Original Paper

Surveillance Metrics and History of the COVID-19 Pandemic in Central Asia: Updated Epidemiological Assessment

Alexander L Lundberg[1,2], PhD, MSc; Egon A Ozer[3,4], MD, PhD; Scott A Wu[5], BA; Alan G Soetikno[5], BS; Sarah B Welch[1,2], MPH; Yingxuan Liu[1], MA; Robert J Havey[6,7], MD; Robert L Murphy[3,6], MD; Claudia Hawkins[3,8], MD, MPH; Maryann Mason[1,2], PhD; Chad J Achenbach[3,6], MD, MPH; Lori A Post[1,2], PhD

[1]Buehler Center for Health Policy and Economics, Robert J. Havey, MD Institute for Global Health, Northwestern University, Chicago, IL, United States

[2]Department of Emergency Medicine, Feinberg School of Medicine, Northwestern University, Chicago, IL, United States

[3]Department of Medicine, Division of Infectious Diseases, Feinberg School of Medicine, Northwestern University, Chicago, IL, United States

[4]Center for Pathogen Genomics and Microbial Evolution, Robert J. Havey, MD Institute for Global Health, Northwestern University, Chicago, IL, United States

[5]Feinberg School of Medicine, Northwestern University, Chicago, IL, United States

[6]Robert J. Havey, MD Institute for Global Health, Northwestern University, Chicago, IL, United States

[7]Department of Medicine, General Internal Medicine and Geriatrics, Feinberg School of Medicine, Northwestern University, Chicago, IL, United States

[8]Center for Global Communicable and Emerging Infectious Diseases, Robert J. Havey, MD Institute for Global Health, Northwestern University,, Chicago, IL, United States

Corresponding Author:
Alexander L Lundberg, PhD, MSc
Buehler Center for Health Policy and Economics
Robert J. Havey, MD Institute for Global Health
Northwestern University
420 E. Superior St.
Chicago, IL, 60611
United States
Phone: 1 312 503 1706
Email: alexander.lundberg@northwestern.edu

Abstract

Background: This study updates the COVID-19 pandemic surveillance in Central Asia we conducted during the first year of the pandemic by providing 2 additional years of data for the region. The historical context provided through additional data can inform regional preparedness and early responses to infectious outbreaks of either the SARS-CoV-2 virus or future pathogens in Central Asia.

Objective: First, we aim to measure whether there was an expansion or contraction in the pandemic in Central Asia when the World Health Organization (WHO) declared the end of the public health emergency for the COVID-19 pandemic on May 5, 2023. Second, we use dynamic and genomic surveillance methods to describe the history of the pandemic in the region and situate the window of the WHO declaration within the broader history. Third, we aim to provide historical context for the course of the pandemic in Central Asia.

Methods: Traditional surveillance metrics, including counts and rates of COVID-19 transmissions and deaths, and enhanced surveillance indicators, including speed, acceleration, jerk, and persistence, were used to measure shifts in the pandemic. To identify the appearance and duration of variants of concern, we used data on sequenced SARS-CoV-2 variants from the Global Initiative on Sharing All Influenza Data (GISAID). We used Nextclade nomenclature to collect clade designations from sequences and Pangolin nomenclature for lineage designations of SARS-CoV-2. Finally, we conducted a 1-sided *t* test to determine whether regional speed was greater than an outbreak threshold of 10. We ran the test iteratively with 6 months of data across the sample period.

Results: Speed for the region had remained below the outbreak threshold for 7 months by the time of the WHO declaration. Acceleration and jerk were also low and stable. Although the 1- and 7-day persistence coefficients remained statistically significant, the coefficients were relatively small in magnitude (0.125 and 0.347, respectively). Furthermore, the shift parameters for either of the 2 most recent weeks around May 5, 2023, were both significant and negative, meaning the clustering effect of new COVID-19 cases became even smaller in the 2 weeks around the WHO declaration. From December 2021 onward, Omicron was the predominant variant of concern in sequenced viral samples. The rolling *t* test of speed equal to 10 became entirely insignificant for the first time in March 2023.

Conclusions: Although COVID-19 continues to circulate in Central Asia, the rate of transmission remained well below the threshold of an outbreak for 7 months ahead of the WHO declaration. COVID-19 appeared to be endemic in the region and no longer reached the threshold of a pandemic. Both standard and enhanced surveillance metrics suggest the pandemic had ended by the time of the WHO declaration.

(JMIR Public Health Surveill 2024;10:e52318) doi: 10.2196/52318

KEYWORDS

SARS-CoV-2; COVID-19; Central Asia; pandemic; surveillance; public health; COVID-19 transmission; speed; acceleration; deceleration; jerk; dynamic panel; generalized method of moments; GMM; Arellano-Bond; 7-day lag; Armenia; Azerbaijan; Cyprus; Faeroe Islands; Georgia; Gibraltar; Kazakhstan; Kosovo; Kyrgyzstan; Macedonia; Russia; Tajikistan Turkey; Turkmenistan; Uzbekistan

Introduction

Background

COVID-19, the disease caused by the virus SARS-CoV-2, was first detected in Wuhan, China, in the fall of 2019 [1-5]. The first case of COVID-19 in Central Asia [6] is believed to have occurred in Russia on January 31, 2020 [7,8]. Our research team conducted an analysis of the pandemic in Central Asia 1 year into the pandemic [9]. This study provides 2 additional years of updated surveillance and analysis for the region.

We adopted the World Bank's definition of Central Asia, which is based on economic development and geographical proximity, encompassing Armenia, Azerbaijan, Cyprus, Faeroe Islands, Georgia, Gibraltar, Kazakhstan, Kosovo, Kyrgyzstan, North Macedonia, Russia, Tajikistan, Turkey, Turkmenistan, and Uzbekistan [6].

The World Health Organization (WHO) declared the end of COVID-19 as a public health emergency of international concern on May 5, 2023 [10-12] based on the recommendation of the COVID-19 Emergency Committee [12]. To that end, we compared how the pandemic was progressing before and after the declaration.

Empirical Definition of Pandemic Versus Epidemic Versus Outbreak Versus Endemic

Epidemiological terms, such as pandemic, epidemic, outbreak, and endemic, are used to describe the occurrence and spread of disease [13,14]. The distinctions between these terms lie in their scope, geographic extent, and severity. An epidemic refers to a sudden increase in the number of disease cases in a specific population or region. If the epidemic spreads across several countries or continents, it becomes a pandemic. An outbreak, on the other hand, describes a sudden increase in a concentrated setting, usually involving a more limited geographic area than an epidemic. Endemic refers to the constant presence of a disease in a particular geographic region or population, with no sudden increases in case volume [15,16].

Traditional Surveillance Versus Enhanced Surveillance

Public health surveillance is the "ongoing, systematic collection, analysis, and interpretation of health-related data essential to planning and evaluation of public health practice" [17]. Surveillance not only explains the burden of death and disease due to a disease or a social condition but also generates research questions and guides researchers on topics that require further investigation [18-32]. Surveillance allows us to compare the burden of disease between geographical regions and to understand which regions are most impacted. The impact can be measured by rates of illness, hospitalization, and mortality and the associated economic costs of disease.

However, traditional surveillance metrics are often presented through either static or cumulative measures of infection rates and deaths [18-32]. In the middle of a burgeoning pandemic, policymakers and public health practitioners also need to use these metrics to understand what is about to happen. Is an outbreak increasing? Will growth switch from linear to exponential? Are more people dying from a condition in one place than another? To inform health policy and practice, knowledge of what is about to happen is often critical. Traditional surveillance metrics can be used to know and forecast infection rates and mortality. To that end, we developed enhanced surveillance metrics that translate traditional metrics into predictions of growth, including where along the epidemiological outbreak curve a particular region is situated. We also include metrics about the speed of the pandemic at the national, regional, and global levels. We measure how acceleration of speed this week compares with last week, as well as how novel infections last week predict new cases this week. We can think of the latter measure as the echoing forward of cases. These metrics were tested and validated in prior research [9,33-43]. For this study, we used both traditional and enhanced surveillance metrics to analyze the possible end to the pandemic in Central Asia.

Objective

This study had 3 objectives. First, we aimed to measure whether there was an expansion or contraction in the pandemic in Central Asia when WHO declared the end of the COVID-19 pandemic as a public health emergency of international concern on May

5, 2023. At both the region and country levels, we used advanced surveillance techniques to describe the status of the pandemic in a 2-week window around the WHO declaration. From a public health perspective, we need to know whether the rate of new COVID-19 cases was increasing, decreasing, or stable from week to week and if any changes in the transmission rate indicated an acceleration or deceleration of the pandemic. Statistical insignificance is significant—it can signal the epidemiological "end" to the pandemic if the rate of new cases is 0 (or very low) and stable, meaning the number of new cases is neither accelerating nor decelerating.

Second, we used dynamic and genomic surveillance methods to describe the history of the pandemic in the region and situate the time window around the WHO declaration within the broader history. We included the ratio of COVID-19 deaths to the number of transmissions as a proxy for the mortality risk from infection at the population level. We also included a historical record of genomic surveillance from sequenced viral specimens to identify the appearance and spread of variants of concern in the region.

Third, we aimed to provide historical context for the course of the pandemic in Central Asia. We addressed several questions: How did countries respond to the pandemic? How did the region fare in terms of disease burden? In addition, what social, economic, and political factors shaped the course of COVID-19 in the region? This context can provide important lessons for disease prevention and mitigation in future pandemics.

Methods

Data Sources

This study conducted trend analyses with longitudinal COVID-19 data from Our World in Data (OWID) [44]. OWID compiles data on COVID-19 cases and mortality from various sources, including individual websites, statistical reports, and press releases. For the region of Central Asia, the data comprised an unbalanced panel of 16 countries and territories, running from July 31, 2020, to May 12, 2023. To analyze the pandemic over time, we used traditional and enhanced surveillance indicators. Traditional indicators include total cases and deaths, along with the 7-day moving average of new cases and deaths [9]. Enhanced surveillance metrics include (1) speed: the weekly average number of new positive tests per day per total country population multiplied by 100,000; (2) acceleration: the weekly average of the day-over-day changes in speed; (3) jerk: the week-over-week change in the acceleration rate of transmissions; and (4) 7-day persistence: the predictive effect of speed, indicating the number of new cases statistically attributable to new cases reported 7 days before. These transmission metrics can identify not only the presence and severity of outbreaks but also whether outbreaks are contracting, escalating, or imminent. For a full glossary of terms, see Multimedia Appendix 1.

To derive the 7-day persistence effect on speed, we established an empirical difference equation that links the number of new positive cases in each country on each day to the number of cases 7 days prior, weekend indicators, and weekly shift variables:

$$y_{it}=\rho y_{it-1}+\beta \mathbf{X}_{it}+\alpha_i+u_{it} \quad \textbf{(1)}$$

The dependent variable y_{it} is speed in country *i* at time *t*, and the independent variables $\mathbf{X}_{it}$ include weekend and recent week indicators, while α_i denotes a country fixed effect and u_{it} is the idiosyncratic error term. Please see the initial study for more details [9]. We estimated the model using the generalized method of moments approach of the Arellano-Bond estimator over a rolling window of 120 days [45-47]. The Arellano-Bond estimator offers several statistical advantages. It (1) enables a statistical examination of the model's predictive ability and validity of model specification; (2) corrects for autocorrelation and heteroskedasticity; (3) is well suited for data with a small number of time periods and large number of countries; and (4) addresses omitted variables, providing a statistical test of correction validity. This method proved effective at identifying and statistically validating changes in the pandemic's evolution within a period of 1 week. For a more comprehensive discussion of the method, see Oehmke et al [41,42].

To identify the appearance and duration of variants of concern, we also used data on sequenced SARS-CoV-2 variants from the Global Initiative on Sharing All Influenza Data (GISAID), which is an effective and trusted online resource for sharing genetic, clinical, and epidemiological COVID-19 data [48-51]. We used Nextclade nomenclature [52] to collect clade designations from sequences and Pangolin nomenclature for lineage designations of SARS-CoV-2 [53,54]. Metadata for the study period were collected on June 22, 2023. To avoid low frequency or potentially erroneous samples, the data set was further filtered to exclude months with fewer than 100 available samples, variant groups with fewer than 5 samples in a month, and variant groups representing less than 0.5% of the total samples in a month. The final data set consisted of 184,386 total samples available on GISAID [48-51]. All statistical analyses were conducted in R (version 4.2.1) with the *plm* package (version 2.6-2) [45,46]. For a snapshot of the data, see Multimedia Appendix 2.

We analyzed the potential "statistical end" to the pandemic with a 1-sided *t* test for whether the mean of speed was equal to or greater than the outbreak threshold of 10. We ran the test on a rolling 6-month window over weekly speed for the region, and we plotted the *P* values from the test over time.

Ethical Considerations

This study followed the guidelines of the World Medical Association's Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects [55,56]. This study was not submitted to the Northwestern University Institutional Review Board because all results are based on publicly available data with no private, identifiable information and the research did not involve any interaction with individual participants.

Results

Table 1 presents the dynamic panel estimates for the most recent time window. The Wald test for the regression was significant ($P<.001$), and the Sargan test failed to reject the validity of the overidentification restrictions (*P*~1). Although the 1- and 7-day lag coefficients were statistically significant, suggesting a cluster effect in which cases on a given day impact cases 1 day and 7 days later, the coefficients were relatively small in magnitude (0.125 and 0.347, respectively). Furthermore, the shift parameters for either of the 2 most recent weeks were both significant and negative, meaning the clustering effect had become even smaller in the 2 weeks around May 5, 2023.

Traditional surveillance metrics for the weeks of April 28, 2023, and May 5, 2023, are provided in Tables 2 and 3. Except for Cyprus, every country had a small number of new COVID-19 cases. The next highest rate of new cases per 100,000 population was 3.04 in Georgia, considered a low transmission rate by the Centers for Disease Control and Prevention (CDC) [57]. This rate falls well below the informal threshold of 10 cases per day per 100,000 population [9,33-43]. Specifically, a "Low" transmission is considered no more than 10 cases per 100,000 population per week. "Moderate" transmission is 10 to 50 cases per 100,000 people per week. "Substantial" transmission is 50 to 100 cases per 100,000 people per week [57,58]. Although Cyprus appears to have been in a large outbreak in the week of April 28, 2023, the territory had 0 reported cases in OWID for the week of May 5, 2023. This drop most likely reflects episodic reporting, seen by several countries and territories around the world at the time.

Overall, the status of the pandemic around the WHO declaration in Central Asia is consistent with an "end" to the pandemic. An outbreak in Cyprus is restricted to the island. Based on the definition of a pandemic or an outbreak in several countries, the data indicate a shift from a pandemic to endemic COVID-19 in Central Asia, while it was epidemic in Cyprus. However, we note that metrics for Russia and Ukraine may be less reliable because of the ongoing war.

Comparing Tables 2 and 3 demonstrates little to no change before and after the WHO declared an end to the pandemic. Without question, Russia had the most cases of COVID-19 transmissions and deaths, but this rank is a function of population size. Thus, a better measure is the number of COVID-19 cases and deaths per 100,000 population. Moreover, death is often a better proxy for the state of an outbreak than transmissions because deaths are less likely to be undercounted [59]. Undercounting may be due to poor public health infrastructure, home antigen testing, or a dearth in polymerase chain reaction (PCR) testing or other resources. Azerbaijan and Russia each reported 0.02 deaths per 100,000 population. When we control for risk of death given the number of COVID-19 transmissions, we find that North Macedonia had the highest conditional death rate of 0.028 deaths per 100,000 population. Even though Cyprus was in an outbreak at the time the WHO declared the end of COVID-19 as a public health emergency, with 268 weekly cases per 100,000 population, the relative risk of death per infection was among the lowest in the region.

Tables 4 and 5 contain enhanced dynamic surveillance metrics for the 2 weeks before and after May 5, 2023. Speed was low for every country, and acceleration was either 0 or negative. The 7-day persistence effect on speed was also 0 or negative. These metrics suggest the pandemic may have indeed ended for the region. Because only a single country was in an outbreak, epidemiologically, COVID-19 would be considered an epidemic in Cyprus and not reach the threshold of a pandemic. We note that the figures in Tables 4 and 5 are calculated as day-over-day averages across the week. Thus, the magnitudes of speed, for example, tend to be roughly one-seventh the magnitudes of weekly speed in Tables 2 and 3.

Table 6 compares the 1-day persistence effect on speed for the 6 countries with nonnegative acceleration on the week of May 5 for both that week and the week prior. In each case, the effect was either 0 or negative and close to 0. Again, these metrics indicate that COVID-19 was well controlled in the region overall.

Figure 1 plots regional speed, acceleration, jerk, and 7-day persistence metrics from July 31, 2020, to May 12, 2023. The horizontal, dashed grey line denotes the informal CDC outbreak threshold of speed equal to 10. The vertical, solid grey lines denote the start of each calendar month. The region was in a nearly continuous state of outbreak from November 2020 until April 2022. A final outbreak occurred from July 2022 to October 2022. The region saw a slight bump in cases around the end of February 2023. This bump occurred around the time of the Russian invasion of Ukraine. However, the region has since seen speed decline and remain stable around 2 new cases per 100,000 population.

Central Asia saw 2 pronounced outbreaks over the course of the pandemic. The first was a rapid spike in weekly speed, reaching a peak of 68 in December 2020. The second, even larger outbreak, reached a peak speed just over 100 in February of 2022. Figure 2 plots variant groups as a proportion of all viral specimens collected and sequenced in the region (and made available through GISAID) each month. The first outbreak occurred just around the appearance of the Alpha variant. The second outbreak was driven by the Omicron variant. Central Asia, like much of the rest of the world, saw a surge in cases amid the heightened transmissibility of Omicron [60].

Another potential indication of the end to the pandemic is the continued dominance of the Omicron variant. Although the region saw a mixture of the ancestral, Alpha, Beta, and Delta variants prior to the arrival of Omicron in November 2021, viral sequences have almost exclusively returned as Omicron and its subvariants ever since.

Figure 3 plots *P* values from a series of 1-sided *t* tests to determine whether speed for the region was equal to or greater than the threshold outbreak of 10. These tests were conducted on a rolling 6-month window of weekly regional speed. The dashed grey line denotes the least restrictive conventional significance level threshold of α=.10. The test first rejected the null in favor of the alternative for the 6-month period ending in mid-February 2021. From then on, the test rejected the null until the start of August 2022. The test statistic became insignificant from approximately mid-February 2023 onward. This more recent lack of statistical significance is consistent with the end to the pandemic in the region, as the test clearly failed to reject the null hypothesis of at least outbreak threshold speed.

With the historical context of enhanced surveillance metrics, the region appeared to be at the end stage of the pandemic. Speed had not been this low for this long since the start of the pandemic. We do note, however, that the military conflict in the region disrupted public health infrastructure. Data were likely to be underreported for Russia and Ukraine in particular. This reality brings some uncertainty to the ostensible end to the pandemic in the region.

Figure 4 provides a timeline of the onset of COVID-19 in Central Asia as well as vaccination programs and major events that likely created additional challenges to disease control, such as the Russian invasion of Ukraine and the earthquake in Turkey. Although Ukraine technically resides in Eastern Europe, millions of refugees fled Ukraine, accelerating the spread of disease in the region. Mass human migration is affiliated with increased disease transmission [61].

Table 1. Arellano-Bond dynamic panel data estimates of the number of daily COVID-19 infections reported by country in Central Asia from April 28, 2023, to May 12, 2023.

Variable	Value	*P* value[a]
1-day lag coefficient	0.125	<.001
7-day lag coefficient	0.347	.006
Shift parameter week of April 28	–0.385	<.001
Shift parameter week of May 5	–0.147	<.001
Weekend effect	–0.461	.60

[a]Wald test: χ^2_6=1641.02, *P*<.001; Sargan: χ^2_{540}=11, *P*~1.

Table 2. Traditional COVID-19 surveillance metrics for Central Asian countries in the week of April 28, 2023.

Country	New COVID-19 cases, n	Cumulative COVID-19 cases, n	New cases, 7-day moving average	Transmission (per 100,000 persons)	New deaths, n	Cumulative deaths, n	Death rate, 7-day moving average	Death rate (per 100,000 persons)	Conditional death rate
Armenia	0	449,113	7.29	0	0	8749	0.29	0	0.019
Azerbaijan	22	831,482	30.71	0.21	4	10,254	2.71	0.04	0.012
Cyprus	2404	660,854	343.43	268.30	10	1364	1.43	1.12	0.002
Georgia	114	1,841,495	123.29	3.04	0	17,065	0.29	0	0.009
Gibraltar	0	20,550	0	0	0	113	0	0	0.005
Kazakhstan	63	1,502,857	49.43	0.32	0	19,072	0	0	0.012
Kosovo	4	273,861	3.14	0.22	0	3206	0	0	0.012
Kyrgyzstan	0	206,888	1.71	0	0	2991	0	0	0.014
North Macedonia	0	348,215	10.43	0	0	9676	0.43	0	0.028
Russia	4215	22,870,557	4382.71	2.91	32	398,463	32	0.02	0.017
Uzbekistan	46	253,146	43.57	0.13	0	1637	0	0	0.006

Table 3. Traditional COVID-19 surveillance metrics for Central Asian countries in the week of May 5, 2023.

Country	New COVID-19 cases, n	Cumulative COVID-19 cases, n	New cases, 7-day moving average	Transmission rate (per 100,000 persons)	New deaths, n	Cumulative deaths, n	Death rate, 7-day moving average	Death rate (per 100,000 persons)	Conditional death rate
Armenia	0	449,148	5	0	0	8749	0	0	0.019
Azerbaijan	20	831,619	19.57	0.19	2	10,262	1.14	0.02	0.012
Cyprus	0	660,854	0	0	0	1364	0	0	0.002
Georgia	0	1,842,046	78.71	0	0	17,070	0.71	0	0.009
Gibraltar	0	20,550	0	0	0	113	0	0	0.005
Kazakhstan	0	1,502,857	0	0	0	19,072	0	0	0.013
Kosovo	0	273,876	2.14	0	0	3206	0	0	0.012
Kyrgyzstan	0	206,888	0	0	0	2991	0	0	0.014
North Macedonia	0	348,276	8.71	0	0	9677	0.14	0	0.028
Russia	3111	22,892,353	3113.71	2.15	28	398,658	27.86	0.02	0.017
Uzbekistan	42	253,405	37	0.12	0	1637	0	0	0.006

Table 4. Enhanced surveillance metrics for Central Asian countries in the week of April 28, 2023.

Country	Speed	Acceleration	Jerk	7-day persistence effect on speed
Armenia	0.26	0	0	–0.04
Azerbaijan	0.30	–0.06	–0.03	–0.03
Cyprus	38.33	38.33	38.33	0
Georgia	3.29	–0.06	0.08	–0.43
Gibraltar	0	0	0	0
Kazakhstan	0.25	0	0.01	–0.03
Kosovo	0.18	–0.03	–0.01	–0.03
Kyrgyzstan	0.03	0	0	0
North Macedonia	0.50	0	0	–0.06
Russia	3.03	–0.23	–0.01	–0.45
Uzbekistan	0.13	0	0	–0.01

Table 5. Enhanced surveillance metrics for Central Asian countries in the week of May 5, 2023.

Country	Speed	Acceleration	Jerk	7-day persistence effect on speed
Armenia	0.18	0	0	–0.01
Azerbaijan	0.19	0	0.05	–0.01
Cyprus	0	–38.33	–38.33	–1.44
Georgia	2.10	–0.43	0.03	–0.12
Gibraltar	0	0	0	0
Kazakhstan	0	–0.05	–0.01	–0.01
Kosovo	0.12	–0.03	–0.02	–0.01
Kyrgyzstan	0	0	0	0
North Macedonia	0.42	0	0	–0.02
Russia	2.15	–0.11	0.08	–0.11
Uzbekistan	0.11	0	0	0

Table 6. Comparison of 1-day persistence in the 6 countries in Central Asia with positive (nonnegative) accelerations for the week of May 5, 2023.

Country	1-day persistence week of April 28	1-day persistence week of May 5
Armenia	–0.02	0
Azerbaijan	–0.03	0
Gibraltar	0	0
Kyrgyzstan	0	0
North Macedonia	0	–0.01
Uzbekistan	–0.01	0

Figure 1. Enhanced weekly surveillance metrics (speed, acceleration, jerk, and 7-day persistence) for COVID-19 infections in Central Asia from July 31, 2020, to May 12, 2023.

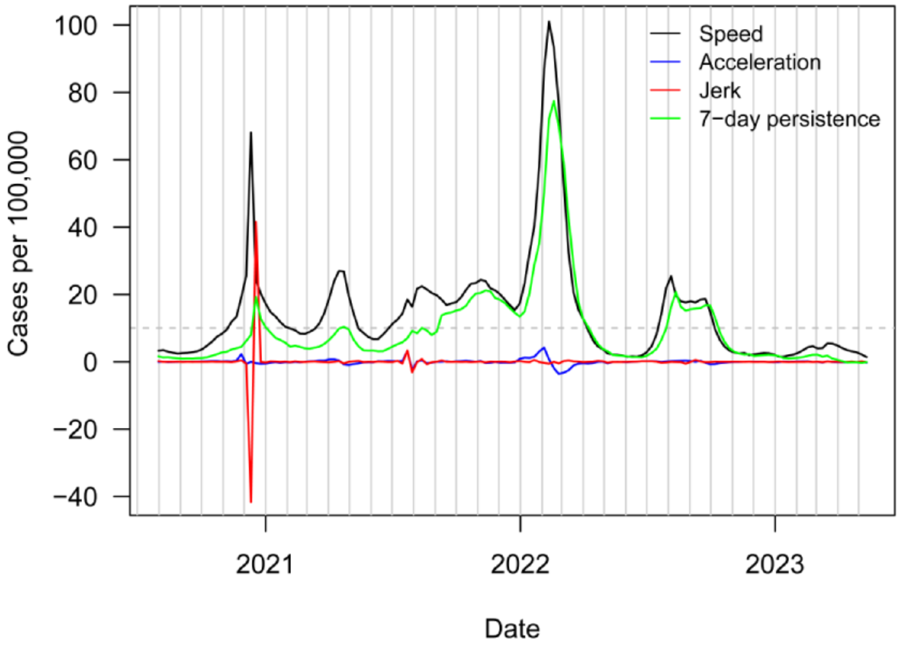


Figure 2. Variant groups as a proportion of all sequenced SARS-CoV-2 specimens from March 2020 to May 2023 in Central Asia (n=184,386). VOC: variant of concern.

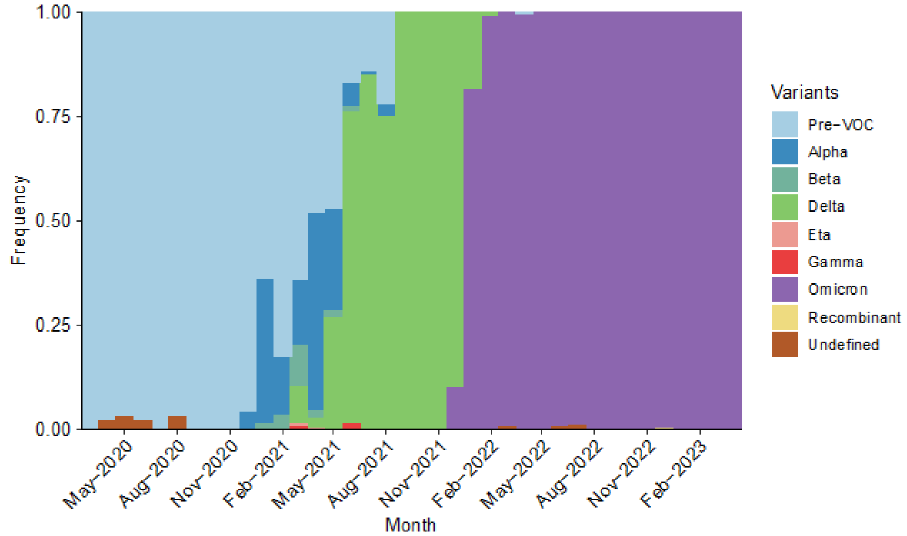


Figure 3. *P* values from *t* tests of weekly COVID-19 transmissions per 100,000 population equal to 10 over a rolling, 6-month window in Central Asia.

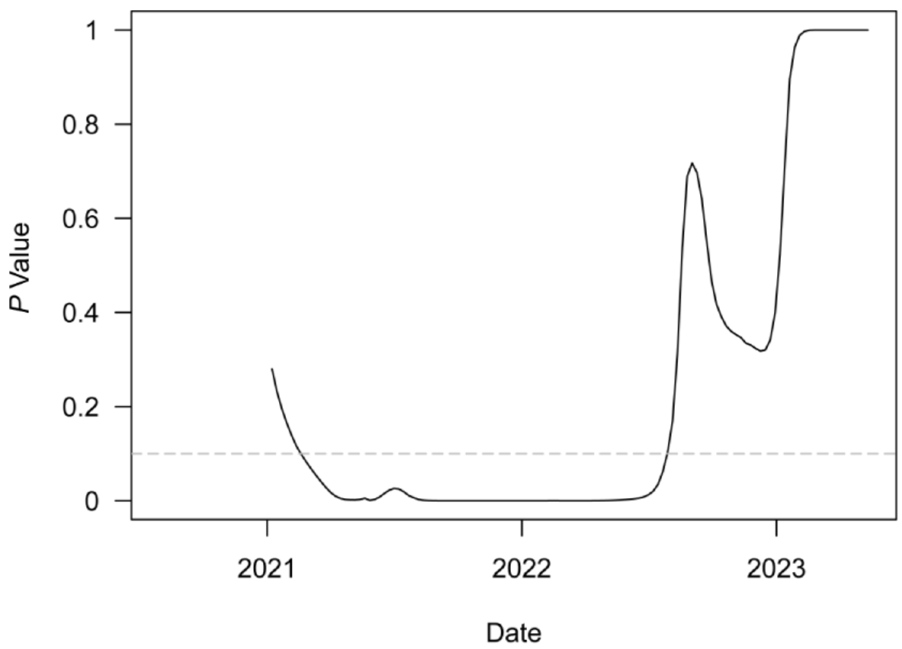
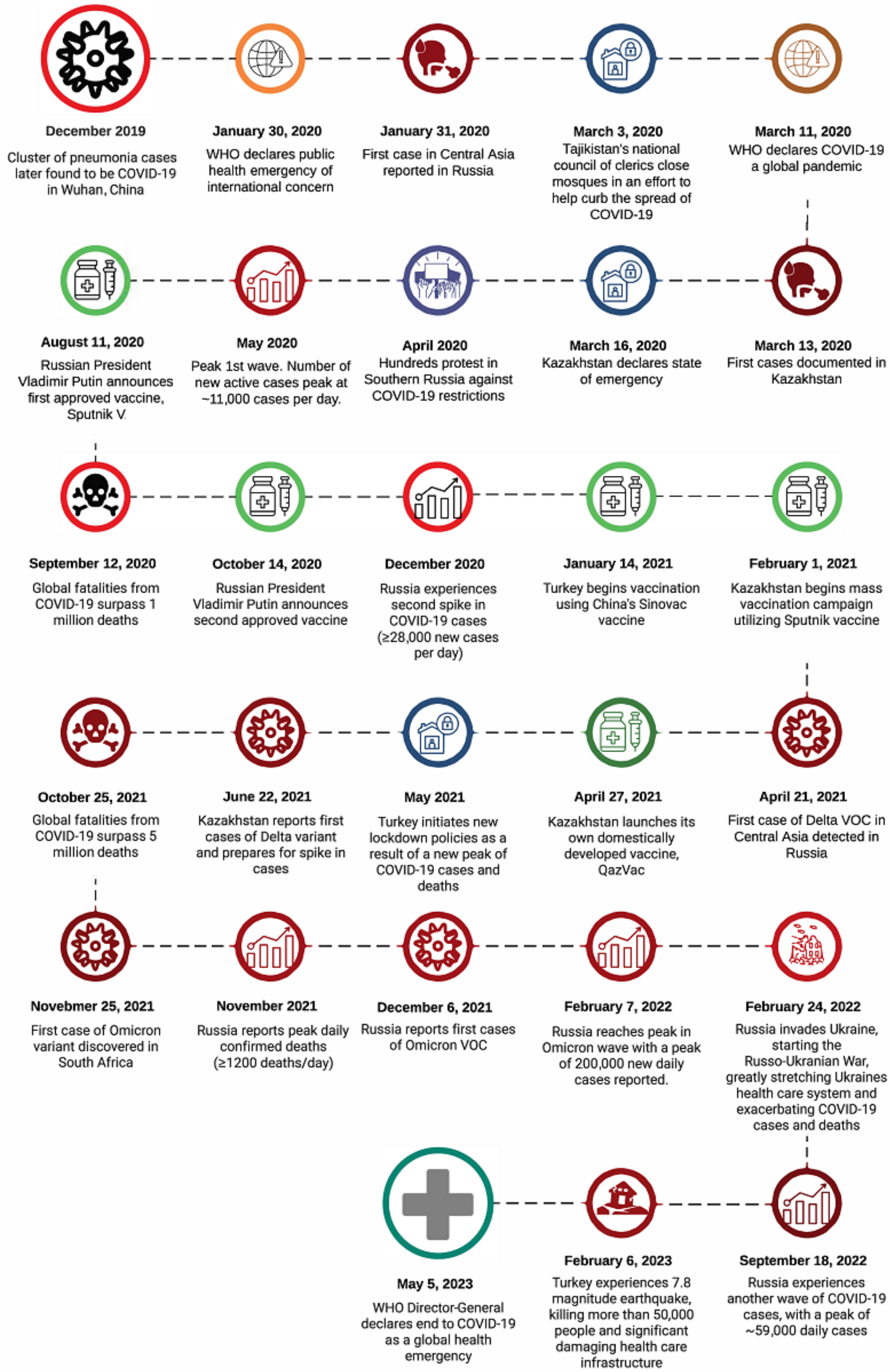


Figure 4. Timeline of the COVID-19 pandemic in Central Asia. WHO: World Health Organization.



Discussion

Summary

The first aim of this study was to assess the status of the pandemic in Central Asia when WHO declared the end of the COVID-19 pandemic as a public health emergency of international concern. In line with the declaration, surveillance metrics suggest the COVID-19 pandemic had ended for the region and switched to an endemic. This categorization aligns with the distinction between pandemic and endemic occurrences, with the former characterized by heightened transmission rates and widespread disease propagation across an entire region. Conversely, the latter denotes the perpetual existence of a disease within a defined global area, devoid of abrupt surges in case numbers [13-16]. Still, to situate the period of the WHO declaration within the broader history, the COVID-19 pandemic had a substantial impact on Central Asia. As seen from Figure

1, the region was in a nearly continuous state of outbreak for most of the pandemic. For the 11 countries represented in Table 3, nearly 500,000 residents had died from COVID-19 by the time of the WHO declaration.

The war between Russia and Ukraine brought a bump in cases, which may be underestimated due to public health infrastructure damage in Ukraine and war propaganda in Russia. Despite the bump, the rate of new cases had been low and relatively stable for approximately 7 months by May 5, 2023. Another mass disaster that presented a COVID-19 challenge to the Central Asian region was the earthquake in Turkey in February 2023 that killed more than 50,000 people, rendering the public health infrastructure severely compromised. Mass disasters and large population movement are affiliated with disease transmission [62-67].

The impact of the pandemic in the region was driven partly by the region's reliance on extractive-sector exports and migrant remittances [68,69]. The closure of international borders exacerbated the region’s economic issues, including an undiversified and informal structure of production and exports, limited private sector involvement, and widespread employment gaps [68,69]. The economic contraction varied dramatically in the region, with Kyrgyzstan experiencing a 12.6% contraction, in contrast to Turkmenistan's reported 1.8% growth [68,70].

The Omicron surge in early 2022 had produced an all-time high in COVID-19 transmission rates when Russia invaded Ukraine in February 2023 [71-73]. The war also exacerbated the impact of the pandemic [74,75], as only one-third of the adult population in Ukraine had been fully vaccinated [76]. The war triggered the displacement of a significant portion of Ukrainians to other parts of Central Asia (as well as to other global regions), leading to surges in not only COVID-19 but other infectious diseases, including tuberculosis [71,72,77]. The conflict also disrupted access to critical medical services and created challenges for COVID-19 vaccine dissemination [71,72,77-80]. The lack of data reporting from the Russian government further fueled public health distrust both domestically and internationally [81-86].

Strict lockdown measures in Central Asia initially helped contain the spread of COVID-19, but the region’s public health care systems were eventually overwhelmed due to insufficient resources [87]. Countries in the region responded idiosyncratically to the pandemic. Some countries promptly acknowledged the virus and implemented containment measures, while others denied its existence and took limited action [68,87]. Russia's response focused on limiting contact with China, including closing borders and implementing strict quarantine measures [88,89]. However, some actions were criticized for being excessively restrictive [90,91].

Public health systems in Central Asia continue to struggle with high rates of infectious and chronic diseases [92,93]. Moreover, underfunding and corruption have resulted in limited access to quality health care in the region [68,94]. Although lockdown measures helped mitigate the impact of COVID-19, many countries in Central Asia experienced high morbidity and mortality [68,94]. Notably, North Macedonia and Georgia had the highest COVID-19 mortality rates in the region and ranked in the top 10 globally [95]. The pandemic also led to reduced health care services for other diseases like HIV, hepatitis, and tuberculosis, further adding to the public health burden [87]. Other humanitarian issues, such as the effects of climate change on agriculture and the Russian invasion of Ukraine, have posed unique energy and economic challenges to neighboring countries [68,96]. The slow recovery from the pandemic is attributed to the lack of reliable public health infrastructure, war, widespread poverty, and export-focused economies in the region [68,96-98]. As of May 2023, long-term financial and economic repercussions are still evident [99].

COVID-19 vaccine hesitancy was particularly high in Central Asia [100]. The development and acceptance of vaccines varied in the region. The early approval of Russia's Sputnik V vaccine drew criticism for its premature release without adequate clinical trials [101-107]. Despite widespread distribution, a considerable proportion of Russians remained hesitant to vaccinate [108-110]. Efforts to increase vaccine access in Central Asia involved partnerships with international organizations, such as the European Union and the WHO [111-115]. However, vaccination rates in the region still lagged behind more developed regions [116].

Economic policies in Central Asia aimed to augment social safety nets and support businesses during the pandemic [68,117]. Still, protests regarding the social toll of the pandemic emerged across the region [118]. In Cyprus, protests against lockdown measures and government corruption led to confrontations with the police [119]. Similar demonstrations occurred in Turkey in response to vaccination mandates [120]. In Russia, rallies and virtual protests criticized lockdown measures and the government's pandemic response [121,122].

Overall, the COVID-19 pandemic had far-reaching effects on Central Asia, impacting health care systems, economies, and social well-being. The region continues to grapple with the aftermath of the pandemic, and addressing its long-term consequences remains a significant challenge. Many countries in the region continue to face challenges due to limited economic and health care resources [9,93].

Limitations

COVID-19 data had become less frequently reported around the world by the time the WHO declared an end to the pandemic [123]. Additionally, more people began to use at-home tests as the pandemic evolved [124], and the Russian invasion of Ukraine damaged public health infrastructure, which may have reduced the accuracy of reported cases in the region. The 7-day persistence measure is intended to mitigate the limitation. The model includes country fixed effects, which control for time-invariant, unobserved heterogeneity among countries. The estimates are also based on a rolling 120-day window, which limits the influence of changes in data reports outside of any particular window. Still, to the extent that a nonincluded country is unrepresentative of the region in disease burden, the omission of a country or territory can influence historical data comparisons. Viral specimen tests for variants of concern in GISAID are also dependent on testing and sequencing capacity, which varied by country across the region.

Conclusions

The concern about potential resurgences of the virus is valid. As long as COVID-19 continues to spread and mutate, the possibility of new variants emerging remains. Variants could potentially be more transmissible, be resistant to vaccines, or cause more severe illness. This underlines the importance of continued vigilance, vaccination efforts, and global cooperation to control the spread of the virus [40].

Central Asia has experienced a relatively high disease burden from COVID-19, with approximately 500,000 deaths. For future pandemics, the ability to limit disease burden ahead of vaccines and treatment modalities will be a challenge, but the challenge can be informed and mitigated from the lessons of the COVID-19 pandemic. An epidemiological task force with a contact-tracing system, coupled with widespread testing of individuals, may be the first line of defense [125]. Lockdown policies, while costly, have also proven effective [126].

Although regional and political cooperation has been a bright spot for pandemic readiness around the world, including Central Asia, the region may face unique difficulties in a future pandemic if military conflict continues to pose a threat to public health [69,127]. Human migration caused by displacement, for example, is affiliated with increased disease transmission [61]. Regional and global efforts to promote peace are therefore an important tool for pandemic preparedness and response. Novel indicators of preparedness at the regional level could be helpful in these efforts, as they can identify countries in relative need of support [128]. Ongoing cooperation will be critical to reduce the disease burden of future pandemics, especially if a novel pathogen arrives outside of peacetime [129,130].

Acknowledgments

Research reported in this publication was generously supported by the Robert J. Havey, MD Institute for Global Health's *Global Innovation Challenge Award* at Northwestern University, Feinberg School of Medicine.

We gratefully acknowledge all data contributors (ie, the authors and their originating laboratories responsible for obtaining the specimens and their submitting laboratories for generating the genetic sequence and metadata and sharing via the Global Initiative on Sharing All Influenza Data (GISAID) Initiative, on which this research is based).

Generative artificial intelligence (AI) was not used in any part of the creation of this manuscript, including data collection and analysis, drafting, and editing.

Data Availability

All data in this study are unrestricted and publicly available in the Our World in Data (OWID) and Global Initiative on Sharing All Influenza Data (GISAID) repositories noted in the Methods section [48,44]. All genome sequences and associated metadata are published in GISAID's EpiCoV database. To view the contributors of each individual sequence with details such as accession number, virus name, collection date, originating lab, submitting lab, and list of authors, visit [131].

Conflicts of Interest

None declared.

Multimedia Appendix 1

Glossary.
[DOCX File , 14 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Data snapshot.
[DOCX File , 15 KB-Multimedia Appendix 2]

References

1. Muralidar S, Ambi SV, Sekaran S, Krishnan UM. The emergence of COVID-19 as a global pandemic: Understanding the epidemiology, immune response and potential therapeutic targets of SARS-CoV-2. Biochimie. Dec 2020;179:85-100. [FREE Full text] [doi: 10.1016/j.biochi.2020.09.018] [Medline: 32971147]
2. Sharma A, Ahmad Farouk I, Lal SK. COVID-19: A review on the novel coronavirus disease evolution, transmission, detection, control and prevention. Viruses. Jan 29, 2021;13(2):202. [FREE Full text] [doi: 10.3390/v13020202] [Medline: 33572857]
3. Chilamakuri R, Agarwal S. COVID-19: characteristics and therapeutics. Cells. Jan 21, 2021;10(2):206. [FREE Full text] [doi: 10.3390/cells10020206] [Medline: 33494237]
4. Hu B, Guo H, Zhou P, Shi Z. Characteristics of SARS-CoV-2 and COVID-19. Nat Rev Microbiol. Mar 06, 2021;19(3):141-154. [FREE Full text] [doi: 10.1038/s41579-020-00459-7] [Medline: 33024307]

5. Seyed Hosseini E, Riahi Kashani N, Nikzad H, Azadbakht J, Hassani Bafrani H, Haddad Kashani H. The novel coronavirus Disease-2019 (COVID-19): Mechanism of action, detection and recent therapeutic strategies. Virology. Dec 2020;551:1-9. [FREE Full text] [doi: 10.1016/j.virol.2020.08.011] [Medline: 33010669]
6. The world by region. The World Bank. URL: https://datatopics.worldbank.org/sdgatlas/archive/2017/the-world-by-region.html [accessed 2024-07-24]
7. First two persons infected with coronavirus identified in Russia. Russian News Agency. Jan 31, 2020. URL: https://tass.com/society/1115101 [accessed 2024-07-24]
8. Russia: First cases of novel coronavirus confirmed January 31. Crisis 24. Jan 31, 2020. URL: https://crisis24.garda.com/alerts/2020/01/russia-first-cases-of-novel-coronavirus-confirmed-january-31 [accessed 2024-07-24]
9. Post LA, Benishay ET, Moss CB, Murphy RL, Achenbach CJ, Ison MG, et al. Surveillance metrics of SARS-CoV-2 transmission in Central Asia: longitudinal trend analysis. J Med Internet Res. Feb 03, 2021;23(2):e25799. [FREE Full text] [doi: 10.2196/25799] [Medline: 33475513]
10. Smith-Schoenwalder C. When Does the COVID-19 Pandemic End? U.S. News & World Report. May 12, 2023. URL: https://www.usnews.com/news/health-news/articles/2023-05-12/when-does-the-covid-19-pandemic-end [accessed 2024-07-24]
11. Burki T. WHO ends the COVID-19 public health emergency. The Lancet Respiratory Medicine. Jul 2023;11(7):588. [doi: 10.1016/s2213-2600(23)00217-5]
12. WHO chief declares end to COVID-19 as a global health emergency. United Nations. May 05, 2023. URL: https://news.un.org/en/story/2023/05/1136367 [accessed 2024-07-24]
13. Lesson 1: Introduction to Epidemiology. CDC Archive. URL: https://archive.cdc.gov/#/details?url=https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section11.html [accessed 2024-07-24]
14. Epidemic, Endemic, Pandemic: What are the Differences? Columbia University Mailman School of Public Health. Feb 19, 2021. URL: https://www.publichealth.columbia.edu/public-health-now/news/epidemic-endemic-pandemic-what-are-differences [accessed 2024-07-24]
15. The Lancet Infectious Diseases. Transitioning to endemicity with COVID-19 research. The Lancet Infectious Diseases. Mar 2022;22(3):297. [doi: 10.1016/s1473-3099(22)00070-6]
16. Pandemic to Endemic: The Race Against Time. Tony Blair Institute for Global Change. Sep 19, 2021. URL: https://institute.global/policy/pandemic-endemic-race-against-time [accessed 2024-07-24]
17. Hong R, Walker R, Hovan G, Henry L, Pescatore R. The power of public health surveillance. Dela J Public Health. Jul 2020;6(2):60-63. [FREE Full text] [doi: 10.32481/djph.2020.07.016] [Medline: 34467112]
18. Teutsch SM, Churchill RE. Principles and practice of public health surveillance. Oxford, United Kingdom. Oxford University Press; 2000.
19. Teutsch SM. Considerations in Planning a Surveillance System. In: Lee LM, Teutsch SM, Thacker SB, St Louis ME, editors. Principles & Practice of Public Health Surveillance (3rd edn). Oxford, United Kingdom. Oxford University Press; 2010:18-31.
20. Teutsch SM, Thacker SB. Planning a public health surveillance system. Epidemiol Bull. Mar 1995;16(1):1-6. [Medline: 7794696]
21. Thacker SB, Qualters JR, Lee LM. Public health surveillance in the United States: evolution and challenges. MMWR Suppl. 2012;61(3):3-9. [FREE Full text]
22. Klaucke DN, Buehler JW, Thacker SB, Parrish RG, Trowbridge FL, Berkelman RL, et al. Surveillance Coordination Group. Guidelines for evaluating surveillance systems. MMWR Supplements. 1988;37(S5):1-18. [FREE Full text]
23. Lee LM, Thacker SB. Public health surveillance and knowing about health in the context of growing sources of health data. Am J Prev Med. Dec 2011;41(6):636-640. [doi: 10.1016/j.amepre.2011.08.015] [Medline: 22099242]
24. Davis AM, Snider DE, Thacker SB, Teutsch SM. CDC guidelines : improving the quality. Centers for Disease Control and Prevention. 1996. URL: https://stacks.cdc.gov/view/cdc/24407 [accessed 2024-07-24]
25. Thacker S, Stroup DF. Future directions for comprehensive public health surveillance and health information systems in the United States. Am J Epidemiol. Sep 01, 1994;140(5):383-397. [doi: 10.1093/oxfordjournals.aje.a117261] [Medline: 8067331]
26. Nsubuga P, White ME, Thacker SB, Anderson MA, Blount SB, Broome CV, et al. Public health surveillance: a tool for targeting and monitoring interventions. In: Jamison DT, Breman JG, Measham AR, editors. Disease Control Priorities in Developing Countries, 2nd edition. New York, NY. Oxford University Press; 2006:2011.
27. Lee LM, Teutsch SM, Thacker SB, St Louis ME. Principles and practice of public health surveillance. Oxford, United Kingdom. Oxford University Press; 2010.
28. Thacker SB, Stroup DF, Rothenberg RB. Public health surveillance for chronic conditions: a scientific basis for decisions. Stat Med. Feb 28, 1995;14(5-7):629-641. [doi: 10.1002/sim.4780140520] [Medline: 7792453]
29. Perry HN, McDonnell SM, Alemu W, Nsubuga P, Chungong S, Otten MW, et al. Planning an integrated disease surveillance and response system: a matrix of skills and activities. BMC Med. Aug 15, 2007;5(1):24. [FREE Full text] [doi: 10.1186/1741-7015-5-24] [Medline: 17697387]
30. Koo D, Thacker SB. In snow's footsteps: Commentary on shoe-leather and applied epidemiology. Am J Epidemiol. Sep 15, 2010;172(6):737-739. [doi: 10.1093/aje/kwq252] [Medline: 20720100]

31. Romaguera R, German RR, Klaucke DN. Evaluating Public Health Surveillance. In: Teutsch SM, Churchill RE, editors. Principles and practice of public health surveillance. Oxford, United Kingdom. Oxford University Press; 2000:176-193.
32. Pappaioanou M, Malison M, Wilkins K, Otto B, Goodman RA, Churchill R, et al. Strengthening capacity in developing countries for evidence-based public health: the data for decision-making project. Soc Sci Med. Nov 2003;57(10):1925-1937. [doi: 10.1016/s0277-9536(03)00058-3] [Medline: 14499516]
33. Post L, Boctor MJ, Issa TZ, Moss CB, Murphy RL, Achenbach CJ, et al. SARS-CoV-2 surveillance system in Canada: longitudinal trend analysis. JMIR Public Health Surveill. May 10, 2021;7(5):e25753. [FREE Full text] [doi: 10.2196/25753] [Medline: 33852410]
34. Post L, Culler K, Moss CB, Murphy RL, Achenbach CJ, Ison MG, et al. Surveillance of the second wave of COVID-19 in Europe: longitudinal trend analyses. JMIR Public Health Surveill. Apr 28, 2021;7(4):e25695. [FREE Full text] [doi: 10.2196/25695] [Medline: 33818391]
35. Post L, Marogi E, Moss CB, Murphy RL, Ison MG, Achenbach CJ, et al. SARS-CoV-2 surveillance in the Middle East and North Africa: longitudinal trend analysis. J Med Internet Res. Jan 15, 2021;23(1):e25830. [FREE Full text] [doi: 10.2196/25830] [Medline: 33302252]
36. Post L, Ohiomoba RO, Maras A, Watts SJ, Moss CB, Murphy RL, et al. Latin America and the Caribbean SARS-CoV-2 surveillance: longitudinal trend analysis. JMIR Public Health Surveill. Apr 27, 2021;7(4):e25728. [FREE Full text] [doi: 10.2196/25728] [Medline: 33852413]
37. Post LA, Argaw ST, Jones C, Moss CB, Resnick D, Singh LN, et al. A SARS-CoV-2 surveillance system in sub-Saharan Africa: modeling study for persistence and transmission to inform policy. J Med Internet Res. Nov 19, 2020;22(11):e24248. [FREE Full text] [doi: 10.2196/24248] [Medline: 33211026]
38. Post LA, Issa TZ, Boctor MJ, Moss CB, Murphy RL, Ison MG, et al. Dynamic public health surveillance to track and mitigate the US COVID-19 epidemic: longitudinal trend analysis study. J Med Internet Res. Dec 03, 2020;22(12):e24286. [FREE Full text] [doi: 10.2196/24286] [Medline: 33216726]
39. Post LA, Lin JS, Moss CB, Murphy RL, Ison MG, Achenbach CJ, et al. SARS-CoV-2 wave two surveillance in East Asia and the Pacific: longitudinal trend analysis. J Med Internet Res. Feb 01, 2021;23(2):e25454. [FREE Full text] [doi: 10.2196/25454] [Medline: 33464207]
40. Post LA, Lorenzo-Redondo R. Omicron: fewer adverse outcomes come with new dangers. The Lancet. Apr 2022;399(10332):1280-1281. [doi: 10.1016/s0140-6736(22)00514-1]
41. Oehmke JF, Moss CB, Singh LN, Oehmke TB, Post LA. Dynamic panel surveillance of COVID-19 transmission in the United States to inform health policy: observational statistical study. J Med Internet Res. Oct 05, 2020;22(10):e21955. [FREE Full text] [doi: 10.2196/21955] [Medline: 32924962]
42. Oehmke JF, Oehmke TB, Singh LN, Post LA. Dynamic panel estimate-based health surveillance of SARS-CoV-2 infection rates to inform public health policy: model development and validation. J Med Internet Res. Sep 22, 2020;22(9):e20924. [FREE Full text] [doi: 10.2196/20924] [Medline: 32915762]
43. Oehmke TB, Post LA, Moss CB, Issa TZ, Boctor MJ, Welch SB, et al. Dynamic panel data modeling and surveillance of COVID-19 in metropolitan areas in the United States: longitudinal trend analysis. J Med Internet Res. Feb 09, 2021;23(2):e26081. [FREE Full text] [doi: 10.2196/26081] [Medline: 33481757]
44. Coronavirus pandemic (COVID-19). Our World in Data. 2020. URL: https://ourworldindata.org/coronavirus [accessed 2024-07-24]
45. Croissant Y, Millo G. Panel data econometrics in R: the plm package. Journal of Statistical Software. 2008;27(2):1-43. [FREE Full text] [doi: 10.18637/jss.v027.i02]
46. R Core Team. R: A language and environment for statistical computing. Vienna, Austria. R Foundation for Statistical Computing; 2021. URL: https://www.R-project.org/ [accessed 2024-07-24]
47. Hansen LP. Large sample properties of generalized method of moments estimators. Econometrica. Jul 1982;50(4):1029. [doi: 10.2307/1912775]
48. Global Initiative on Sharing All Influenza Data (GISAID). 2024. URL: https://www.gisaid.org/ [accessed 2024-04-18]
49. Khare S, Gurry C, Freitas L, Schultz MB, Bach G, Diallo A, GISAID Core Curation Team, et al. GISAID's role in pandemic response. China CDC Wkly. Dec 03, 2021;3(49):1049-1051. [FREE Full text] [doi: 10.46234/ccdcw2021.255] [Medline: 34934514]
50. Shu Y, McCauley J. GISAID: Global initiative on sharing all influenza data - from vision to reality. Euro Surveill. Mar 30, 2017;22(13):30494. [FREE Full text] [doi: 10.2807/1560-7917.ES.2017.22.13.30494] [Medline: 28382917]
51. Nasereddin A, Golan Berman H, Wolf DG, Oiknine-Djian E, Adar S. Identification of SARS-CoV-2 variants of concern using amplicon next-generation sequencing. Microbiol Spectr. Aug 31, 2022;10(4):e0073622. [FREE Full text] [doi: 10.1128/spectrum.00736-22] [Medline: 35758686]
52. Huddleston J, Hadfield J, Sibley T, Lee J, Fay K, Ilcisin M, et al. Augur: a bioinformatics toolkit for phylogenetic analyses of human pathogens. J Open Source Softw. Jan 2021;6(57):2906. [FREE Full text] [doi: 10.21105/joss.02906] [Medline: 34189396]

53. Rambaut A, Holmes EC, O'Toole Á, Hill V, McCrone JT, Ruis C, et al. A dynamic nomenclature proposal for SARS-CoV-2 lineages to assist genomic epidemiology. Nat Microbiol. Nov 15, 2020;5(11):1403-1407. [FREE Full text] [doi: 10.1038/s41564-020-0770-5] [Medline: 32669681]
54. O'Toole Á, Scher E, Underwood A, Jackson B, Hill V, McCrone JT, et al. Assignment of epidemiological lineages in an emerging pandemic using the pangolin tool. Virus Evol. 2021;7(2):veab064. [FREE Full text] [doi: 10.1093/ve/veab064] [Medline: 34527285]
55. World Medical Association Declaration of Helsinki- ethical principles for medical research involving human subjects. World Medical Association. URL: https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/ [accessed 2024-07-24]
56. Hu M. Pandemic surveillance: Privacy, security, and data ethics. Northampton, MA. Edward Elgar Publishing; 2022.
57. Levenson E, Firger J. What the CDC's 'substantial' and 'high' levels of Covid-19 transmission actually mean. CNN. Jul 28, 2021. URL: https://www.cnn.com/2021/07/28/health/substantial-or-high-covid-19-transmission-wellness/index.html [accessed 2024-07-24]
58. Christie A, Brooks JT, Hicks LA, Sauber-Schatz EK, Yoder JS, Honein MA, et al. CDC COVID-19 Response Team. Guidance for implementing COVID-19 prevention strategies in the context of varying community transmission levels and vaccination coverage. MMWR Morb Mortal Wkly Rep. Jul 27, 2021;70(30):1044-1047. [FREE Full text] [doi: 10.15585/mmwr.mm7030e2] [Medline: 34324480]
59. Stoto M. Public health assessment in the 1990s. Annu Rev Public Health. 1992;13:59-78. [doi: 10.1146/annurev.pu.13.050192.000423] [Medline: 1599602]
60. Lundberg AL, Lorenzo-Redondo R, Ozer EA, Hawkins CA, Hultquist JF, Welch SB, et al. Has Omicron changed the evolution of the pandemic? JMIR Public Health Surveill. Jan 31, 2022;8(1):e35763. [FREE Full text] [doi: 10.2196/35763] [Medline: 35072638]
61. Buckee C, Noor A, Sattenspiel L. Thinking clearly about social aspects of infectious disease transmission. Nature. Jul 30, 2021;595(7866):205-213. [doi: 10.1038/s41586-021-03694-x] [Medline: 34194045]
62. Ćurković M, Svetina L, Košec A. Double jeopardy; What happens when an epidemic is followed by an earthquake? Spat Spatiotemporal Epidemiol. Feb 2021;36:100402. [FREE Full text] [doi: 10.1016/j.sste.2021.100402] [Medline: 33509429]
63. Fakhruddin B, Blanchard K, Ragupathy D. Are we there yet? The transition from response to recovery for the COVID-19 pandemic. Prog Disaster Sci. Oct 2020;7:100102. [FREE Full text] [doi: 10.1016/j.pdisas.2020.100102] [Medline: 34171013]
64. Joshi N, Dash MK, Jayakumar R. Transmission modes of COVID-19 disease pandemic in the light of ancient wisdom of Ayurveda medicine: a review. J Complement Integr Med. May 17, 2021;19(1):71-82. [doi: 10.1515/jcim-2020-0390] [Medline: 34002582]
65. Hariri-Ardebili MA, Lall U. Superposed natural hazards and pandemics: breaking dams, floods, and COVID-19. Sustainability. Aug 04, 2021;13(16):8713. [doi: 10.3390/su13168713]
66. Qureshi M. Management of Mass Fatalities. In: Ciottone G, editor. Ciottone's Disaster Medicine. New York, NY. Elsevier; 2024:347-353.
67. Quigley MC, Attanayake J, King A, Prideaux F. A multi-hazards earth science perspective on the COVID-19 pandemic: the potential for concurrent and cascading crises. Environ Syst Decis. May 16, 2020;40(2):199-215. [FREE Full text] [doi: 10.1007/s10669-020-09772-1] [Medline: 32427170]
68. COVID-19 crisis response in Central Asia. OECD. Nov 16, 2020. URL: https://www.oecd.org/en/publications/2020/11/covid-19-crisis-response-in-central-asia_a456db3e.html [accessed 2024-07-24]
69. Gleason G, Baizakova K. COVID-19 in the Central Asian region. Connections. 2020;19(2):101-114. [FREE Full text]
70. Smith-Spark L. The countries making dubious claims over Covid-19 – and what that means for the world. CNN. Mar 05, 2021. URL: https://www.cnn.com/2021/03/05/world/covid-tanzania-turkmenistan-north-korea-intl/index.html [accessed 2024-02-20]
71. Maggioni A, Gonzales-Zamora JA, Maggioni A, Peek L, McLaughlin SA, von Both U, et al. Cascading risks for preventable infectious diseases in children and adolescents during the 2022 invasion of Ukraine. Int J Environ Res Public Health. Jun 08, 2022;19(12):7005. [FREE Full text] [doi: 10.3390/ijerph19127005] [Medline: 35742254]
72. Roberts L. Surge of HIV, tuberculosis and COVID feared amid war in Ukraine. Nature. Mar 15, 2022;603(7902):557-558. [doi: 10.1038/d41586-022-00748-6] [Medline: 35292767]
73. Armitage R. Battlefronts in Ukraine: Russian invasion and COVID-19. Br J Gen Pract. Jun 30, 2022;72(720):334-334. [doi: 10.3399/bjgp22x719945]
74. Allam Z, Bibri SE, Sharpe SA. The rising impacts of the COVID-19 pandemic and the Russia–Ukraine war: energy transition, climate justice, global inequality, and supply chain disruption. Resources. Oct 28, 2022;11(11):99. [doi: 10.3390/resources11110099]
75. Chumachenko D, Chumachenko T. Impact of war on the dynamics of COVID-19 in Ukraine. BMJ Glob Health. Apr 15, 2022;7(4):e009173. [FREE Full text] [doi: 10.1136/bmjgh-2022-009173] [Medline: 35428677]
76. The Lancet Regional Health-Europe. The regional and global impact of the Russian invasion of Ukraine. Lancet Reg Health Eur. Apr 2022;15:100379. [doi: 10.1016/j.lanepe.2022.100379] [Medline: 35531494]

77. Kumar N, Acharya A, Gendelman HE, Byrareddy SN. The 2022 outbreak and the pathobiology of the monkeypox virus. J Autoimmun. Jul 2022;131:102855. [FREE Full text] [doi: 10.1016/j.jaut.2022.102855] [Medline: 35760647]
78. Uwishema O, Sujanamulk B, Abbass M, Fawaz R, Javed A, Aboudib K, et al. Russia-Ukraine conflict and COVID-19: a double burden for Ukraine's healthcare system and a concern for global citizens. Postgrad Med J. Aug 2022;98(1162):569-571. [FREE Full text] [doi: 10.1136/postgradmedj-2022-141895] [Medline: 35654572]
79. Kovoor J, Bacchi S, Gupta AK, Maddern GJ. COVID-19 and the Ukraine-Russia conflict: warnings from history. Br J Surg. Jul 15, 2022;109(8):777. [FREE Full text] [doi: 10.1093/bjs/znac133] [Medline: 35513353]
80. Ramírez C, Durón RM. The Russia-Ukraine war could bring catastrophic public-health challenges beyond COVID-19. Int J Infect Dis. Jul 2022;120:44-45. [FREE Full text] [doi: 10.1016/j.ijid.2022.04.016] [Medline: 35427786]
81. Malchrzak W, Babicki M, Pokorna-Kałwak D, Doniec Z, Mastalerz-Migas A. COVID-19 vaccination and Ukrainian refugees in Poland during Russian–Ukrainian war—narrative review. Vaccines. Jun 16, 2022;10(6):955. [doi: 10.3390/vaccines10060955]
82. Su Z, McDonnell D, Cheshmehzangi A, Ahmad J, Šegalo S, Pereira da Veiga C, et al. Public health crises and Ukrainian refugees. Brain Behav Immun. Jul 2022;103:243-245. [FREE Full text] [doi: 10.1016/j.bbi.2022.05.004] [Medline: 35550853]
83. Rahimi F, Talebi Bezmin Abadi A. The Ukrainian refugee crisis and the COVID-19 pandemic in Europe. Int J Surg. Jun 2022;102:106671. [FREE Full text] [doi: 10.1016/j.ijsu.2022.106671] [Medline: 35569760]
84. Scherbov S, Gietel-Basten S, Ediev D, Shulgin S, Sanderson W. COVID-19 and excess mortality in Russia: Regional estimates of life expectancy losses in 2020 and excess deaths in 2021. PLoS One. Nov 2, 2022;17(11):e0275967. [FREE Full text] [doi: 10.1371/journal.pone.0275967] [Medline: 36322565]
85. Russia: Really Part of Europe? The Globalist. Oct 17, 2014. URL: https://www.theglobalist.com/russia-really-part-of-europe/ [accessed 2024-02-27]
86. Troianovski A. 'You Can't Trust Anyone': Russia's Hidden Covid Toll Is an Open Secret. The New York Times. Oct 18, 2021. URL: https://www.nytimes.com/2021/04/10/world/europe/covid-russia-death.html [accessed 2024-02-18]
87. Balakrishnan VS. COVID-19 response in central Asia. The Lancet Microbe. Nov 2020;1(7):e281. [doi: 10.1016/s2666-5247(20)30177-4]
88. King EJ, Dudina VI. COVID-19 in Russia: Should we expect a novel response to the novel coronavirus? Glob Public Health. Mar 19, 2021;16(8-9):1237-1250. [doi: 10.1080/17441692.2021.1900317] [Medline: 33736569]
89. Putin extends Russia's coronavirus nonworking period. Aljazeera. Feb 20, 2020. URL: https://www.aljazeera.com/news/2020/4/2/putin-extends-russias-coronavirus-nonworking-period [accessed 2024-02-18]
90. Simmons A. Putin Exploits Coronavirus to Justify Centralized Russian Power. The Wall Street Journal. Mar 27, 2020. URL: https://www.wsj.com/articles/putin-exploits-coronavirus-to-justify-centralized-russian-power-11585306801 [accessed 2024-02-18]
91. Thanks to covid-19, Vladimir Putin has become almost invisible. The Economist. Oct 02, 2021. URL: https://www.economist.com/europe/2021/10/02/thanks-to-covid-19-vladimir-putin-has-become-almost-invisible [accessed 2024-02-18]
92. Rechel B, Ahmedov M, Akkazieva B, Katsaga A, Khodjamurodov G, McKee M. Lessons from two decades of health reform in Central Asia. Health Policy Plan. Jul 24, 2012;27(4):281-287. [doi: 10.1093/heapol/czr040] [Medline: 21609971]
93. Adambekov S, Kaiyrlykyzy A, Igissinov N, Linkov F. Health challenges in Kazakhstan and Central Asia. J Epidemiol Community Health. Jan 07, 2016;70(1):104-108. [doi: 10.1136/jech-2015-206251] [Medline: 26254293]
94. Alfano V. COVID-19 in Central Asia: exploring the relationship between governance and non-pharmaceutical intervention. Health Policy Plan. Sep 13, 2022;37(8):952-962. [FREE Full text] [doi: 10.1093/heapol/czac023] [Medline: 35260888]
95. Mortality Analyses. Johns Hopkins University & Medicine. Mar 16, 2023. URL: https://coronavirus.jhu.edu/data/mortality [accessed 2024-01-27]
96. Conflict, COVID-19, climate and economic crises deepen inequalities among children in Europe and Central Asia – UNICEF. Unicef. Mar 08, 2023. URL: https://www.unicef.org/eca/press-releases/conflict-covid-19-climate-and-economic-crises-deepen-inequalities-among-children [accessed 2024-02-18]
97. ESCAP. Feb 25, 2020. URL: https://www.unescap.org/kp/2020/covid-19-north-and-central-asia-impacts-responses-strategies-build-back-better# [accessed 2024-02-27]
98. COVID-19 and Economic Recovery Potential in the CAREC Region. Asian Development Bank. Mar 2022. URL: https://www.adb.org/publications/covid-19-and-economic-recovery-potential-in-the-carec-region [accessed 2024-02-18]
99. Mallawaarachchi T, Rahut DB. Realising rural economic transformation: Pathways to inclusive and sustainable prosperity in post-COVID-19 Asia. Econ Anal Policy. Mar 2023;77:1076-1082. [FREE Full text] [doi: 10.1016/j.eap.2023.01.009] [Medline: 36687265]
100. Saadah F. To save lives and livelihoods: boosting COVID-19 vaccine acceptance in Europe and Central Asia. World Bank Blogs. Mar 14, 2022. URL: https://blogs.worldbank.org/europeandcentralasia/save-lives-and-livelihoods-boosting-covid-19-vaccine-acceptance-eca [accessed 2024-02-18]
101. Fiolet T, Kherabi Y, MacDonald C, Ghosn J, Peiffer-Smadja N. Comparing COVID-19 vaccines for their characteristics, efficacy and effectiveness against SARS-CoV-2 and variants of concern: a narrative review. Clin Microbiol Infect. Feb 2022;28(2):202-221. [FREE Full text] [doi: 10.1016/j.cmi.2021.10.005] [Medline: 34715347]

102. Cazzola M, Rogliani P, Mazzeo F, Matera MG. Controversy surrounding the Sputnik V vaccine. Respir Med. Oct 2021;187:106569. [FREE Full text] [doi: 10.1016/j.rmed.2021.106569] [Medline: 34399368]
103. Jones I, Roy P. Sputnik V COVID-19 vaccine candidate appears safe and effective. The Lancet. Feb 2021;397(10275):642-643. [doi: 10.1016/s0140-6736(21)00191-4]
104. Lawton G. Sputnik V vaccine goes global. New Scientist. Apr 2021;250(3331):10-11. [doi: 10.1016/s0262-4079(21)00671-0]
105. Cohen J. Russia's approval of a COVID-19 vaccine is less than meets the press release. Science. Aug 11, 2020. URL: https://www.science.org/content/article/russia-s-approval-covid-19-vaccine-less-meets-press-release [accessed 2024-02-27]
106. Zhao J, Zhao S, Ou J, Zhang J, Lan W, Guan W, et al. COVID-19: coronavirus vaccine development updates. Front Immunol. Dec 23, 2020;11:602256. [FREE Full text] [doi: 10.3389/fimmu.2020.602256] [Medline: 33424848]
107. Parkins K. Sputnik V controversy: still no raw data. Clinical Trials Arena. Jun 02, 2021. URL: https://www.clinicaltrialsarena.com/features/sputnik-v-controversy-still-no-raw-data/ [accessed 2024-02-18]
108. Lazarus JV, Wyka K, White TM, Picchio CA, Gostin LO, Larson HJ, et al. A survey of COVID-19 vaccine acceptance across 23 countries in 2022. Nat Med. Feb 09, 2023;29(2):366-375. [doi: 10.1038/s41591-022-02185-4] [Medline: 36624316]
109. Number of COVID-19 vaccine doses administered in Europe as of January 18, 2023, by country. Statista. Jan 18, 2023. URL: https://www.statista.com/statistics/1196071/covid-19-vaccination-rate-in-europe-by-country/ [accessed 2024-01-15]
110. Nikolskaya P. Sputnik V shows higher Omicron-antibody levels than Pfizer in preliminary study. Reuters. Jan 20, 2022. URL: https://www.reuters.com/world/europe/sputnik-v-shows-higher-omicron-antibody-levels-than-pfizer-preliminary-study-2022-01-20/#:~:text=The%20study%2C%20that%20will%20seek,those%20vaccinated%20with%20Pfizer%2FBioNtech [accessed 2024-02-18]
111. Health workers build confidence in COVID-19 vaccination in Kazakhstan;. The World Health Organization. Dec 22, 2022. URL: https://www.who.int/europe/news/item/22-12-2022-health-workers-build-confidence-in-covid-19-vaccination-in-kazakhstan [accessed 2024-02-16]
112. de Bengy Puyvallée A, Storeng KT. COVAX, vaccine donations and the politics of global vaccine inequity. Global Health. Mar 05, 2022;18(1):26. [FREE Full text] [doi: 10.1186/s12992-022-00801-z] [Medline: 35248116]
113. Yoo K, Mehta A, Mak J, Bishai D, Chansa C, Patenaude B. COVAX and equitable access to COVID-19 vaccines. Bull World Health Organ. May 05, 2022;100(05):315-328. [doi: 10.2471/blt.21.287516]
114. COVID-19 medicines. European Medicines Agency. URL: https://www.ema.europa.eu/en/human-regulatory/overview/public-health-threats/coronavirus-disease-covid-19/covid-19-medicines [accessed 2024-01-27]
115. A community leader in Kyrgyzstan issues an urgent call to fellow villagers: Get vaccinated. The World Health Organization. Feb 27, 2023. URL: https://www.who.int/europe/news/item/27-02-2023-a-community-leader-in-kyrgyzstan-issues-an-urgent-call-to-fellow-villagers--get-vaccinated [accessed 2024-02-18]
116. Holder J. Tracking Coronavirus Vaccinations Around the World. The New York Times. Mar 13, 2023. URL: https://www.nytimes.com/interactive/2021/world/covid-vaccinations-tracker.html [accessed 2024-01-27]
117. Policy Responses to COVID-19. International Monetary Fund. URL: https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19 [accessed 2024-03-07]
118. Central Asia: Pandemic Response Threatens Rights. Human Rights Watch. Jan 13, 2021. URL: https://www.hrw.org/news/2021/01/13/central-asia-pandemic-response-threatens-rights [accessed 2024-02-16]
119. Kambas M. Clashes erupt at rally against corruption, COVID-19 curbs in Cyprus. Reuters. Feb 13, 2021. URL: https://www.reuters.com/article/us-cyprus-protests-idUSKBN2AD0I0 [accessed 2024-02-26]
120. Sezer M. Thousands protest new Turkish vaccine and test rules. Reuters. Sep 12, 2021. URL: https://www.reuters.com/world/middle-east/thousands-protest-new-turkish-vaccine-test-rules-2021-09-11/ [accessed 2024-02-16]
121. More Jailed In Russia's North Ossetia For COVID-Related Protests. Radio Free Europe Radio Free Liberty. Nov 12, 2021. URL: https://www.rferl.org/a/north-ossetia-jailed-covid-protests/31558846.html [accessed 2024-02-20]
122. Bodner M. Virtual graffiti: Russians angry with coronavirus lockdown vent online. NBC News. Apr 24, 2020. URL: https://www.nbcnews.com/news/world/russians-use-digital-maps-protest-strict-coronavirus-lockdown-conditions-n1191681 [accessed 2024-01-27]
123. Stein R. As the pandemic ebbs, an influential COVID tracker shuts down. National Public Radio. Feb 10, 2023. URL: https://www.npr.org/sections/health-shots/2023/02/10/1155790201/as-the-pandemic-ebbs-an-influential-covid-tracker-shuts-down #:~:text=In%20another%20sign%20of%20the,March%2010%2C%20officials%20told%20NPR [accessed 2024-04-02]
124. Ritchey MD, Rosenblum HG, Del Guercio K, Humbard M, Santos S, Hall J, et al. COVID-19 self-test data: challenges and opportunities - United States, October 31, 2021-June 11, 2022. MMWR Morb Mortal Wkly Rep. Aug 12, 2022;71(32):1005-1010. [FREE Full text] [doi: 10.15585/mmwr.mm7132a1] [Medline: 35951486]
125. Benati I, Coccia M. Effective contact tracing system minimizes COVID-19 related infections and deaths: policy lessons to reduce the impact of future pandemic diseases. JPAG. Aug 24, 2022;12(3):1. [doi: 10.5296/jpag.v12i3.19834]
126. Askitas N, Tatsiramos K, Verheyden B. Estimating worldwide effects of non-pharmaceutical interventions on COVID-19 incidence and population mobility patterns using a multiple-event study. Sci Rep. Jan 21, 2021;11(1):1972. [FREE Full text] [doi: 10.1038/s41598-021-81442-x] [Medline: 33479325]

127. Rakhimov M. Internal and External Dynamics of Regional Cooperation in Central Asia. Journal of Eurasian Studies. Jul 01, 2010;1(2):95-101. [doi: 10.1016/j.euras.2010.04.002]
128. Coccia M. Preparedness of countries to face COVID-19 pandemic crisis: Strategic positioning and factors supporting effective strategies of prevention of pandemic threats. Environ Res. Jan 2022;203:111678. [FREE Full text] [doi: 10.1016/j.envres.2021.111678] [Medline: 34280421]
129. Coccia M. Pandemic prevention: lessons from COVID-19. Encyclopedia. May 31, 2021;1(2):433-444. [doi: 10.3390/encyclopedia1020036]
130. Ear S. Viral Sovereignty and the Political Economy of Pandemics: What Explains how Countries Handle Outbreaks? New York. Routledge; 2022.
131. Acknowledgement of Data Contributors. GISAID. Aug 01, 2023. URL: https://doi.org/10.55876/gis8.230801ve [accessed 2024-07-24]

Abbreviations

CDC: Centers for Disease Control and Prevention
GISAID: Global Initiative on Sharing All Influenza Data
OWID: Our World in Data
PCR: polymerase chain reaction
WHO: World Health Organization

Edited by A Mavragani; submitted 30.08.23; peer-reviewed by D Owusu, S Pesälä; comments to author 06.12.23; revised version received 21.03.24; accepted 29.04.24; published 28.08.24

Please cite as:
Lundberg AL, Ozer EA, Wu SA, Soetikno AG, Welch SB, Liu Y, Havey RJ, Murphy RL, Hawkins C, Mason M, Achenbach CJ, Post LA
Surveillance Metrics and History of the COVID-19 Pandemic in Central Asia: Updated Epidemiological Assessment
JMIR Public Health Surveill 2024;10:e52318
URL: https://publichealth.jmir.org/2024/1/e52318
doi: 10.2196/52318
PMID: 39013115