



**An International Comparison of the COVID-19
Experiences of the Group-of-Seven and
the BRICS Countries**

by

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An International Comparison of the COVID-19 Experiences of the Group-of-Seven and the BRICS Countries[§]

Lawrence J. Lau¹ and Yanyan Xiong²

October 2021

Abstract: The COVID-19 pandemic has been around since December 2019. In this study, the experiences of the Group-of-Seven Countries (G-7—Canada, France, Germany, Italy, Japan, the U.K. and the U.S.) and the BRICS Countries (Brazil, Russia, India, China and South Africa) are compared in terms of the numbers of confirmed cases and deaths, and infection and mortality rates. The objective is to see whether such a comparison may yield some insight on how and when the COVID-19 pandemic in the world will finally be under control. The key turns out to be the minimisation of secondary and higher-order transmissions of the virus. This requires first, the practice of good personal hygiene and social distancing on the part of all the residents; second, mandatory rapid testing and exhaustive contact tracing, by the public health authorities; and third, lockdown, quarantine and travel restrictions by the government. The governments of the individual countries must fight the COVID-19 epidemic as if it were a war if they expect to succeed in bringing the epidemic under control in their respective countries.

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1. Introduction

In February 2020, we published on the internet an article, “Don’t Panic, Be Cautious, and Together We Can Stop the Coronavirus Epidemic!”, in the Asia-Pacific Biotech News.³ We predicted then that the COVID-19 epidemic would end on the Mainland of China by the end of March. And it did. This was followed by another article (Lau and Xiong (2020b)), and culminated in a book by us, The COVID-19 Epidemic in China (Lau and Xiong (2021)).

The COVID-19 pandemic has been around since December 2019. While the COVID-19 epidemic has been and continues to be under control in Mainland China,⁴ the same cannot be said of the other major countries (Jamison and Wu (2021)). The objective of the current article is to compare the COVID-19 experience of China with those of the Group-of-Seven Countries (G-7—Canada, France, Germany, Italy, Japan, the U.K. and the U.S.) and the other BRICS Countries (Brazil, Russia, India and South Africa), with the hope that such a comparison may yield some insight on how and when the COVID-19 pandemic will finally be under control.

In Table 1, we list the twelve countries in our study alphabetically and indicate their 2020 populations in millions, GDP in billion U.S. Dollars, GDP per capita in thousand U.S. Dollars, as well as the estimated start date of the COVID-19 epidemic in the respective countries. The start date of the epidemic is defined as the first date on which the cumulative total number of confirmed COVID-19 cases reached 20 in that country.⁵ The aggregate population and GDP of the twelve countries altogether constitute 51.3 percent and 71.1 percent of the world population and GDP in 2020 respectively.

³ A hard copy was subsequently published in Asia-Pacific Biotech News, Special Issue 1, March 2020, pp. 90-107, doi: s0219030320001202.

⁴ In what follows, China refers to the Mainland of China.

⁵ We follow the convention used by Jamison, Lau, Wu and Xiong (2020).

Table 1: 2020 Population, GDP, GDP per Capita and the Start Date of the COVID-19 Epidemic in G-7 and BRICS Countries

Country	2020 Population, millions	2020 GDP, US\$ billions	2020 GDP per Capita, US\$ thousands	Start Date of COVID-19 Epidemic
Brazil	212.56	1,444.73	6.80	08/03/2020
Canada	38.01	1,643.41	43.24	29/02/2020
China	1,411.78	15,570.91	11.03	22/12/2019
France	67.39	2,603.00	38.63	27/02/2020
Germany	83.24	3,806.06	45.72	26/02/2020
India	1,380.00	2,622.98	1.90	04/03/2020
Italy	59.55	1,886.45	31.68	21/02/2020
Japan	126.23	5,206.23	41.25	01/02/2020
Russia	144.10	1,483.50	10.29	09/03/2020
South Africa	59.31	301.92	5.09	13/03/2020
The U.K.	67.22	2,707.74	40.28	28/02/2020
The U.S.	329.48	20,936.60	63.54	21/02/2020

Sources: Data on population and GDP in current US\$ (except for China and Japan) are collected from World Development Indicators. Data on Chinese population and GDP are collected from National Bureau of Statistics of China. Data on Japanese population and GDP are collected from the Cabinet Office of Japan.

2. The Cumulative Population Infection Rate

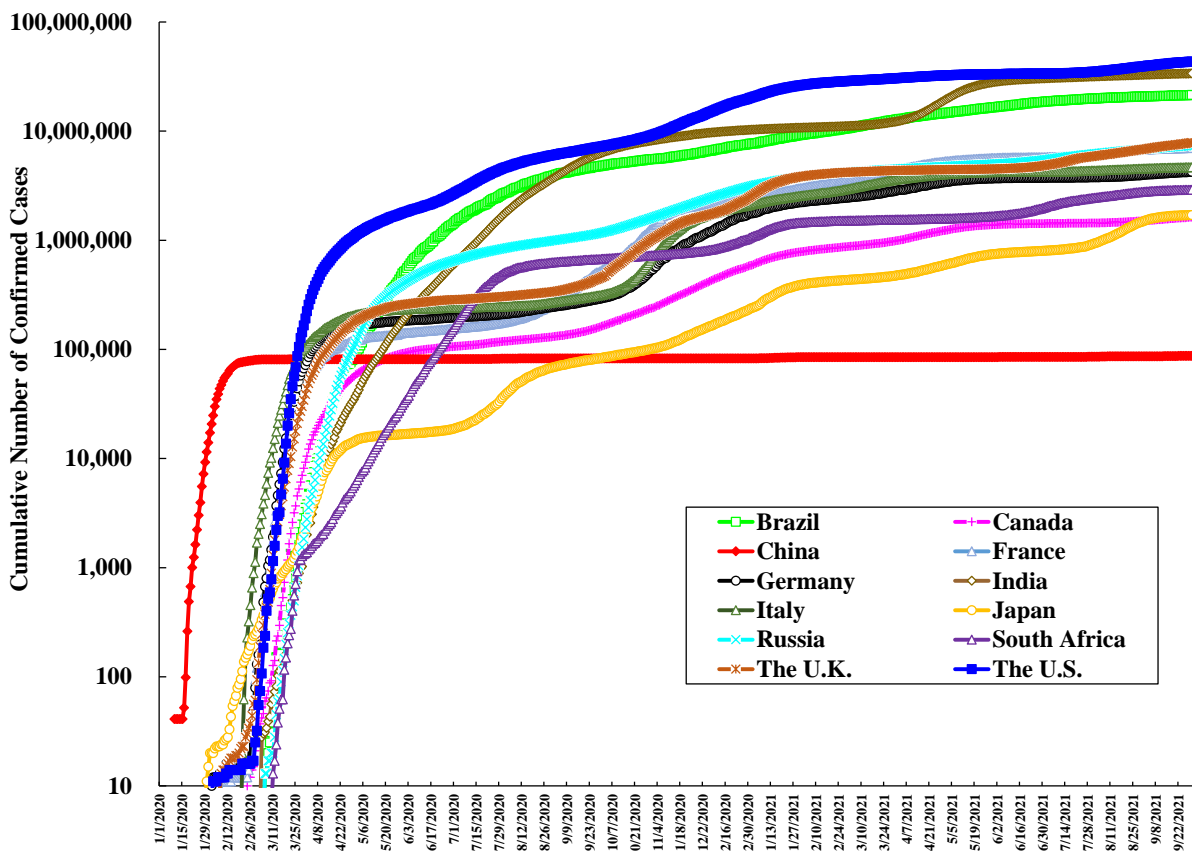
In Chart 1, the cumulative total number of confirmed COVID-19 cases of the twelve selected major countries over time are presented. At the beginning of the COVID-19 epidemic in each country, the cumulative total number of confirmed cases tends to rise rapidly. Then it will continue to grow, but at a gradually slower rate. When it finally stops growing, the cumulative total number of cases curve will turn flat, and that is when the epidemic is finally over. Chart 1 indicates that as of 30 September 2021, the cumulative cases curves continued to grow, albeit at different rates, for every country except China (the red line). China is the only major country that has the COVID-19 epidemic under control.

As of 30 September 2021, the U.S. (the blue line) had the highest number of cumulative total confirmed cases, at 43.46 million,⁶ followed by India (the dark brown line), with just below 33.77 million. Brazil (the light green line) was in the third place with 21.43 million.

⁶ The data for China are taken from its National Health Commission. The data for France are collected from Worldometer. The data for all the other countries are downloaded from Our World in Data.

The cumulative total number of cases of China, the first country with the COVID-19 outbreak, increased rapidly at the beginning. However, the cumulative total began to stabilise around 81,050 by the middle of March 2020, and ended with 87,113 on 30 September 2021, 18 months later, excluding imported cases, and 96,162, otherwise. This amounts to an average of just a little more than ten newly confirmed cases per day since March 2020. We use the average number of newly confirmed cases per day of 20 as a criterion of whether the COVID-19 epidemic is under control in a country. Chart 1 shows that China has by far the lowest cumulative total number of cases among all twelve countries by a couple of orders of magnitude.⁷ Canada (the pink line), with the second lowest cumulative total number of cases, had 1.63 million⁸, followed by Japan (the yellow line) with 1.70 million.

Chart 1: Cumulative Total Number of Confirmed Cases, G-7 and BRICS Countries



Sources: Data on the cumulative total number of confirmed cases for China are taken from its National Health Commission. The data for all the other countries, except France, are downloaded from Our World in Data. The data for France are collected from Worldometer because the French data in Our World in Data show some hard-to-explain anomalies such as declines in the cumulative number of confirmed cases.

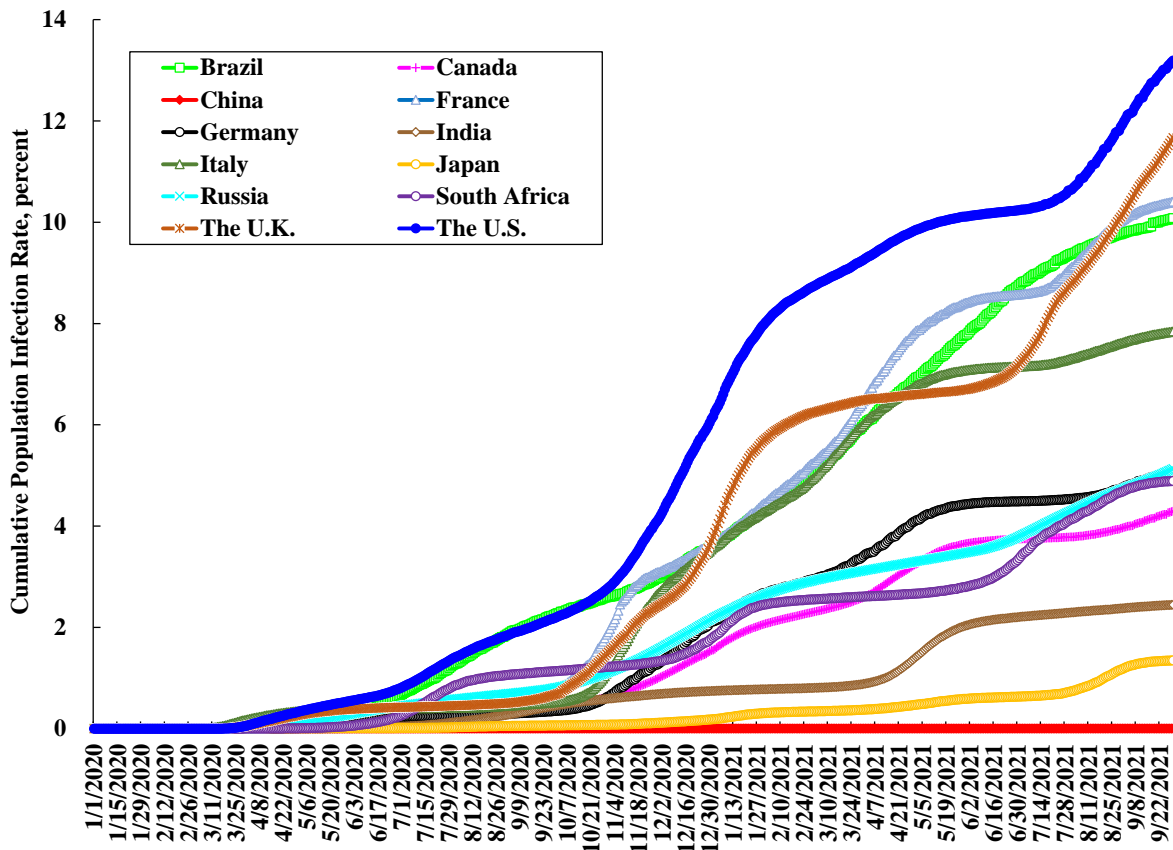
⁷ Note that the vertical axis of Chart 1 is on a logarithmic scale.

⁸ This is almost seventeen times the cumulative total number of confirmed cases in China, even though the Chinese population is more than thirty-seven times the Canadian population.

In Chart 2, the cumulative population infection rates, that is, the cumulative total number of confirmed COVID-19 cases as a percent of the 2020 population of the twelve selected major countries over time are presented. The population infection rate depends on the measures undertaken by the governments of the respective countries to try to control the transmission of the COVID-19 virus, such as lockdown, testing, isolation, contact tracing, quarantine and social distancing (Marziali et al (2021)). It is of course more challenging and difficult in countries with a high population density and/or a culture of low compliance with laws and regulations (Shiina et al (2021)). As of 30 September 2021, the U.S. (the blue line) had the highest population infection rate, at 13.2 percent, implying that more than thirteen out of every one-hundred residents in the U.S. were infected. The U.S. was followed by the U.K. (the brown line), with 11.7 percent, and France (the light blue line), with 10.4 percent. China (the red line) had the lowest population infection rate, at 0.01 percent, excluding imported cases. Japan (the yellow line) had the second lowest population infection rate, at 1.3 percent, followed by India (the dark brown line) with 2.4 percent. The contrast among the countries is most striking.

For a country with the COVID-19 epidemic under control, the cumulative population infection rate should be approaching a constant, that is, the population infection rate curve should be turning flat. An examination of Chart 2 suggests that, in addition to the Chinese curve, only the Indian, Japanese and German curves appear to be approaching constant levels. Both the U.S. and U.K. curves seem to be rising sharply, even though they appeared to be levelling off in late July and mid-June of 2021 respectively. Abrupt rises of the population infection rate can also be observed for France (July 2021), India (April), Japan (August 2021) and South Africa (June 2021) and may be related to the appearance of new mutant varieties of the Coronavirus which are more infectious.

Chart 2: The Cumulative Population Infection Rates, G-7 and BRICS Countries, percent



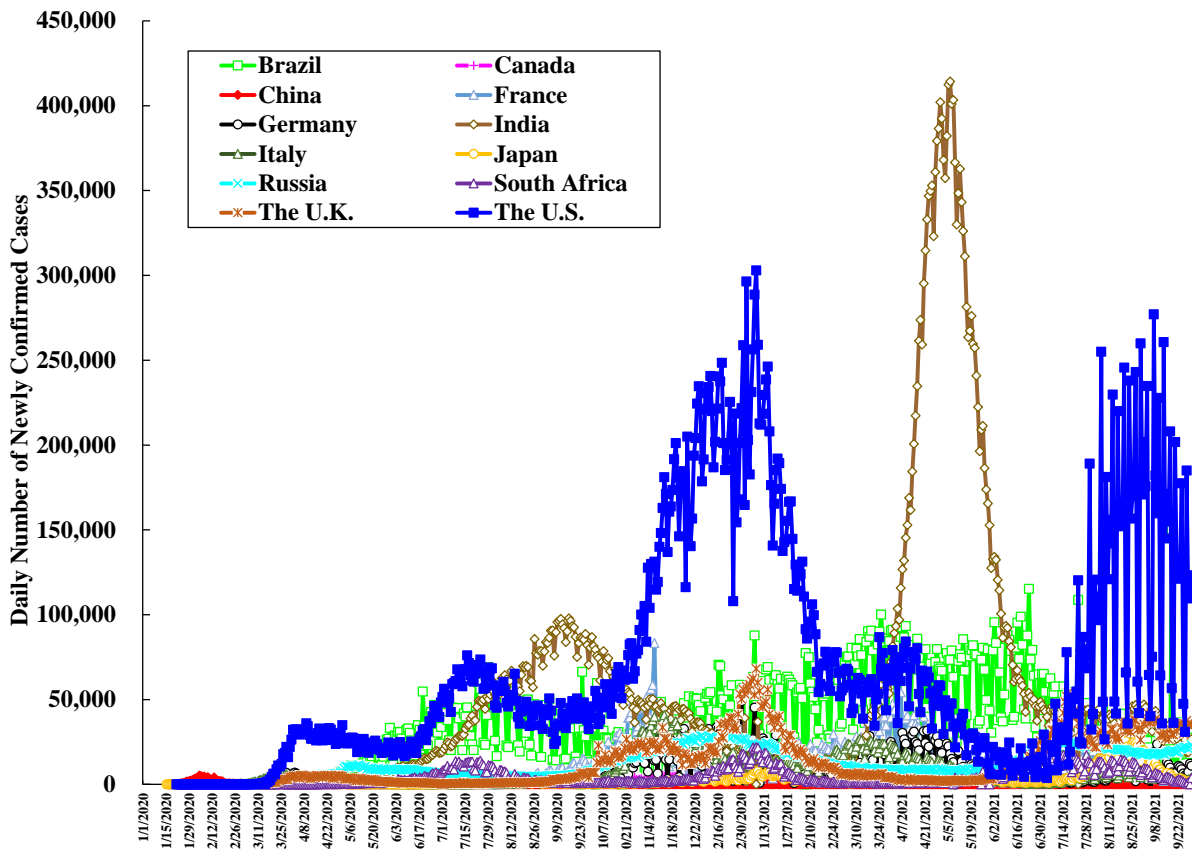
Sources: Authors' calculations. Data sources for the cumulative confirmed cases of each country are the same as Chart 1. Data sources for the population of each country are the same as Table 1.

In Chart 3, the daily number of confirmed COVID-19 cases of the twelve selected major countries over time are presented. (This is actually the daily rate of change of the cumulative total number of confirmed COVID-19 cases.) At the beginning of the COVID-19 epidemic in each country, the daily total number of confirmed cases also tends to rise rapidly, but with significant fluctuations. Then it will begin to decline, and at some point will approach zero. That is when the epidemic is finally over.

Chart 3 indicates that as of 30 September 2021, the daily number of newly confirmed cases curve was still far from zero for every major country except China (the red line). Despite occasional surges, the average daily total number of newly confirmed cases of China has been 12.02 since 1 July 2020, not quite zero, but low enough to be considered the only major country that has the COVID-19 epidemic under control. As of 30 September 2021, the U.S. (the blue line) had the highest daily number of newly confirmed cases, at 110,594, followed by the U.K. (the brown line), with 35,833. Brazil (the light green line) was in the third place with 27,527. At its peak, the U.K. had a daily number of newly confirmed cases of more than 400,000. Chart

3 also shows that after China (the red line), with 10 newly confirmed cases on 30 September 2021, Japan (the yellow line) has the second lowest daily number of newly confirmed cases, at 1,568, followed by Canada (the pink line), at 3,318. If the current trend continues, the daily number of newly confirmed cases in Japan may fall below 20 before the end of 2021. It is likely to take longer for the other countries.

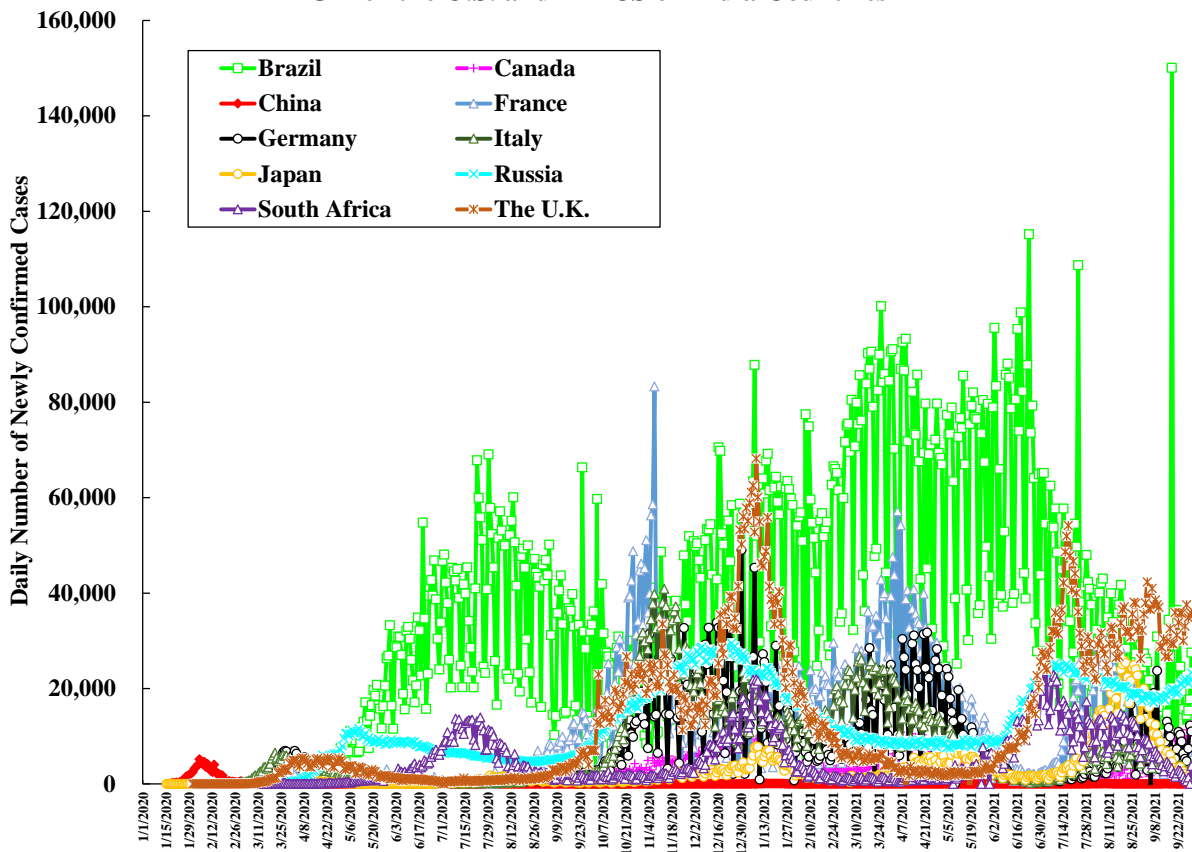
Chart 3: Daily Number of Newly Confirmed Cases, G-7 and BRICS Countries



Sources: Same as Chart 1.

Because of the vast differences in the numbers of daily newly confirmed cases, the details of some countries are obscured. We reproduce Chart 3 without India and the U.S. as Chart 3A. Chart 3A shows that the U.K., Brazil, and Russia have a long way to go to bring their daily number of newly confirmed cases down to the low double-digit level. Japan, Canada and South Africa are the most likely countries to succeed in controlling the COVID-19 epidemic.

Chart 3A: Daily Number of Newly Confirmed Cases, G-7 ex the U.S. and BRICS ex India Countries



Sources: Same as Chart 1.

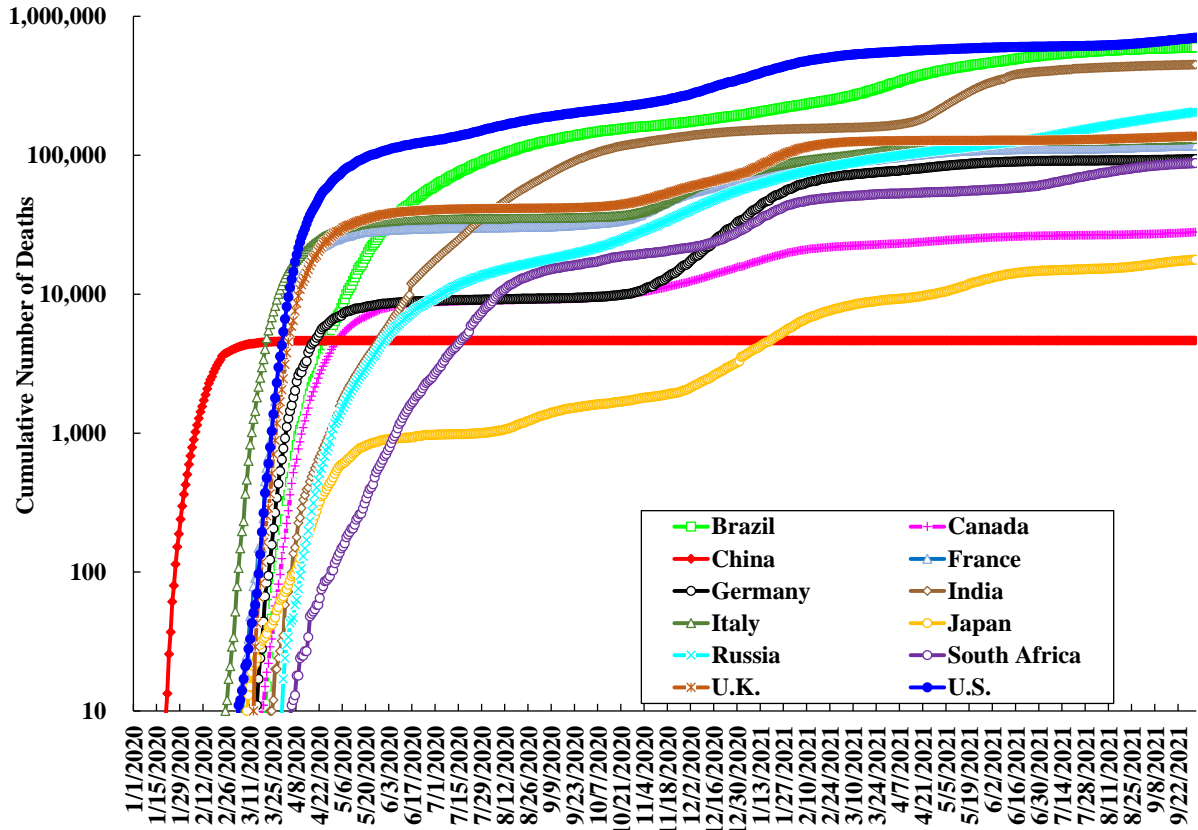
3. The Cumulative Population Mortality Rate

In Chart 4, the cumulative total number of confirmed COVID-19 deaths of the twelve selected major countries over time are presented. As of 30 September 2021, the U.S. (the blue line) had the highest number of cumulative deaths, at 697,851,⁹ followed by Brazil (the light green line), with 596,749. India (the dark brown line) was in the third place with 448,339. China is the first country with the outbreak, and the cumulative total number of deaths rose rapidly as the cumulative total number of confirmed cases rose, even though with a time lag. As the cumulative number of cases stabilised in China, the cumulative number of deaths also stabilised, at around 4,630 by the middle of April 2020, and ended with 4,636 on 30 September 2021. Chart 4 shows that China has by far the lowest cumulative total number of deaths among all twelve countries also by a couple of orders of magnitude. This should not have been a surprise, given that China also had the lowest cumulative total number of confirmed cases.

⁹ The data for China are taken from its National Health Commission. The data for all the other countries are downloaded from Our World in Data.

Japan (the yellow line) had the second lowest cumulative total number of deaths, 17,664, followed by Canada (the pink line) with 27,914.

Chart 4: Cumulative Total Number of Confirmed Deaths, G-7 and BRICS Countries

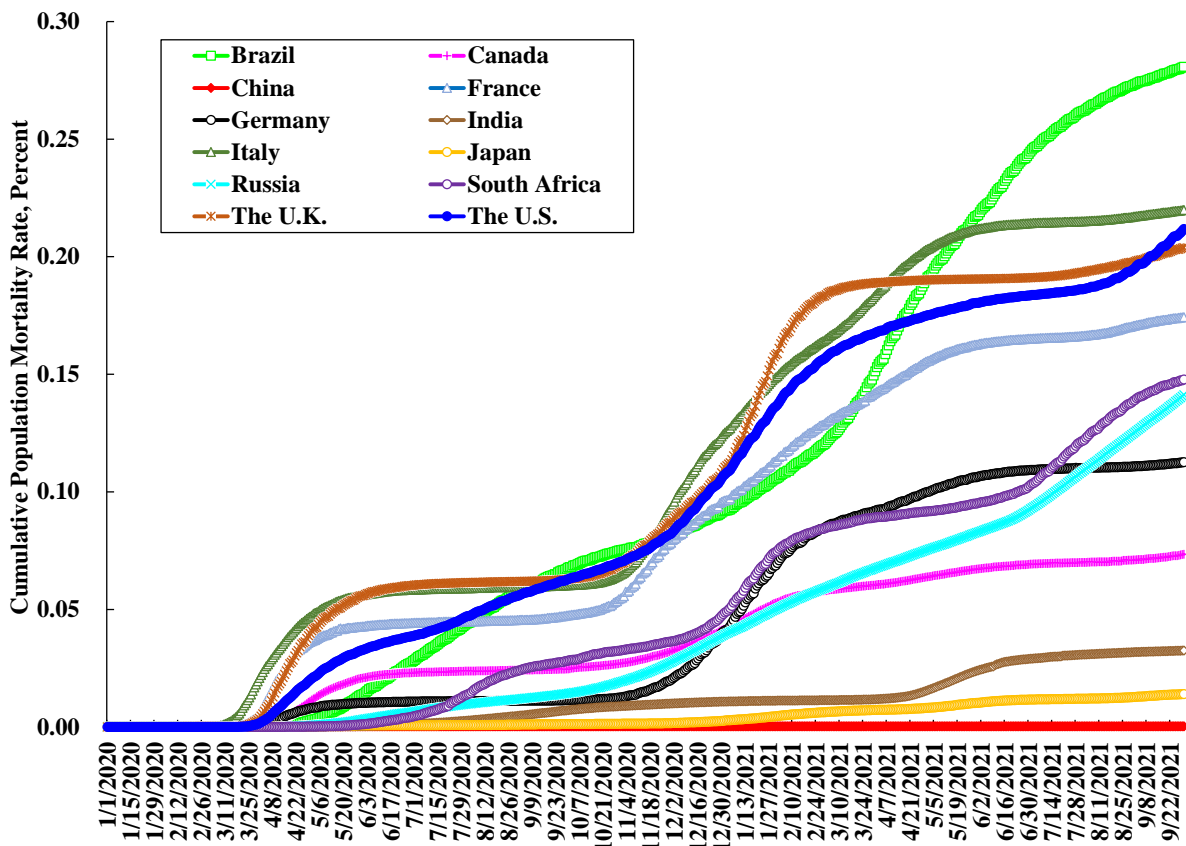


Sources: The data for China are taken from its National Health Commission. The data for all the other countries are downloaded from Our World in Data.

In Chart 5, the cumulative population mortality rates, that is, the cumulative total number of confirmed COVID-19 deaths as a percent of the 2020 population of the twelve selected major countries over time are presented. The cumulative population mortality rate of a country is by definition also equal to the product of its population infection rate (cases per capita) times its case-mortality rate (death per case), which will be examined below. Thus, it can be low because of a low population infection rate, that is, it has done a good job in controlling the spread of the COVID-19 virus. It can also be low because of a low case-mortality rate, that is, it has sufficiently good healthcare so that a COVID-19 patient has a high probability of recovery. Or it can be low because it has both a low population infection rate and a low case-mortality rate.

As of 30 September 2021, Brazil (the light green line) had the highest population mortality rate, at 0.28 percent, followed by Italy (the dark green line), with 0.22 percent. The U.S. (the blue line) was in third place, with 0.21 percent. China had the lowest population mortality rate, at 0.00 percent.¹⁰ Japan (the yellow line) had the second lowest population mortality rate, at 0.01 percent, followed by India (the dark brown line), at 0.03 percent. Of the G-7 countries, only Canada and Germany seem to have cumulative population mortality rates that approach constants, that is, the cumulative numbers of COVID-19 deaths are not rising.

Chart 5: The Cumulative Population Mortality Rates, G-7 and BRICS Countries, percent



Source: Authors' calculations. Data sources for the cumulative number of deaths of each country are the same as Chart 4. Data sources for population of each country are the same as Table 1.

¹⁰ There have been no deaths from imported cases.

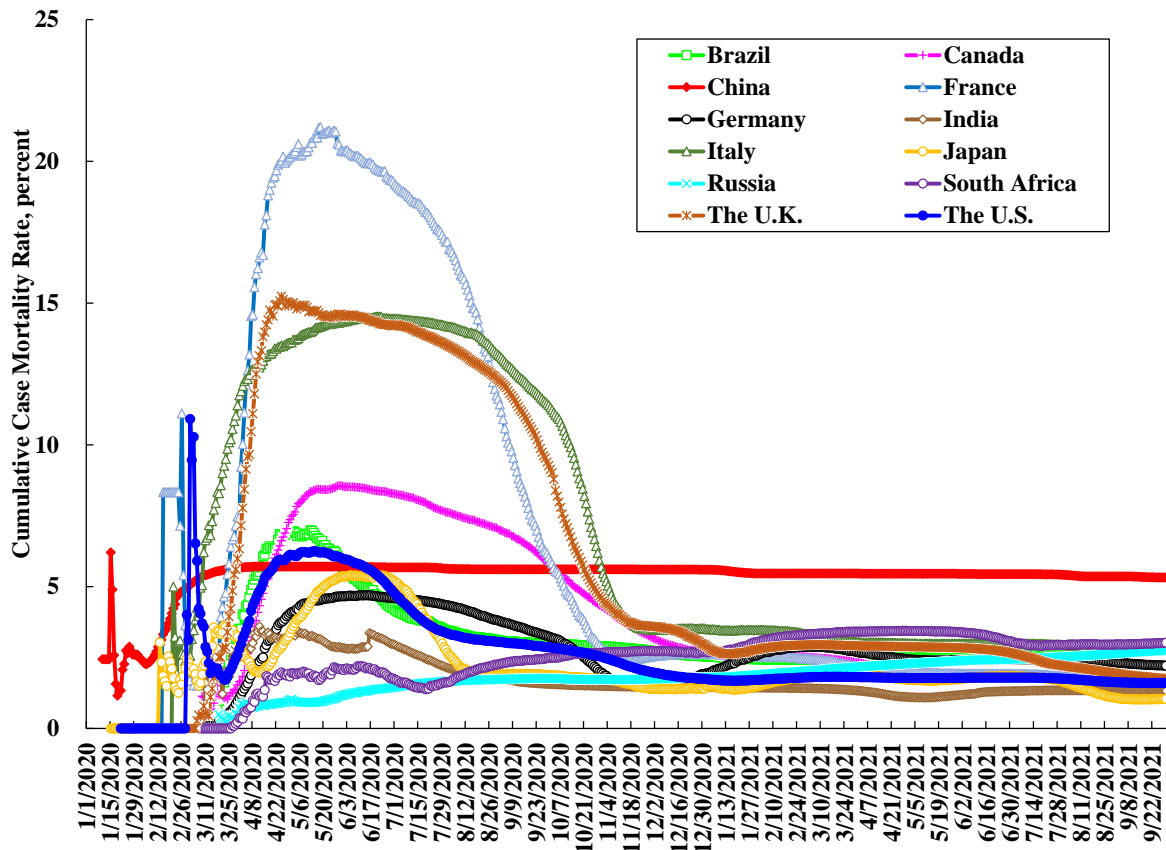
4. The Evolution of the Case-Mortality Rate

We note that even though Canada had a lower cumulative total number of confirmed cases than Japan, it had a higher cumulative total number of confirmed deaths than Japan. This brings us to compare the cumulative case-mortality rate, that is, the ratio of the cumulative total number of deaths to the cumulative total number of confirmed cases, across countries. The case-mortality rate depends on the adequacy of the healthcare infrastructure and services in each country, relative to its respective local demand. Countries with a high case load may therefore also have a high case-mortality rate because the healthcare infrastructure and services are overwhelmed by the demand. It may also depend on the demographic and ethnic compositions of the population. For example, older populations have been found to have a significantly higher COVID-19 case-mortality rate than younger populations.

In Chart 6, the cumulative case-mortality rates of the twelve selected countries over time are presented and compared. In general, the case-mortality rate is expected to rise rapidly at the beginning of the epidemic, reach a peak,¹¹ and then decline gradually over time, as medical treatments of the COVID-19 virus improve with experience and vaccines which, while they cannot be 100 percent effective against the virus, nevertheless reduce the severity of the resulting illness, become available. Chart 6 is broadly consistent with this general picture, even though in some countries there may be more than a single peak, with the exceptions of China (the red line) and Russia (the turquoise line), to be explained below. The case-mortality rates of China, France, Germany, India, Italy, Japan and the U.S. all seem to have more than one peak.

¹¹ However, a peak that occurs very soon after the start date of the epidemic is most likely the result of cumulative delayed reporting and should be ignored.

Chart 6: The Cumulative Case-Mortality Rates, G-7 and BRICS Countries



Sources: Authors' calculations. Data sources for the cumulative number of confirmed cases of each country are the same as Chart 1. Data sources for the cumulative number of deaths of each country are the same as Chart 4.

Chart 6 shows that as of 30 September 2021, China (the red line) had the highest cumulative case-mortality rate among the twelve countries, 5.32 percent, followed by South Africa (the purple line), at 3.02 percent. Italy (the dark green line) was in the third place with 2.80 percent. By comparison, Japan (the yellow line) had the lowest cumulative case-mortality rate of 1.04 percent, followed by India (the dark brown line) with 1.33 percent and the U.S. (the blue line) with 1.61 percent. With the exception of China, the case-mortality rates of all the other countries are as of this writing all clustered between 1.04 and 3.02 percent. It is somewhat puzzling that China, which has the lowest cumulative total numbers of both confirmed cases and deaths, would have not only the highest, but also a significantly higher, case-mortality rate.

China was the first country faced with the outbreak of the COVID-19 epidemic, and at the time little was known as to how patients infected by the virus can and should be treated. The Chinese case-mortality rate was therefore quite high at the very beginning, and reached a peak of 6.20 percent on 15 January 2020. The Chinese peak is, nevertheless, still significantly

lower than the peak case-mortality rates of Brazil,¹² Canada,¹³ France,¹⁴ Italy,¹⁵ the U.K.¹⁶ and the U.S.,¹⁷ but higher than those of Germany, India, Japan, and South Africa. The Russian cumulative case-mortality rate has been growing and continues to grow and does not seem to have reached its peak yet.

Due to China's successful control of the spread of the COVID-19 epidemic, both its cumulative total numbers of confirmed cases and deaths have almost stopped growing since April 2020. As a result, its very slowly declining cumulative case-mortality rate has become almost a constant, at 5.32 percent. At the same time, the COVID-19 epidemic continues to spread in other countries. Over time, however, due to better and more proven medical treatments, the use of vaccines, and the mutations and developments of the virus itself, COVID-19 has become more infectious but less fatal, resulting in a gradual decline in case-mortality rates in most countries. It is therefore of interest to consider an alternative measure of the case-mortality rate in the different countries. Instead of cumulating the number of confirmed cases and deaths from the start date of the epidemic, we begin the cumulation only on the 181st day after the start date of the COVID-19 epidemic in a country. It is hoped that this measure can reflect the "steady-state" situation since it includes only the newly confirmed cases and deaths from that point onwards. The results are presented in Chart 7.

Chart 7 shows that China (the red line) has the lowest "steady-state" case-mortality rate of 0.04 percent, followed by Japan (the yellow line), at 1.00 percent. Canada (the pink line) has the third lowest case-mortality rate at 1.25 percent. South Africa (the purple line) has the highest "steady-state" case-mortality rate of 3.21 percent, followed by Russia (the turquoise line), at 2.92 percent. Brazil (the light green line) has the third highest case-mortality rate at 2.72 percent. For all countries except Russia, this case-mortality rate has been declining over time, which is a good sign. We note, however, that the rankings of countries, leaving out China, are still different between Charts 6 and 7.

¹² 6.99 on 12 May 2020.

¹³ 8.56 on 29 May 2020.

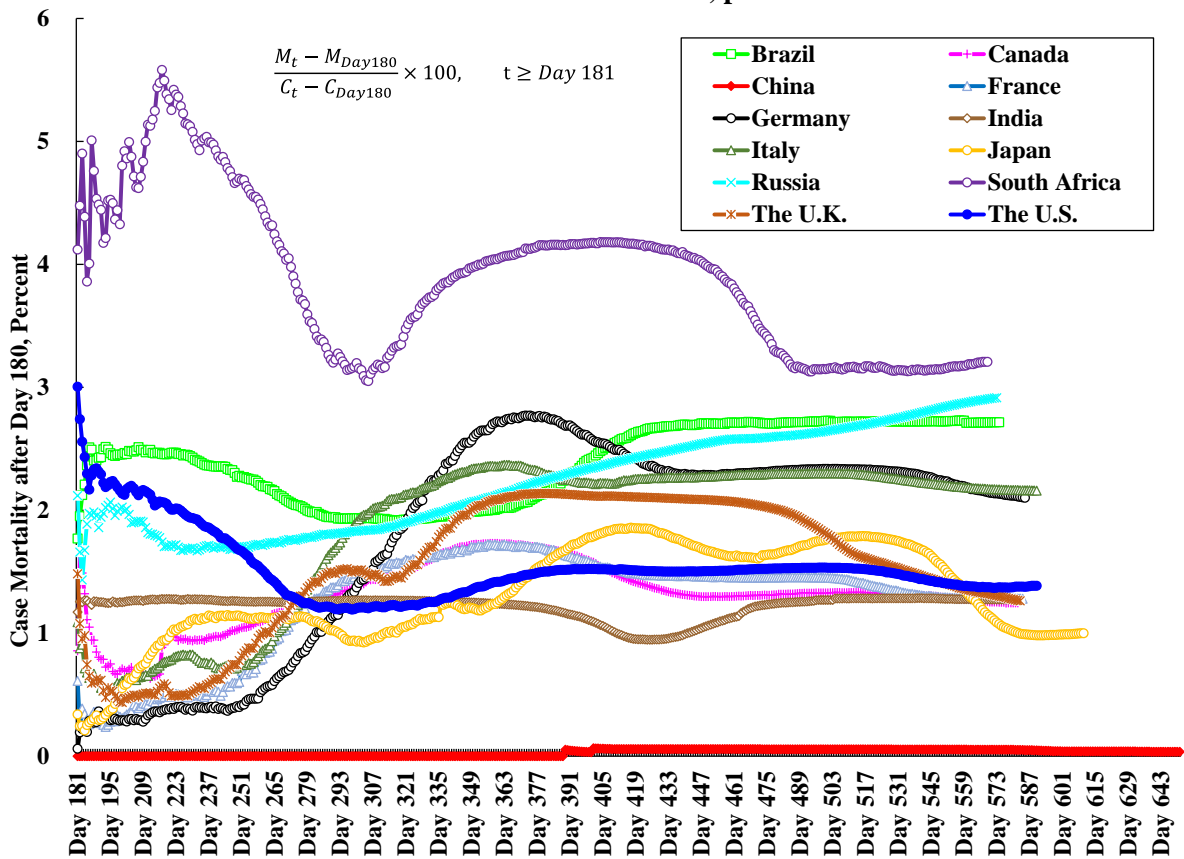
¹⁴ 21.21 on 18 May 2020.

¹⁵ 14.53 on 20 June 2020.

¹⁶ 15.24 on 25 April 2020.

¹⁷ 10.91 on 2 March 2020.

Chart 7: The Cumulative Case-Mortality Rates Starting 180 Days after the Start Date, G-7 and BRICS Countries, percent



Sources: Author’s calculations. Same as Chart 6.

5. Concluding Remarks

We summarise the results of our international comparison in Table 2. Table 2 shows that China has by far the lowest population infection and population mortality rates of all twelve countries. It does have the highest case-mortality rate, but as explained in Section 4 above, this is the result of both the cumulative total number of cases and deaths not growing over time. If we consider a “steady-state” case-mortality rate instead, China also has the lowest. Moreover, China is the only major country that has the COVID-19 epidemic under control. Japan has the second lowest population infection rate, the second lowest population mortality rate, and the lowest case-mortality rate among the twelve countries. Somewhat unexpectedly, India has the third lowest population infection rate, the third lowest population mortality rate, and the second lowest case-mortality rate.¹⁸

¹⁸ Given the disparity between the healthcare availability between India and the G-7 countries, it is a puzzle why the case-mortality rate of India is so low. It can be due to the under-reporting of COVID-19 confirmed cases because of the relative scarcity of testing, and the possible mis-attribution of COVID-19 deaths to other causes.

By comparison, Table 2 also shows that the U.S. has the highest population infection rate and the third highest population mortality rate. However, it also has the third lowest case-mortality rate, after Japan and India, and lower than all the other G-7 countries. The U.K. has the second highest population infection rate, the fourth highest population mortality rate and a respectable case-mortality rate.

Table 2: International Comparisons of the COVID-19 Experiences, 30 September 2021

Country	2020 Permanent Resident Population (millions)	Cumulative Number of Confirmed Cases (millions)	Population Infection Rate, percent	Population Mortality Rate, percent	Case Mortality Rate, percent
Brazil	212.56	21.43	10.08	0.28	2.79
Canada	38.01	1.63	4.29	0.07	1.71
China	1,411.78	0.09	0.01	0.00	5.32
France	67.39	7.01	10.41	0.17	1.67
Germany	83.24	4.24	5.09	0.11	2.21
India	1,380.00	33.77	2.45	0.03	1.33
Italy	59.55	4.67	7.85	0.22	2.80
Japan	126.23	1.70	1.35	0.01	1.04
Russia	144.10	7.40	5.14	0.14	2.75
South Africa	59.31	2.90	4.89	0.15	3.02
The U.K.	67.22	7.84	11.67	0.20	1.75
The U.S.	329.48	43.46	13.19	0.21	1.61

Sources: Same as Table 1, Chart 1, Chart 2, Chart 5 and Chart 6.

How did China manage to control the epidemic successfully? The key is the minimisation of secondary and higher-order transmissions of the virus. This requires first, the practice of good personal hygiene (such as wearing masks and frequent washing of hands) and social distancing on the part of all the residents (Küpper et al (2020)); second, mandatory rapid testing, followed by quarantine and treatment if necessary, and exhaustive contact tracing, by the public health authorities; and third, lockdown, quarantine and travel restrictions by the government (to prevent exports and imports of the virus) (Feng et al (2020); Pearce, Lawlor and Brickley (2020)). The blockade and lockdown of the City of Wuhan in China on the Eve of the Chinese New Year in 2020 was critical to preventing the COVID-19 virus from spreading to other provinces and regions of China (see also Lau and Xiong (2021)). Recently, the availability of effective vaccines against the COVID-19 virus provides an alternative approach for countries with ready access to vaccines—mass vaccination can also help to minimise potential transmissions.

The real surprise is the differential performance between different grouping of countries. A first comparison is between the developed G-7 countries and the BRICS countries (this is almost like a comparison between developed and developing countries). The results are presented in Table 3. Table 3 shows that the BRICS countries as a group has almost the same cumulative total number of confirmed cases as the G-7 countries, around 70 million, even though its total population is four times that of the G-7 countries. Its population infection rate and its population mortality rate are all significantly lower than those of the G-7 countries. Its case mortality rate is higher, 1.91 versus 1.73, but not by a huge margin, considering the huge differences in the availability and quality of healthcare services between the BRICS and G-7 countries.¹⁹

Table 3: A Comparison of the G-7 and BRICS Country Groups, 30 September 2021

Country Group	2020 Permanent Resident Population (millions)	Cumulative Number of Confirmed Cases (millions)	Population Infection Rate, percent	Population Mortality Rate, percent	Case Mortality Rate, percent
G-7	771.12	70.56	9.15	0.16	1.73
BRICS	3,207.76	65.58	2.04	0.04	1.91

Sources: Authors' calculations. Same as Table 2.

A second comparison is among continents: Africa (represented by South Africa), Asian countries (China, India and Japan), European countries (France, Germany, Italy, Russia and the U.K.), and North American countries (Canada and the U.S.). The results are presented in Table 4. Table 4 shows that the Asian countries as a group has by far the largest total population, but the lowest population infection, population mortality, and case-mortality rates among the four groups.²⁰ South Africa has the second lowest population infection rate and population mortality rate. However, its case-mortality rate is the highest, reflecting the developing status of its healthcare infrastructure. The European countries as a group has the second highest population infection, population mortality, and case-mortality rate. Finally, the North American countries as a group has the highest population infection and population

¹⁹ It is possible to argue that there could have been more under-reporting of both the number of confirmed cases and the number of deaths in the BRICS countries than in the G-7 countries. However, it will take huge under-reporting adjustments to raise the population infection and mortality rates of the BRICS countries to the same levels as the G-7 countries.

²⁰ This is consistent with the findings of Jamison and Wu (2021), which analyses a much larger group of countries.

mortality rates and the second highest case-mortality rate. It is somewhat surprising that GDP per capita does not seem to be a useful predictor of the epidemic outcomes.

Table 4: A Comparison of African, Asian, European and North American Country Groups, 30 September 2021

Country Group	2020 Permanent Resident Population (millions)	Cumulative Number of Confirmed Cases (millions)	Population Infection Rate, percent	Population Mortality Rate, percent	Case Mortality Rate, percent
South Africa	59.31	2.90	4.89	0.15	3.02
Asian Countries	2,918.01	35.56	1.22	0.02	1.32
European Countries	421.51	31.17	7.40	0.16	2.19
North American Countries	367.49	45.09	12.27	0.20	1.61

Sources: Authors' calculations. Same as Table 2.

When will the COVID-19 epidemic be over? We shall consider the epidemic to be over in a country when the daily number of newly confirmed cases falls below 20. This can happen if the population is almost fully vaccinated. However, there are now many instances of break-through infections, that is, infections of people who supposedly have been fully vaccinated, possibly because of mutations of the COVID-19 virus. Thus, the continuation of good hygienic practices, mandatory rapid testing and contact tracing, isolation, quarantine and lockdown may still be necessary, at least until the discovery of a specific proven drug or treatment against the COVID-19 virus. Even then, the same methods may have to be used again if another fatal virus emerges.

With these requirements in mind and taking into account the healthcare infrastructure, vaccine availability, and the local cultures, we predict that the epidemic will come to an end in Japan by the end of 2021. For the developed countries of Europe and North America, the complete end of the epidemic will probably occur some time in 2022. For the developing economies of the world, we shall probably be looking at the end of 2022. Of course, the availability of an effective drug or treatment will accelerate this timetable.

The total number of fatalities from the COVID-19 pandemic around the world to date has almost reached 5 million, approximately one-quarter of the estimated total military casualties of World War II or the total fatalities of the 1918 influenza pandemic, and is expected

to rise further. In the absence of a proven effective drug for the treatment of COVID-19, the governments of the individual countries must fight the epidemic as if it were a war if they expect to succeed in bringing the epidemic under control in their respective countries.

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