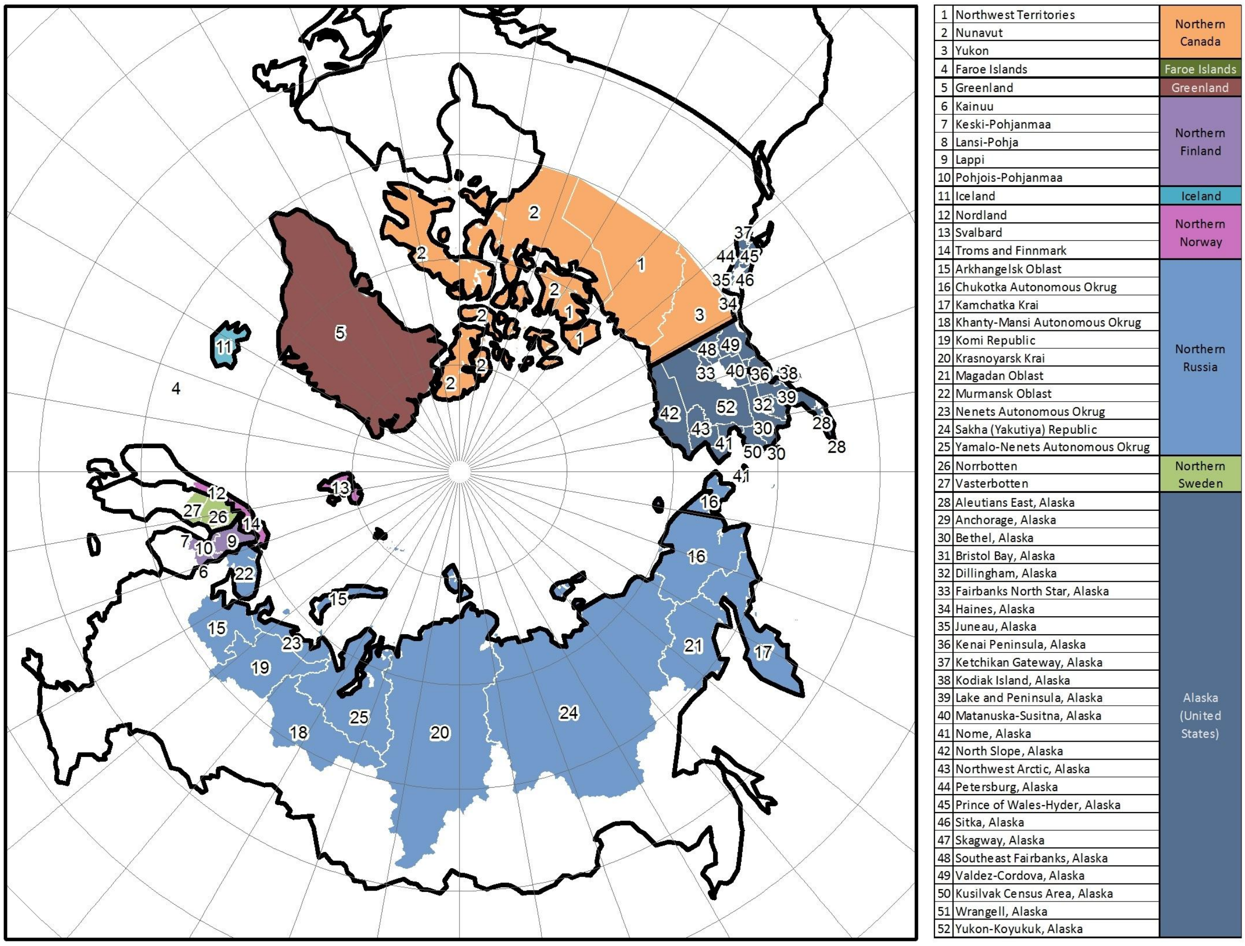


Figure 1. Study area

Variables and definitions

Key epidemiological variables were analysed and are defined here. *Confirmed cases* are individuals detected with SARS-CoV-2 nucleic acid or antigen in their clinical specimen (ECDC, 2020). *Daily increase* is the number of cases confirmed within 24 hours after the previous reporting. *Incidence rate* represents a cumulative number of confirmed cases per 100,000 residents in a given period of time. *Confirmed deaths* are the number of deaths resulting from a clinical illness due to COVID-19 infection (ECDC, 2020). *Mortality rate* is the number of confirmed deaths attributable to COVID-19 infection per 100,000 residents in a given period of time. *Case Fatality Ratio*, or CFR, is the total number of deaths divided by the total number of confirmed cases at a given point in time. Given that data are from diverse sources and multiple jurisdictions, the specific definitions used by the reporting agencies may inevitably vary and have to be interpreted with some caution.

Results

Pandemic outcomes

The analysis of the key pandemic variables (positive COVID-19 cases and deaths (totals), cases and deaths per 100,000 and CFR) indicates that the pandemic had a severe impact on many Arctic regions, although the levels of morbidity and mortality varied considerably. The Arctic as a whole had 20,234.1 positive cases and 234.8 deaths per 100,000 (as of September 1, 2022). A number of regions had elevated case load (e.g., Iceland, Faroe Islands, Alaska) partially because of small population numbers. In contrast, Northern Canada, Norway, and Russia had relatively low incident rates, although the reasons for that may vary (from low levels of infection to underreporting). At the same time, the highest mortality indicators are found in Northern Russia (283.8 per 100,000), Northern Sweden (191.7) and Alaska (188.8). These figures likely reflect public health policy, healthcare, and vaccination campaign challenges in these regions. High mortality also corresponds with the elevated CFR in these countries. If in the Arctic as a whole the CFR stood at 1.2%, in Northern Russia it was 1.7%, in Northern Sweden it was 0.7%, and in Alaska it was 0.5%. It is notable, however, that in all Arctic regions (with the sole exception of Russia) the mortality and CFR were below the national levels of the respective countries. For example, in Alaska mortality was 188.8 per 100,000 versus 324.0 in the U.S. and the CFR was 0.5% versus 1.1% (Table 1). Therefore, most Arctic jurisdictions experienced a less severe COVID-19 pandemic than more southern regions of the same Arctic states.

Table 1. Key COVID-19 pandemic outcomes by Arctic region and county (Data on Sep 1, 2022)

Country/Territory	Cases (cumulative)	Deaths (cumulative)	Cases (per 100,000)	Deaths (per 100 000)	CFR (%)
Arctic	2,474,606	28,721	20234.1	234.8	1.2
Iceland	204,717	213	56220.2	58.5	0.1
Greenland	11,971	21	21367.2	37.5	0.2
Faroe Islands	34,658	28	71464.2	57.7	0.1
Denmark	3,092,530	6,934	53391.3	119.7	0.2
Alaska	292,819	1,338	41319.6	188.8	0.5
USA	96,527,639	1,072,520	29162.2	324.0	1.1
Northern Finland	126,970	n/a	15972.7	n/a	n/a
Finland	1,266,917	5,690	22865.6	102.7	0.4
Northern Canada	19,881	59	14405.1	42.7	0.3
Canada	4,176,359	44,043	11065.5	116.7	1.1
Northern Norway	89,932	113	18339.3	23.0	0.1
Norway	1,460,246	3,980	26877.3	73.3	0.3
Northern Sweden	108,881	796	26223.8	191.7	0.7
Sweden	2,569,152	19,873	25439.0	196.8	0.8
Northern Russia	1,584,777	26,153	17199.5	283.8	1.7
Russia	19,578,730	384,441	13416.1	263.4	2.0

Source: ARCTICenter (2023).

Spatiotemporal dynamics of the COVID-19 pandemic

Figure 2 shows the cumulative number of confirmed COVID-19 cases in the Arctic from February 2020 until October 1, 2022. As can be easily seen, the pandemic has gone through several "waves" (surges in incidents of the infection followed by a substantial decrease sustained over a certain period (Zhang et al., 2021)). Often these waves are given a label derived from a predominant strain of SARS-CoV-2 at the time of its occurrence, although multiple strains co-existed throughout every wave. Overall, the pandemic started relatively late in many Arctic regions, and the first wave did not occur until summer 2020 (Petrov et al., 2020). A delayed start may have been related to the remoteness of Arctic regions, as well as the strict preventive policies implemented in some jurisdictions. In the first year of the pandemic, new COVID-19 cases peaked again around mid-December 2020 ("second wave" (Petrov et al., 2021b)) and then decreased in the early months of 2021. The second and the third ("Delta") waves were well-pronounced, with the "Delta" wave clearly detectable in October-December of 2021 (Tiwari et al., 2022). This was immediately followed by the fourth, "Omicron," wave in the early 2022, which dwarfed previous infection rates (Figure 3). The Omicron wave brought major outbreaks to the Faroe Islands and Iceland, which previously had very few COVID-19 instances. This wave receded by summer of 2022, but positive cases increased again in the fall after many COVID-19 healthcare measures were relaxed. A rise in infections in fall of 2022 clearly indicates that the COVID-19 pandemic in the Arctic was continuing.

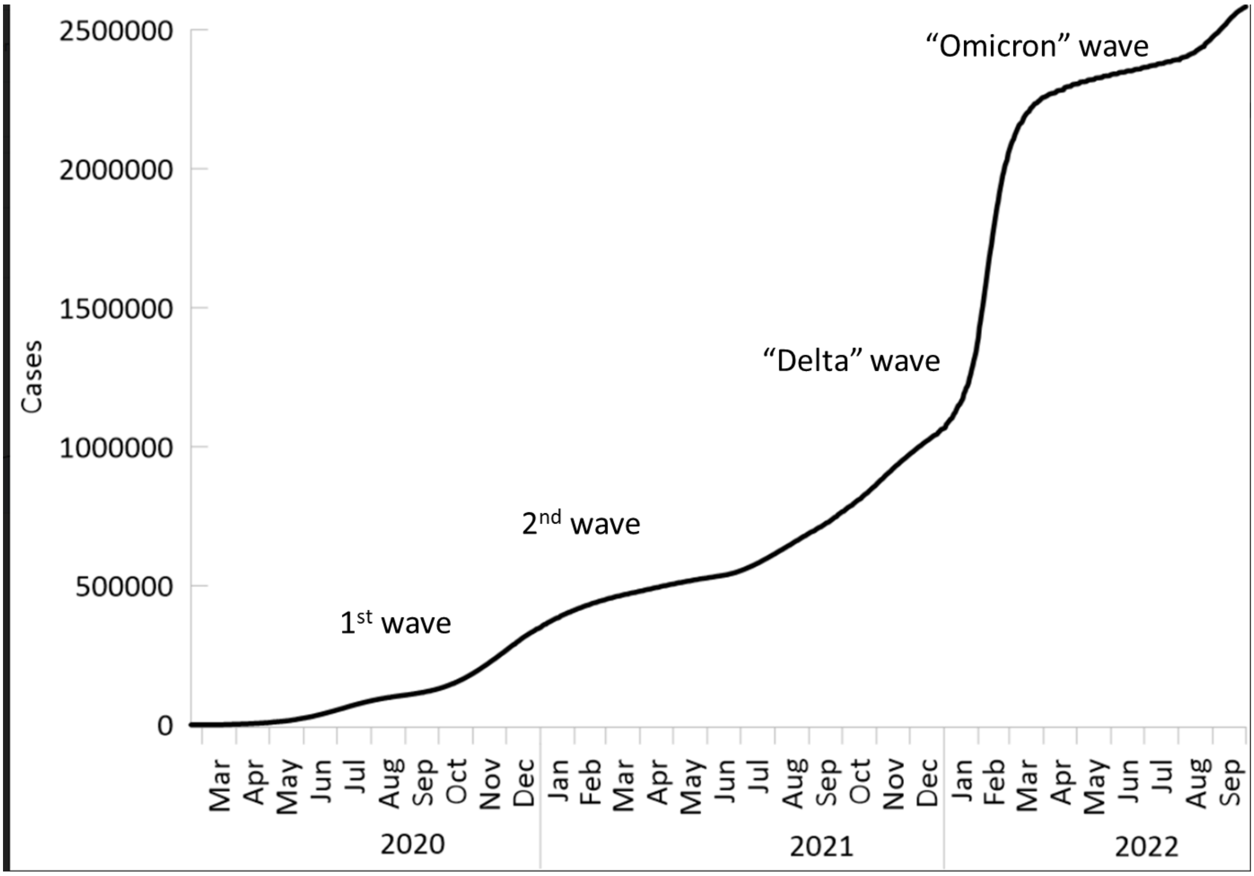


Figure 2. Cumulative Confirmed COVID-19 Cases and Pandemic Waves in the Arctic (February 20, 2020-October 1, 2022)

Cumulative COVID-19 cases and fatalities per 100,000 for each region of the Arctic are demonstrated in Figure 3. The dynamics of COVID-19 deaths likely reflect a differential timing of pandemic onset, difference in anti-COVID policies, and variable success of vaccination campaigns. For example, due to strict public health measures, early in the pandemic COVID-19-related deaths were low with the exception of Sweden, which also posted dramatic early CFRs (Figure 4). Each subsequent wave brought about a spike in death rates. For instance, during the

Delta wave of 2021 in the Arctic, there was an increase of 205.8 percent in cases and 334.8 percent in deaths compared to the previous year. At the same time the Omicron wave of infections in early 2022 did not lead to a distinct increase in mortality. The CFR actually declined in all jurisdiction within a few months after introduction of COVID in the given jurisdiction, except for Northern Russia, where CFR did not decline until the start of 2022. In 2020-2022, the Arctic's cumulative CFR was 1.2%, which is relatively high compared to the global and European ratios (Alrasheedi, 2023, JHCRC, 2023), but mostly influenced by the high CFR in Russia with other Arctic regions experiencing CFRs under 1%.

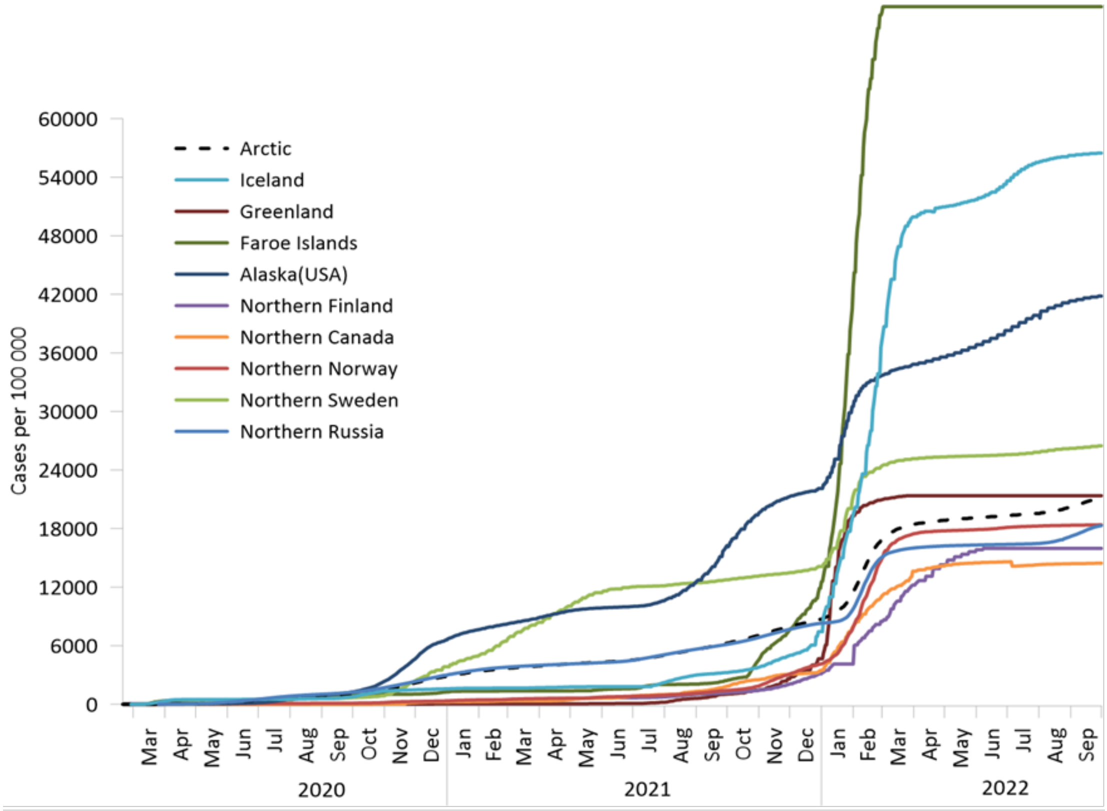
Northern Russia, due to its large population size, has been a driving force behind Arctic COVID-19 cases and fatality trends. Although detected infections per 100,000 in Northern Russia were lower than in some other Arctic regions, the cumulative mortality and CFR were higher, especially later in the pandemic (Figure 3). Northern Russia was one of only a few Arctic jurisdictions with both COVID-19 mobility and fatalities rates higher than in the southern parts of the country. For most Arctic states, the northern regions exhibited lower rates than the national figures (Petrov et al., 2021a).

Alaska experienced similar waves as the rest of the Arctic. The initial COVID-19 spike took place in summer of 2020 (prompted by summer travel and fisheries) with a big wave in the fall. In late 2021, confirmed COVID-19 incidents per 100,000 precipitously increased marking the very pronounced Delta and Omicron waves. During that period, Alaska COVID-19 indicators were more than twice as high as the Arctic as a whole. The growth in infections slowed in March, but rose again in summer of 2022.

Northern Sweden is a very interesting region in respect to the COVID-19 dynamics given its initially relaxed approach to public health emergency policies (Kamerlin & Kasson, 2020). Sweden, including its northern parts, demonstrated rapid growth in COVID-19 cases and deaths very early in the pandemic (spring 2020). Notably, CFR in this period was nearly 9% and CFR five to eight times higher than elsewhere in the Arctic. Both reported infections and fatalities per 100,000 in Northern Sweden were also high during 2021, but in the fall of 2021, the region experienced only a modest increase in new confirmed cases and deaths, seemingly avoiding a distinct Delta wave. Still the Omicron wave in early 2022 was well pronounced.

Greenland, Iceland, and the Faroe Islands reported relatively few positive COVID-19 cases and deaths throughout the pandemic. Iceland went through a short period of growth and decline in new cases between mid-July and October of 2021 followed by a rapid increase in the cases from November onward. Meanwhile Greenland, after mid-July 2021, experienced an upward trend in new cases that further accelerated in late fall and spring of 2022 constituting an outbreak associated with the Omicron wave. A similarly drastic rise was observed in the Faroe Islands. Although both Greenland and the Faroe Islands had very low COVID-19-related mortality during the earlier stages of the pandemic, they saw an increase in the number of deaths in November of 2021.

Northern Norway and Northern Finland had few reported infections and deaths for the first eighteen months of the pandemic. Following a gradual increase starting in spring 2021, new cases quickly rose from November 2021 to March 2022 constituting the Delta and Omicron waves. In Finland elevated daily positive cases extended until June. The number of deaths also grew in this period. Northern Canada had a relatively mild pandemic until summer 2021, when infections started to climb during multi-spike Delta and Omicron waves. Still, Northern Canada, along with Northern Norway and Finland, remain the least pandemic-affected Arctic regions (Figures 3).



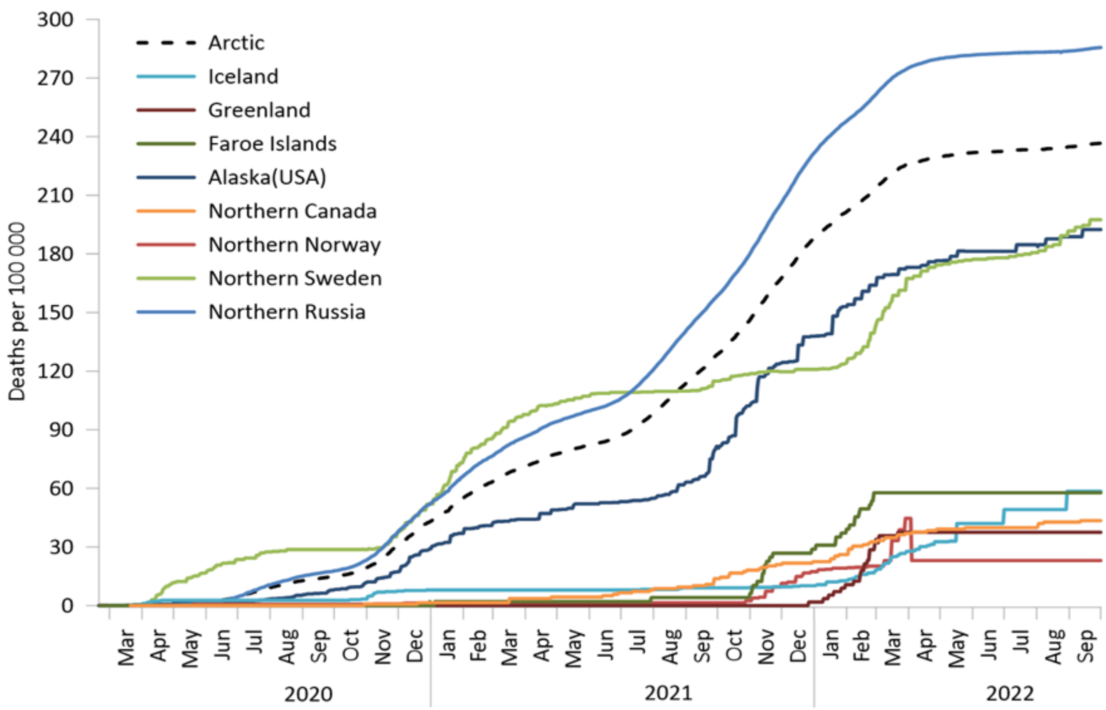


Figure 3. Cumulative cases per 100,00 (top); Cumulative deaths (Bottom) per 100,000, (February 20, 2020-October 1, 2022)

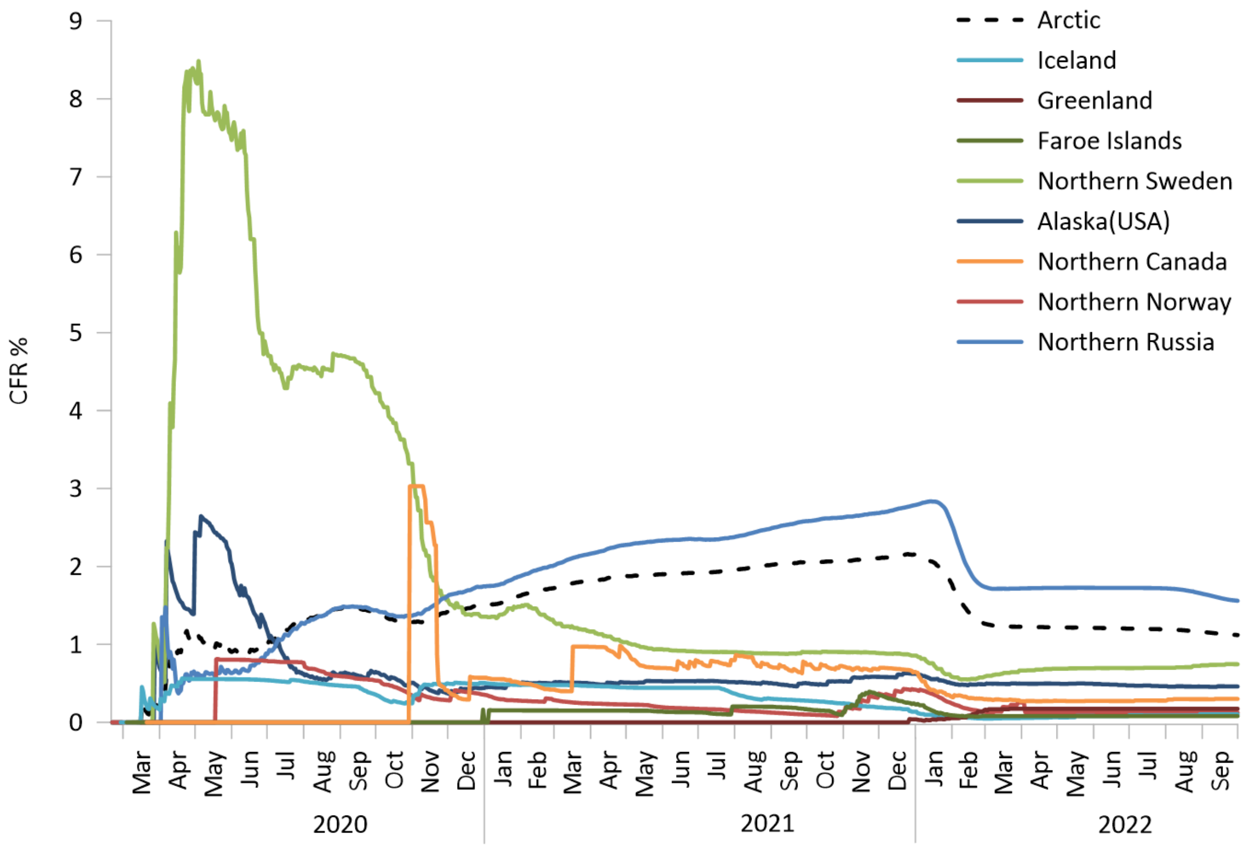


Figure 4. Case-Fatality Ratio (CFR)

Spatiotemporal dynamics of vaccination in the Arctic

As of September 2022, nearly 70% of Arctic residents were fully vaccinated (as defined by a given jurisdiction). The Arctic presents a globally interesting case for examining the spatiotemporal dynamics of COVID-19 vaccination implementation. In fact, some Arctic regions were among the first places in the world where vaccines were broadly distributed and used (Petrov et al., 2021nature, Figure 5). In particular, Alaska and northern Canada started vaccination campaigns as early as December 2020. Northern Canada reached a 50% mark of fully vaccinated population by May of 2021. Although other Arctic jurisdictions started vaccinations later, most of them rapidly increased vaccination rates and attained a 60-70% attainment level by fall of 2021 (Figure 5). The exceptions were Alaska and Northern Russia. In Alaska, despite the December 2020 start, the vaccine uptake was lagging in the subsequent months. In Northern Russia the vaccination campaign was slow and conducted with limited success due in part, to higher vaccine hesitancy (Lazarus et al., 2023) and resistance (Roshchina et al., 2022).

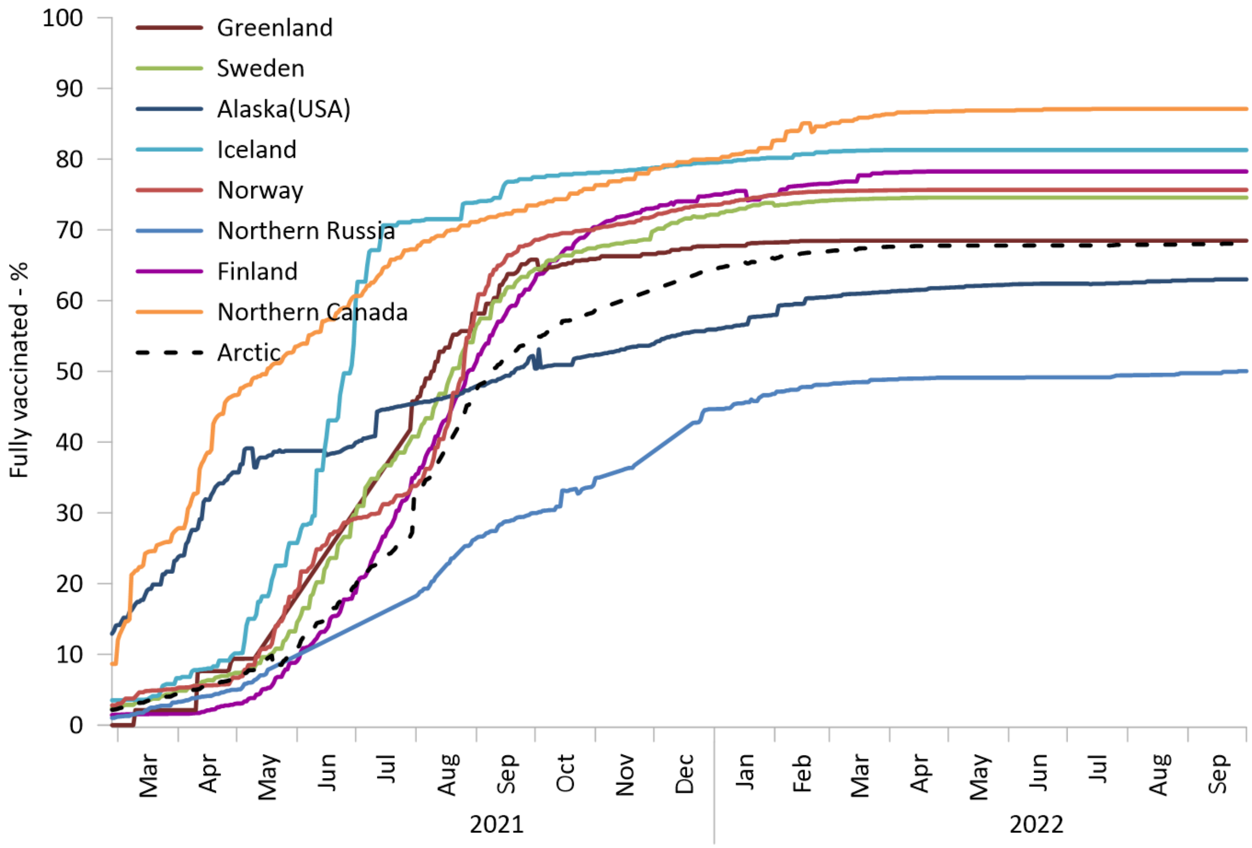


Figure 5. Fully vaccinated individuals by Arctic region (%)

Discussion and conclusions

Overall dynamics: patterns and regional differences

The COVID-19 pandemic in the Arctic is not over: a rise in reported infections in fall of 2022 indicates it very clearly. Although the general course of the pandemic in the Arctic was similar to global and national trends, the COVID-19 pandemic in the Arctic exhibited several important and distinct characteristics. First of all, the onset of the pandemic in most regions was delayed. In part this was due to the remoteness of Arctic communities, and in part because of the stringent anti-COVID measures instituted in most jurisdictions. Remoteness is thought to initially help in delaying the beginning of the pandemic, and thus, to secure more time for preparation for its eventual arrival. On the other hand, when infections and morbidity rise, distant locations of Arctic communities may become an impediment (the "curse of remoteness, Petrov et al., 2021a) for delivering timely high-quality healthcare. This delayed onset, with subsequent major outbreaks, were evident in the Faroe Islands, Greenland, Iceland, and many other Arctic regions. Thus, even though the arrival of a pandemic appears to be inevitable, remote communities can be better prepared for dealing with the disease with careful planning. Notably, mortality and CFR in most northern localities (with the exception of Russia) were considerably below the levels found in more central, southern regions of the same Arctic states. In addition to a delayed onset, factors like strict enforcement of anti-pandemic polices, rapid vaccinating campaigns, ability to exercise self-determination in healthcare, and the engagement of Indigenous knowledge contributed to this outcome (Petrov et al., 2023).

There have been studies that identified typologies of Arctic regions based on COVID-19 trends (Petrov, et al. 2022, Tiwari et al., 2022). Tiwari et al (2022) suggested distinguishing *four regional types* of pandemic dynamics in the Arctic: the first type is characterized by drastic spikes and lows in the daily positive cases. This type of dynamic is observed in Greenland, Iceland, the Faroe Islands, Northern Norway, Northern Finland, and Northern Canada, which were relatively unaffected by the pandemic until late 2021 largely due to strict quarantine measures and subsequent vaccination and battled major surges of infections and deaths during the Delta and Omicron waves. Alaska's represents a separate type, with relatively similar early dynamic, but with a very large outbreak of COVID-19 later in the pandemic (fall 2021-spring 2022), when most anti-COVID restrictions and mandates were ended. Northern Sweden and Northern Russia could be recognized as two additional types of the COVID-19 dynamics. In Northern Sweden a protracted wave was associated with less strict preventive policies in 2020 that determined high infection and mortality rates throughout year one, which subsequently reduced due to tightening measures. Northern Sweden generally avoided the Delta wave, but experienced an Omicron wave in winter-spring 2022. Finally, Northern Russia's trend was characterized by persistently high daily cases and deaths. The pandemic appears to be more severe in the Russian Arctic than elsewhere in the Arctic or in Russia, potentially reflecting the inconsistent and top-down anti-COIVID policies, limited healthcare capacities, and poor availability and/or uptake of vaccines in remote communities (Åslund, 2020).

Lessons learned

As mentioned, many Arctic jurisdictions experienced a less severe COVID-19 pandemic than southern regions of the same states despite greater socioeconomic, infrastructure, and health vulnerabilities in Arctic communities. This is an important notion that may have implications for public health policies. The availability of additional sources of resilience associated with Indigenous knowledge, cultures, and practices may have plaid a major role in the pandemic outcomes. In most notable cases, the Arctic Indigenous communities were able to capitalize on multigenerational memories of the past epidemics, engage Indigenous knowledge and practices, and exercise self-determination in order to combat the pandemic (ITK, 2020; Foxworth et al., 2021; Petrov et al., 2023). For example, Indigenous communities in Alaska and Northern Canada instituted very strict quarantines and other preventive measures, utilized the knowledge of the land to practice isolation and healing, implemented their own priorities in administering western and traditional healthcare (such as focusing on elders, culturally-appropriate treatment, spiritual healing, etc.), and exercised control over vaccination campaigns and other healthcare activities thus asserting their sovereignty in public health affairs. Exercising self-determination, in part or in full, appears to be a factor of pandemic severity among Indigenous communities. Consequently, a strong consideration should be given to recognizing and investing in the Indigenous Peoples' capacity to manage their own healthcare (in the Arctic and elsewhere in the world) as a key policy to ensure preparedness for combating this and future pandemics.

Acknowledgements

This research is supported by NSF PLR #2034886.

References

Adams, L. V., & Dorough, D. S. (2022). Accelerating Indigenous health and wellbeing: the Lancet Commission on Arctic and Northern Health. Lancet (London, England), 399(10325), 613-614.

Alrasheedi, A. A. (2023). The Prevalence of COVID-19 in Europe by the End of November 2022: A Cross-Sectional Study. Cureus, 15(1).

ARCTICenter (2023) Arctic COVID-19 dashboard (https://arctic.uni.edu/arctic-covid-19) Accessed on January 15, 2023.

Arctic Council. (2020). COVID-19 in the Arctic: briefing document for senior arctic officials. Available from: https://oaarchive.arctic-council.org/handle/11374/2473

Åslund, A. (2020). Responses to the COVID-19 crisis in Russia, Ukraine, and Belarus. *Eurasian Geography and Economics*, *61*(4-5), 532-545.

Bansal, M., 2020. Cardiovascular disease and COVID-19. Diabetes & Metabolic Syndrome: Clinical Research & Reviews.

Barro, R.J., Ursúa, J.F. and Weng, J., 2020. The coronavirus and the great influenza pandemic: Lessons from the "spanish flu" for the coronavirus's potential effects on mortality and economic activity (No. w26866). National Bureau of Economic Research.

Chatwood, S., Bjerregaard, P., & Young, T. K. (2012). Global health—A circumpolar perspective. American Journal of Public Health, 102(7), 1246–1249.

Ciotti, M., Ciccozzi, M., Terrinoni, A., Jiang, W.-C., Wang, C.-B., & Bernardini, S. (2020). The COVID-19 pandemic. Critical Reviews in Clinical Laboratory Sciences, 57(6), 365–388.

Cook, D., & Jóhannsdóttir, L. (2021). Impacts, Systemic Risk and National Response Measures Concerning COVID-19—The Island Case Studies of Iceland and Greenland. In Sustainability (Vol. 13, Issue 15). https://doi.org/10.3390/su13158470

Einarsson, E., Larsen, J. N., Nilsson, A., & Young, O. R. (2004). Arctic human development report 2004. Stefansson Arctic Institute, Akureyri, Iceland 242pp.

Erber, E., Beck, L., De Roose, E. and Sharma, S., 2010. Prevalence and risk factors for self-reported chronic disease amongst Inuvialuit populations. Journal of Human Nutrition and Dietetics, 23, pp.43-50.

Fleury, K., & Chatwood, S. (2022). Canadian Northern and Indigenous health policy responses to the first wave of COVID-19. Scandinavian Journal of Public Health, 14034948221092185.

Foxworth, R., Redvers, N., Moreno, M. A., Lopez-Carmen, V. A., Sanchez, G. R., & Shultz, J. M. (2021). Covid-19 Vaccination in American Indians and Alaska Natives—Lessons from Effective Community Responses. New England Journal of Medicine, 385(26), 2403-2406.

Golubeva, E., Emelyanova, A., Kharkova, O., Rautio, A., & Soloviev, A. (2022). Caregiving of Older Persons during the COVID-19 Pandemic in the Russian Arctic Province: Challenges and Practice. In International Journal of Environmental Research and Public Health (Vol. 19, Issue 5). https://doi.org/10.3390/ijerph19052775

Huot, S., Ho, H., Ko, A., Lam, S., Tactay, P., MacLachlan, J., & Raanaas, R. K. (2019). Identifying barriers to healthcare delivery and access in the Circumpolar North: important insights for health professionals. International Journal of Circumpolar Health, 78(1), 1571385.

Inuit Tapiriit Kanatami (ITK). (2020). The Potential Impacts of COVID-19 on Inuit Nunangat. Ottawa.

Johns Hopkins Coronavirus Resource Center (JHCRC), 2023. https://coronavirus.jhu.edu/data/mortality Accessed on January 14, 2023.

Jungsberg, L., Turunen, E., Heleniak, T., Wang, S., Ramage, J., & Roto, J. (2019). Atlas of population, society and economy in the Arctic.

Kapitsinis, N. (2020). The underlying factors of the COVID-19 spatially uneven spread. Initial evidence from regions in nine EU countries. Regional Science Policy & Practice, 12(6), 1027–1045.

Kilbourne, E.D., 2006. Influenza pandemics of the 20th century. Emerging infectious diseases, 12(1), p.9

Lazarus, J. V., Wyka, K., White, T. M., Picchio, C. A., Gostin, L. O., Larson, H. J., ... & El-Mohandes, A. (2023). A survey of COVID-19 vaccine acceptance across 23 countries in 2022. Nature Medicine, 1-10.

Lemieux, T., Milligan, K., Schirle, T., & Skuterud, M. (2020). Initial impacts of the COVID-19 pandemic on the Canadian labour market. Canadian Public Policy, 46(S1), S55–S65.

MacIntyre, C. R. (2020). Global spread of COVID-19 and pandemic potential. Global Biosecurity, 1(3).

Markova, V. N., Alekseeva, K. I., Neustroeva, A. B., & Potravnaya, E. V. (2021). Analysis and forecast of the poverty rate in the Arctic Zone of the Republic of Sakha (Yakutia). Studies on Russian Economic Development, 32(4), 415–423.

Men, F., & Tarasuk, V. (2021). Food insecurity amid the COVID-19 pandemic: food charity, government assistance, and employment. Canadian Public Policy, 47(2), 202–230.

Murphy, N.J., Schraer, C.D., Theile, M.C., Boyko, E.J., Bulkow, L.R., Doty, B.J. and Lanier, A.P., 1997. Hypertension in Alaska Natives: association with overweight, glucose intolerance, diet and mechanized activity. Ethnicity & Health, 2(4), pp.267-275.

Petrov, A. N., Dorough, D. S., Tiwari, S., Welford, M., Golosov, N., Devlin, M., ... & DeGroote, J. (2023). Indigenous health-care sovereignty defines resilience to the COVID-19 pandemic. Lancet (London, England).

Petrov, A. N., Welford, M., Golosov, N., DeGroote, J., Degai, T., & Savelyev, A. (2020a). Spatiotemporal dynamics of the COVID-19 pandemic in the arctic: early data and emerging trends. International Journal of Circumpolar Health, 79(1), 1835251.

Petrov, A. N., Welford, M., Golosov, N., DeGroote, J., Devlin, M., Degai, T., & Savelyev, A. (2021a). Lessons on COVID-19 from Indigenous and remote communities of the Arctic. Nature Medicine, 27(9), 1491–1492. https://doi.org/10.1038/s41591-021-01473-9

Petrov, A. N., Welford, M., Golosov, N., DeGroote, J., Devlin, M., Degai, T., & Savelyev, A. (2021b). The "second wave" of the COVID-19 pandemic in the Arctic: regional and temporal dynamics. International Journal of Circumpolar Health, 80(1), 1925446. https://doi.org/10.1080/22423982.2021.1925446

Richardson, L., & Crawford, A. (2020). COVID-19 and the decolonization of Indigenous public health. Cmaj, 192(38), E1098–E1100.

Roshchina, Y., Roshchin, S., & Rozhkova, K. (2022). Determinants of COVID-19 vaccine hesitancy and resistance in Russia. Vaccine, 40(39), 5739-5747.

Simonsen, L., Spreeuwenberg, P., Lustig, R., Taylor, R.J., Fleming, D.M., Kroneman, M., Van Kerkhove, M.D., Mounts, A.W. and Paget, W.J., 2013. Global mortality estimates for the 2009 Influenza Pandemic from the GLaMOR project: a modeling study. PLoS Med, 10(11), p.e1001558

Tiwari, S., Petrov, A. N., Devlin, M., Welford, M., Golosov, N., DeGroote, J., ... & Ksenofontov, S. (2022). The second year of pandemic in the Arctic: examining spatiotemporal dynamics of the COVID-19 "Delta wave" in Arctic regions in 2021. International Journal of Circumpolar Health, 81(1), 2109562.

Watson, O. J., Barnsley, G., Toor, J., Hogan, A. B., Winskill, P., & Ghani, A. C. (2022). Global impact of the first year of COVID-19 vaccination: a mathematical modelling study. The Lancet Infectious Diseases, 22(9), 1293-1302.

Zhang, S. X., Arroyo Marioli, F., Gao, R., & Wang, S. (2021). A Second Wave? What Do People Mean by COVID Waves? - A Working Definition of Epidemic Waves. Risk management and healthcare policy, 14, 3775–3782. https://doi.org/10.2147/RMHP.S326051