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Research Article

2021–2022 monitoring, early warning, and forecasting of global infectious diseases



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ABSTRACT

Background: COVID-19 has had a considerable impact on society since 2019, and the disease has high mortality and infection rates. There has been a particular focus on how to best manage COVID-19 and how to analyze and predict the epidemic status of infectious diseases in general.

Methods

The present study analyzed the COVID-19 epidemic patterns and made predictions of future trends based on the statistics obtained from a global infectious disease network data monitoring and early warning system (OBN, <http://27.115.41.130:8888/OBN/>). The development trends of other major infectious diseases were also examined.

Results

The global COVID-19 pandemic showed periodic increases throughout 2021. At present, there is a high incidence in European countries, especially in Eastern Europe, followed by in Africa. The risk of contracting COVID-19 was divided into high, medium–high, medium, medium–low, and low grades depending on the stage of the epidemic in each examined region over the current period. The occurrence and prevalence of major infectious diseases throughout the world did not significantly change in 2021.

Conclusions

The COVID-19 pandemic has strongly impacted people's lives and the economy. The effects of global infectious diseases can be ameliorated by strengthening monitoring and early warning systems and by facilitating the international exchange of information.

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Since 2019, the coronavirus disease 2019 (COVID-19) pandemic has had a considerable effect on society. It is important to be able to manage and predict future epidemics of COVID-19 and other infectious diseases. The present study conducted data analysis and forecasting related to the COVID-19 epidemic status and examined the development trends of other major infectious diseases using statistics provided by a global infectious disease network data monitoring and early warning system (OBN, <https://27.115.41.130:8888/OBN/>). The findings provide a basis for predicting the trends in effective global surveillance, early warning, prevention, and control of infectious diseases near the end of 2021 and into 2022. The results also provide information on the management and analysis methods used to predict the future status of infectious disease epidemics, especially COVID-19. The data used in the present study were obtained before November 17, 2021.

1. Methods

The crawler method was adopted to collect data from publicly available sources on the internet, and a database was created. The improved moving average prediction limit mathematical model was used to analyze the collected data.^{1–2} The global infectious disease network data monitoring and early warning system (OBN, <https://27.115.41.130:8888/OBN/>) is a system that can predict the status of future infectious disease epidemics based on the above methods. Data analysis and forecasting of the COVID-19 epidemic status and the development trends of other major infectious diseases were conducted using epidemic statistical data from OBN.

2. Results*2.1. COVID-19 epidemic trends*

COVID-19 has high mortality and infection rates. The global COVID-19 pandemic showed periodic increases throughout 2021.

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A large number of cases, ranging from 400,000 to 900,000 new confirmed cases per day, was reported for more than a year since October 2020. COVID-19 epidemics form a “peak-trough” cycle approximately every 4 months, and the pandemic is currently in the fourth wave. The increase in the number of cases is mainly attributable to new cases being reported in Europe. A graph showing COVID-19 epidemic trends is presented in Fig. 1.

2.2. Characteristics of the COVID-19 global pandemic

Currently, different countries exhibit different COVID-19 infection and mortality rates. At present, there is a high incidence in European countries, especially in Eastern Europe, followed by Africa. By contrast, Asia, North America, Oceania, South America, and other regions are in a periodic “trough” of the epidemic. This is because countries in Asia, North America, and Oceania have enforced more restrictive control measures, resulting in reduced infection rates.

2.3. Status of the COVID-19 epidemic in European countries

As shown in Fig. 2, European countries such as Russia, Germany, and Ukraine are experiencing a rapid rise in COVID-19 cases. An increase in incidence is currently being reported in central and eastern European countries.

2.4. Status of the COVID-19 epidemic in Asian countries

Asian countries experienced a 3–6-month epidemic period that was temporarily and quickly controlled through strict control measures. Previous findings have shown that the level of adherence to strict control measures determines whether the COVID-19 epidemic will rebound in Asian countries (Fig. 3).

2.5. Status of the COVID-19 epidemic in parts of the Americas

As shown in Fig. 4, COVID-19 infection rates in some parts of the Americas are similar to those reported in Asian countries.

2.6. Status of the COVID-19 epidemic in parts of Oceania

Australia and New Zealand are the largest countries in the Oceania region. These countries have reported periods of rapid decline and rapid increases in COVID-19 infections in the recent past (Fig. 5). These two countries have no land borders, and their air traffic control measures are different; thus, the epidemic experience of the two countries is not closely related.

2.7. Status of the COVID-19 epidemic in African countries

African countries have been less affected by COVID-19 compared with more economically developed regions (Fig. 6). However, most countries in this region have reported recurrent outbreaks.

3. COVID-19 epidemic trends based on a mathematical model

COVID-19 trends (the short-, medium-, and long-term trends of average daily newly confirmed cases) in various countries and regions (accurate to the province, state, county, road, and other secondary administrative levels) were explored using a system tool. The risk of contracting COVID-19 was divided into high, medium-high, medium, medium-low, and low grades depending on the stage of the epidemic in each region over the investigated period. Seven high-risk regions were identified, mainly in parts of Russia and Holland (Table 1).

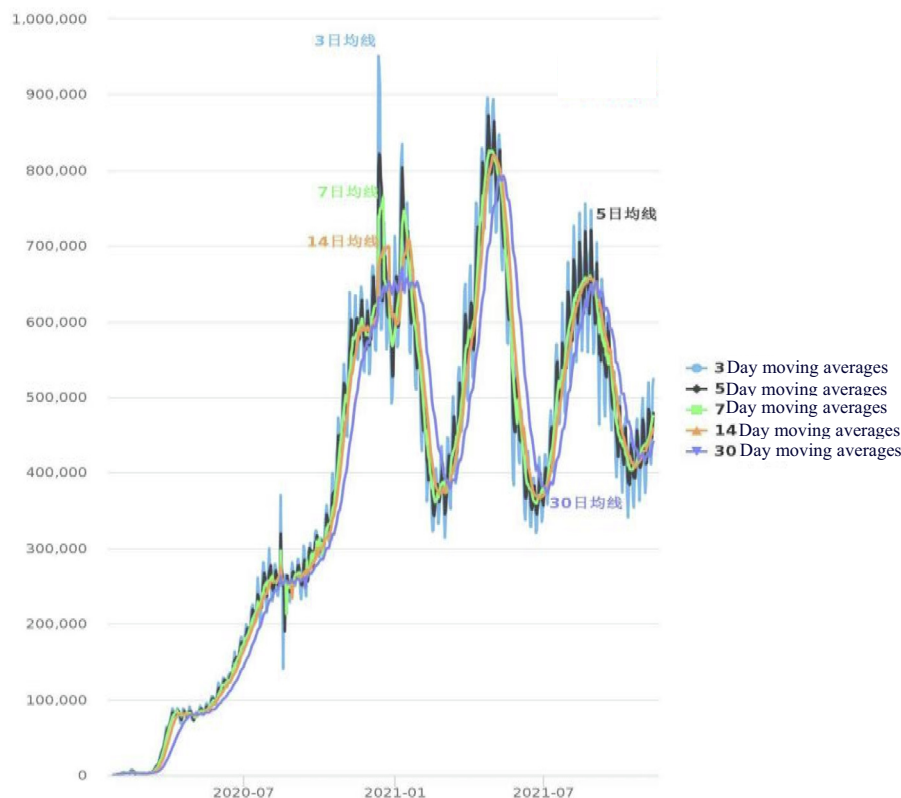


Fig. 1. Trend of COVID-19 epidemic. The global COVID-19 epidemic showed a periodic increase in 2021. COVID-19 epidemic formed a “peak-trough” cycle approximately every-four months, and it is currently in the fourth increasing phase.

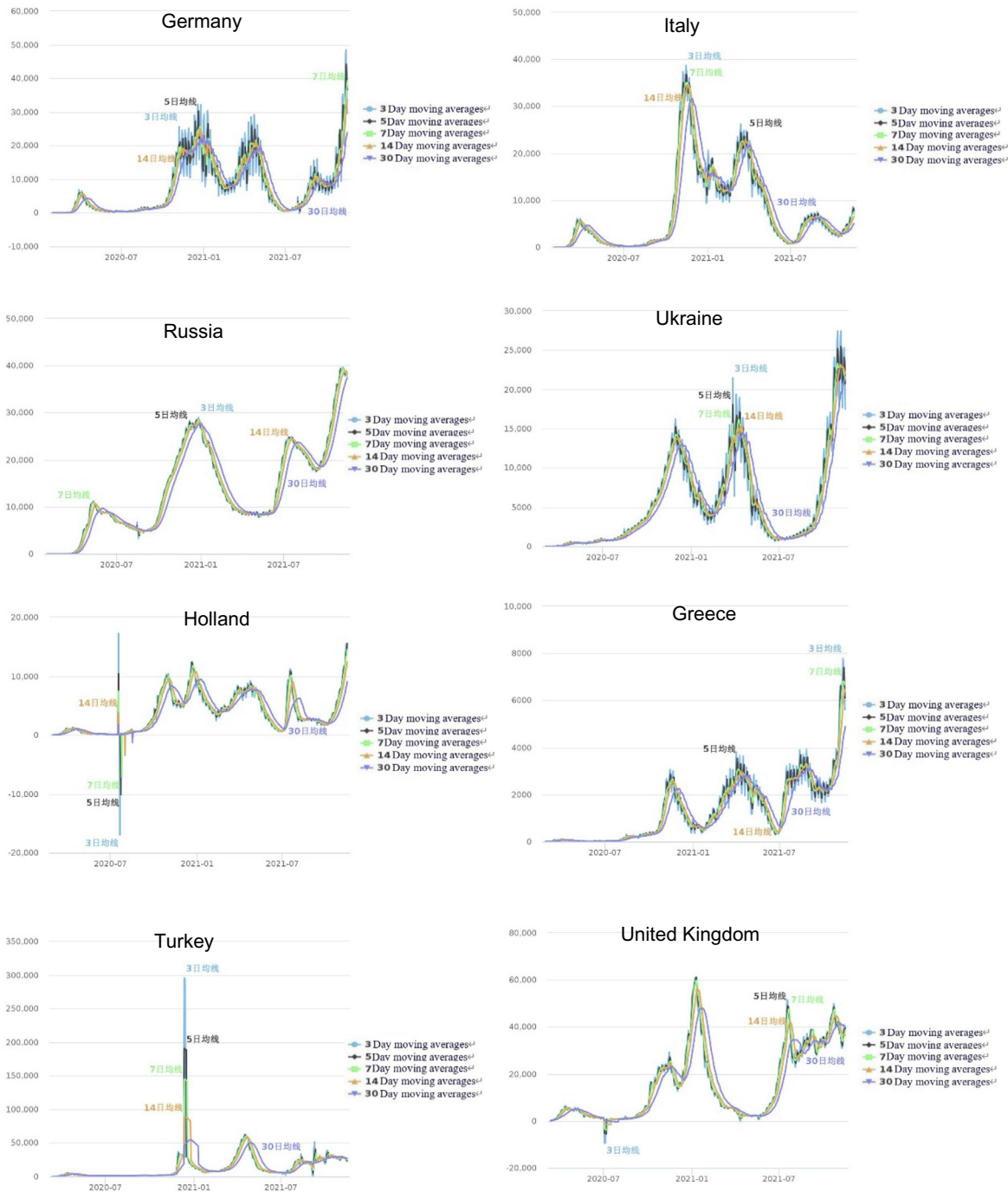


Fig. 2. Status of COVID-19 epidemic in some European countries. European countries are experiencing rapid rise in COVID-19 outbreaks, such as Russia, Germany and Ukraine.

A total of 90 medium–high risk regions were identified, mainly in Russia, India, Colombia, Italy, and Chile, but also in other countries and regions (Table 2). The data assessment classification was automatically updated daily.

4. Occurrence and prevalence of major infectious diseases in 2021

The global occurrence and prevalence of major infectious diseases did not appreciably change in 2021.^{3–6} For example, the

distributions of the natural foci of major infectious diseases have not shown significant change. Established natural epidemic diseases such as yellow fever, dengue fever, plague, tick-borne relapsing fever, leptospirosis, anthrax, rabies, brucellosis, Ebola, and Oriental equine encephalitis had outbreaks in 2021. In addition, there were no major changes in the location or scope of impact of these infectious diseases. Moreover, the main factors affecting the distribution and prevalence of natural foci diseases, such as entomology, climate, landforms, and zoonotic origins, have not markedly changed. There have been no fundamental changes in the seasonal prevalences of major global infectious

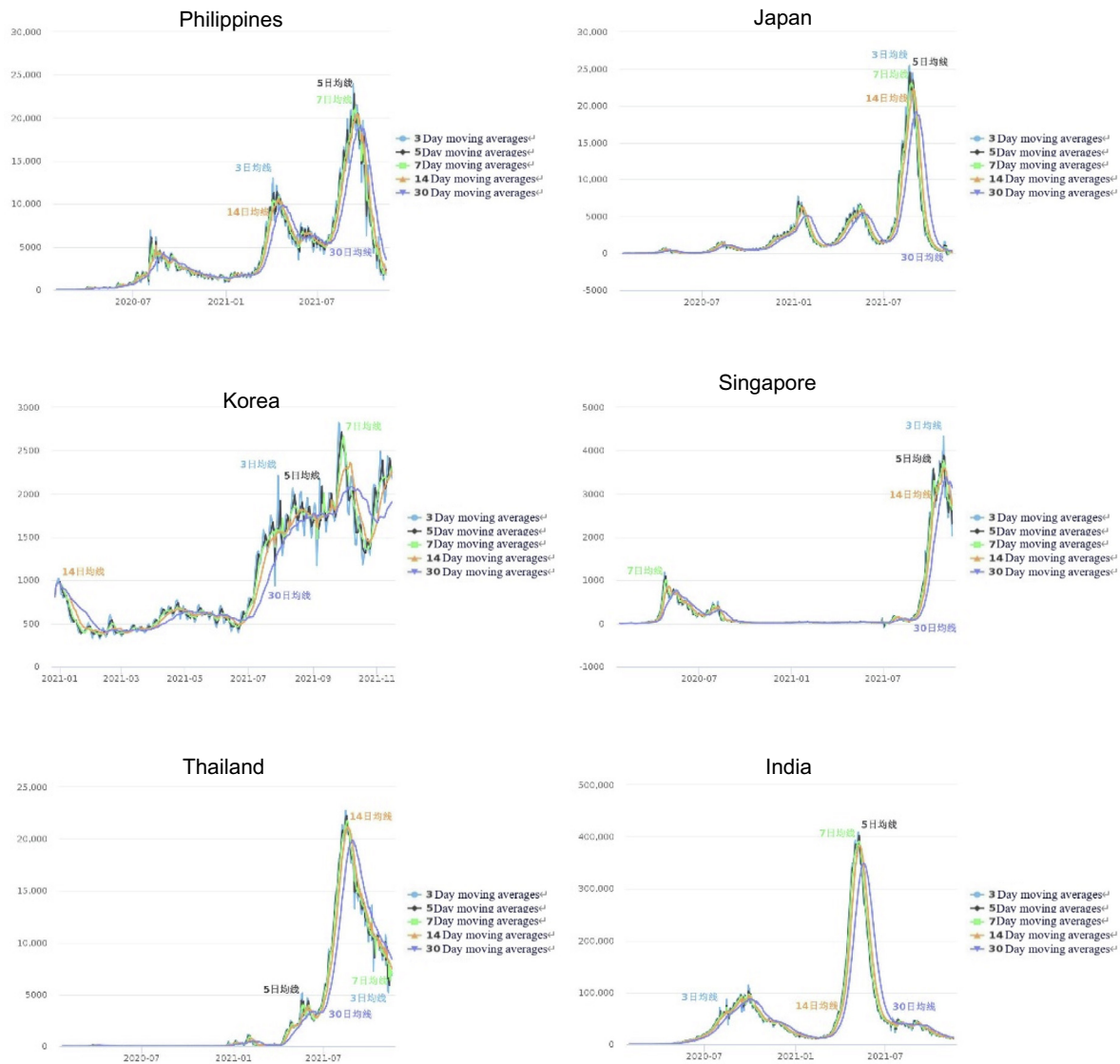


Fig. 3. Status of COVID-19 epidemic in some Asian countries. The epidemic in Asian countries were temporarily controlled.

diseases. Infectious diseases with evident seasonal epidemic characteristics, such as influenza, measles, encephalitis b, meningitis, mumps, and hand, foot and mouth disease, have been reported in 2021, but there have been no significant changes in incidence.

5. Discussion

5.1. Factors associated with COVID-19 epidemic trends

COVID-19 vaccination status. Several countries have advocated COVID-19 vaccination to prevent severe disease and reduce infection rates, but vaccination has not significantly reduced the spread of COVID-19 in most countries and regions. Nevertheless, vaccination is currently the most effective approach for preventing and controlling COVID-19 outbreaks. Vaccination plays a prominent role in preventing severe COVID-19 and reducing hospitalization and mortality rates. At present, more than 100 countries and regions (293 in total) have reported that 40 % of their population is vaccinated (data obtained on November 17, 2021). Forty-seven countries and regions have begun administering booster vaccina-

tions, but only six countries have administered a booster vaccination dose to at least 20 % of the population.

Clinical research on COVID-19 therapies. The use of specific therapies to treat COVID-19 is highly important because the COVID-19 vaccines cannot effectively prevent the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The antivirals Paxlovid, developed by Pfizer, and Molnupiravir, developed by Merck, are undergoing review by the United States Food and Drug Administration for clinical use. Paxlovid is 89 % effective in preventing progression to severe disease and death in high-risk patients, whereas Molnupiravir reduces the risk of hospitalization or death by 50 % in patients with mild or moderate COVID-19. Progress on the research and development of targeted therapies for COVID-19 has also been reported in China. Two biological products, a COVID-19-specific immunoglobulin developed by Sinopharm Group and an anti-SARS-CoV-2 monoclonal antibody, are currently in clinical trials.

Mechanism of SARS-CoV-2 immune escape. The delta and omicron variants have a significantly higher rate of immune escape relative to the other variants.

Implementation of control measures. Recent findings indicate that social control measures are the most effective methods for

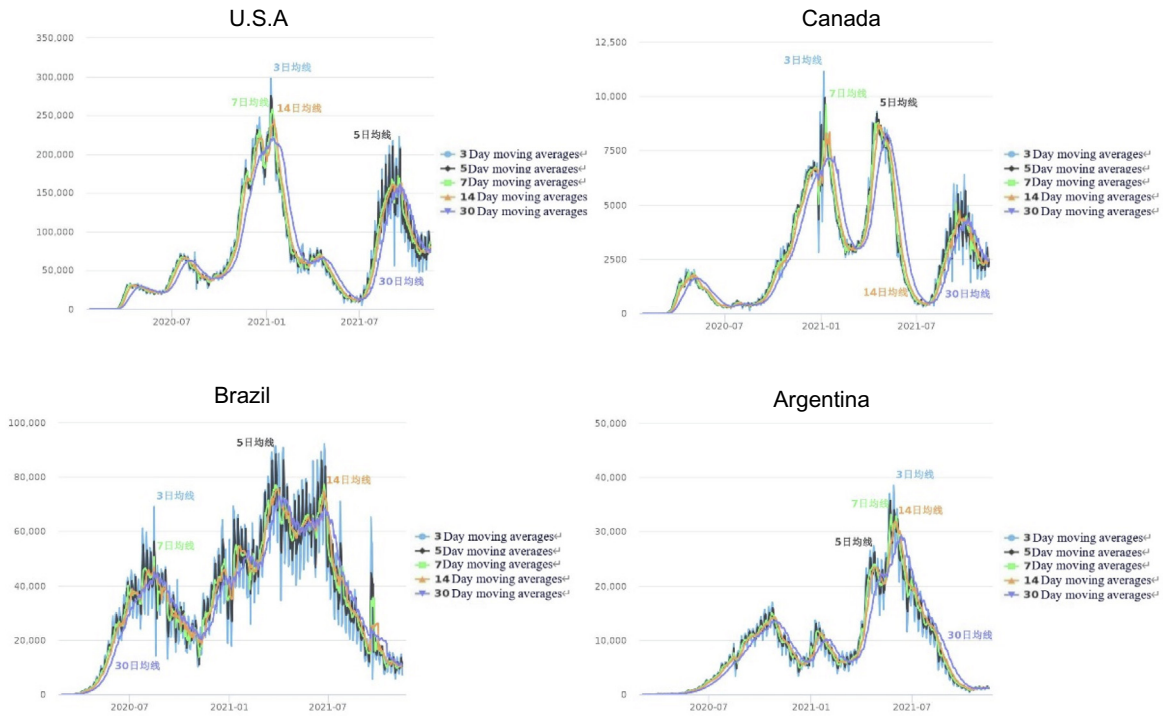


Fig. 4. Status of COVID-19 epidemic in part of Americas. The epidemic in some of Americas countries were also temporarily controlled.

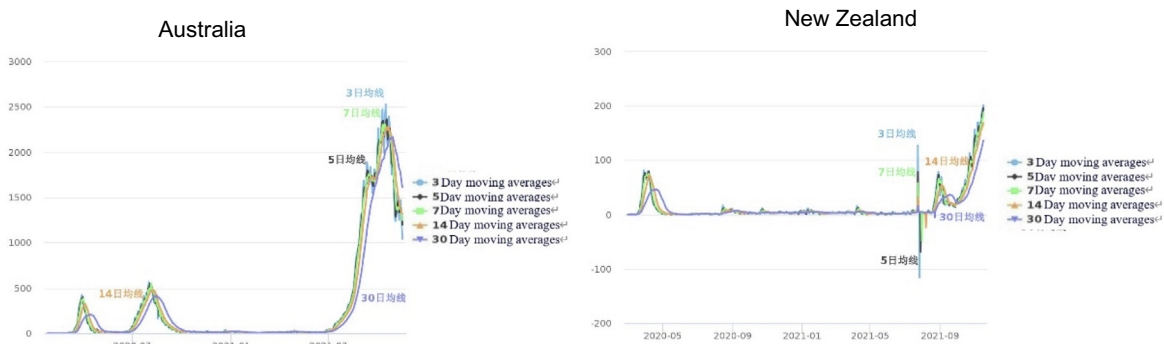


Fig. 5. Status of COVID-19 epidemic in Australia and New Zealand. COVID-19 infections rates in Australia were decline but it was increase in New Zealand.

containing COVID-19 outbreaks. Social control measures mainly include identifying and isolating infected persons and their close contacts, social distancing, wearing masks, washing hands frequently, and reducing or preventing the movement of people across regions. These measures are effective in preventing the spread of COVID-19. However, they significantly affect the local economy and society.

5.2. Analysis of COVID-19 epidemics and predictions for the future

The daily number of new COVID-19 cases globally remains high, and the world is currently in the fourth wave of the pandemic. The trends and patterns of rotation of patients contributing to the global COVID-19 outbreak across continents have not changed. Currently, the main regions exhibiting high rates of COVID-19 infections are Europe, South Korea, Egypt, New Zealand, and Singapore. The status of the COVID-19 pandemic is not predicted to change in the short term (3–6 months). There will continue to be pressure on China to prevent possible infections from outside of

the country and to rebound from local outbreaks. Densely populated urban areas and economically developed areas are more severely affected than rural, sparsely populated and less-developed areas. The weight order of factors that impact the COVID-19 epidemic status is social control measures > COVID-19 therapies > vaccine coverage. Effective social control measures and therapeutics are the main methods for alleviating COVID-19 epidemics. Countries should explore the diversity of how SARS-CoV-2 can come into countries, and they should strengthen the prevention and control of these routes, such as cold chain systems and border crossings.

5.3. Impact of COVID-19 on other infectious diseases

The COVID-19 pandemic has somewhat affected the occurrence and prevalence of other major infectious diseases. Social control measures have significantly reduced the incidence of these infectious diseases because the ability to spread these pathogenic microorganisms has been substantially curbed. Thus, the occur-

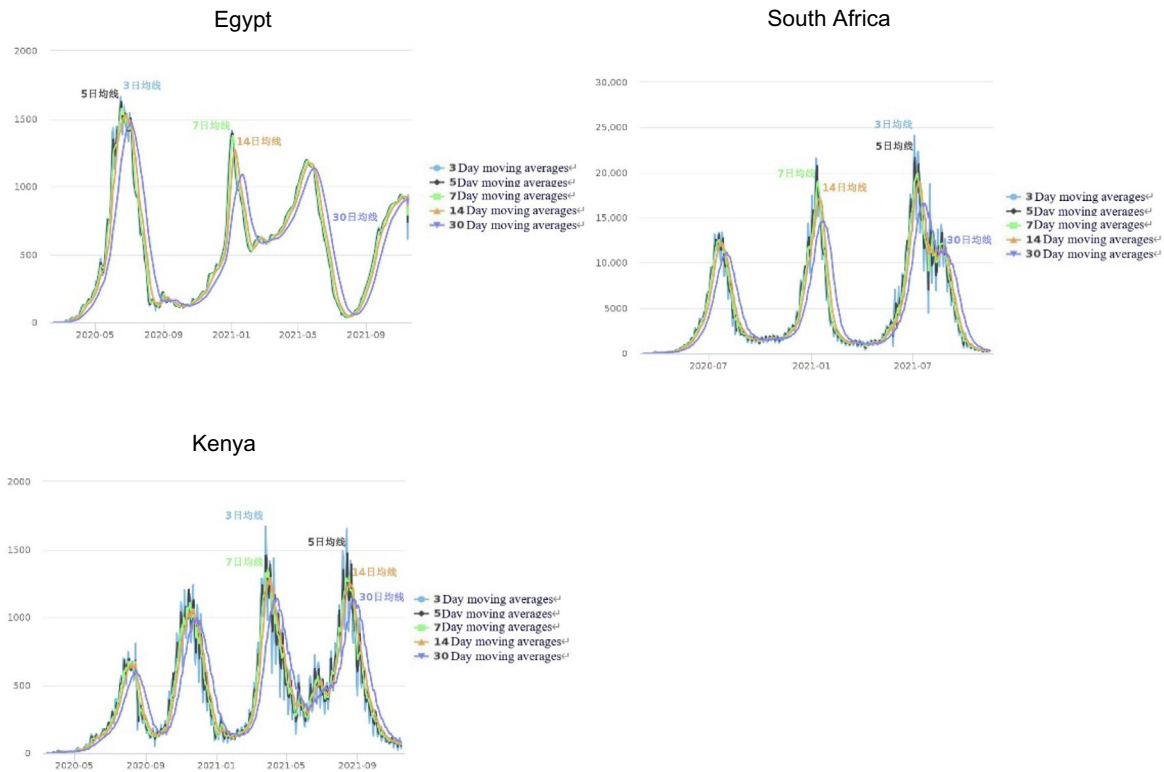


Fig. 6. Status of COVID-19 epidemic in some African countries. African countries were less affected by COVID-19, but it had recurrent.

Table 1
High-risk regions for contracting COVID-19.

warningdate	level	country_c	province_c
2021/11/14 0:00	1	Russia	Adige republic
2021/11/13 0:00	1	Russia	Kemerovo Oblast
2021/11/13 0:00	1	Holland	Herba Lycopi
2021/11/9 0:00	1	Holland	Zuid-Holland
2021/11/9 0:00	1	Holland	Noord-Brabant
2021/11/7 0:00	1	Russia	The Republic of Cabadino-Balkaria
2021/11/7 0:00	1	Holland	Friesland
2021/11/7 0:00	1	Holland	Flevoland Utrecht

rence of and harm caused by these infectious diseases have been reduced to a certain extent.^{7–12} This impact has been more prominent in areas that are more susceptible to imported infectious diseases, whereas a lower impact has been exhibited for infectious diseases that have a natural foci. For instance, the number of dengue fever cases decreased by 90 % in Guangdong, China in 2021. In the Democratic Republic of the Congo in 2021, communicable disease outbreaks with natural foci (such as Ebola, measles, and malaria) have been less affected by COVID-19. Infectious diseases transmitted through drinking water and food have not been significantly affected by the presence of COVID-19. For example,

Table 2
Select medium–high risk regions for contracting COVID-19.

Warning date	Level	Country	Province
2021/11/11 0:00	2	Russia	Oblast Swerdlowsk
2021/11/11 0:00	2	Russia	Leningrad Oblast
2021/11/11 0:00	2	Russia	Republic of Khakassia
2021/11/11 0:00	2	Russia	Bashkortostan republic
2021/11/11 0:00	2	Columbia	Sucre
2021/11/11 0:00	2	Columbia	Departamento de Córdoba
2021/11/11 0:00	2	Holland	Zuid-Holland
2021/11/11 0:00	2	Canada	Ontario
2021/11/11 0:00	2	United states of American	New York
2021/11/11 0:00	2	Ukraine	Zakapatia State
2021/11/11 0:00	2	Italy	Sicily
2021/11/11 0:00	2	India	Gujarat
2021/11/11 0:00	2	United Kingdom	Gibraltar
2021/11/12 0:00	2	Russia	Samara Oblast
2021/11/12 0:00	2	Russia	Penza Oblast
2021/11/12 0:00	2	Russia	Krasnoyarsk Krai
2021/11/12 0:00	2	Columbia	Casanare
2021/11/12 0:00	2	Columbia	Caquetá
2021/11/12 0:00	2	Portugal	NULL
2021/11/13 0:00	2	Russia	Komi republic

(continued on next page)

Table 2 (continued)

Warning date	Level	Country	Province
2021/11/13 0:00	2	United states of American	Vermont
2021/11/13 0:00	2	United states of American	Ohio
2021/11/13 0:00	2	Chile	Ñuble
2021/11/14 0:00	2	Austria	NULL
2021/11/14 0:00	2	Russia	Tomsk Oblast
2021/11/14 0:00	2	Russia	Oblast Saratow
2021/11/14 0:00	2	Russia	Rostov Oblast
2021/11/14 0:00	2	Russia	Omsk Oblast
2021/11/14 0:00	2	Russia	Novosibirsk Oblast
2021/11/14 0:00	2	Russia	Novgorod Oblast
2021/11/14 0:00	2	Russia	The Republic of Cabardino-Balkaria
2021/11/14 0:00	2	Russia	Altai Krai
2021/11/14 0:00	2	Columbia	Guainia
2021/11/14 0:00	2	Columbia	Departamento del Quindío
2021/11/14 0:00	2	Comorin	NULL
2021/11/14 0:00	2	Italy	Piemonte
2021/11/14 0:00	2	Chile	Tarapac

the incidence of cholera, norovirus enteritis, bacillary dysentery, typhoid/paratyphoid, and other epidemic outbreaks in various regions has not markedly changed during the COVID-19 pandemic compared with the incidences in previous years.

In conclusion, the global effects of infectious diseases can be ameliorated by strengthening infectious disease monitoring and early warning systems and by facilitating the international exchange of information. We should pay attention to the information provided by the OBN system, and monitor the COVID-19 status throughout the world. There should also be a focus on whether the omicron variant will change the COVID-19 epidemic patterns.

CRedit authorship contribution statement

Jie Luan: Writing – original draft. **Jianbo Ba:** Writing – review & editing. **Bin Liu:** Data curation. **Xiongli Xu:** Data curation. **Dong Shu:** Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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