Global Pandemic Trends of COVID-19 in 2020

Hai-Zhen Chen
Affiliated Tumor Hospital of Nantong University - Nantong

Bo Cai
Nantong Center for Disease Control and Prevention - Nantong

Jian-Guo Chen (chenjg@ntu.edu.cn)
Affiliated Tumor Hospital of Nantong University - Nantong https://orcid.org/0000-0003-4102-8934

Research

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Abstract

Background: The novel coronavirus pneumonia (COVID-19) has been global threaten to public health. This paper provides perspective to the decision-making for public health control of the pandemic or the spread of epidemic.

Methods: According to the WHO global reported database, we developed and used the number of cumulative cases, and the number of cumulative deaths to calculate and analyze rates of incidence, mortality, and fatality by country, with respect to the 30 highest outbreak (Top 30) countries.

Results: As of December 31, 2020, of the global population of 7.585 billion, the cumulative number of reported cases was 81,475,053, and the cumulative number of deaths was 1,798,050. The incidence rate of COVID-19 was 1074.13 per 100,000 population, the mortality rate was 23.70 per 100,000, and the case fatality rate was 2.21%. Among the Top 30 countries, the five countries with the highest number of reported cumulative cases were, in rank, the United States (19,346,790 cases), India (10,266,674), Brazil (7,563,551), Russia (3,159,297) and France (2,556,708), and the five countries with the highest number of cumulative deaths were the United States (335,789 cases), Brazil (192,681), India (148,738), Mexico (123,845) and Italy (73,604). Globally, the countries with the highest incidence rate were, in rank, Andorra, Luxembourg, Montenegro, San Marino, and Czechia; the countries with the highest mortality rate were, in rank, San Marino, Belgium, Slovenia, Italy, and North Macedonia. The highest fatality rate was found in Yemen, Mexico, Montserrat, Isle of Man, and Ecuador, respectively. In China, 96,673 cases of COVID-19 and 4788 deaths were reported in 2020, ranking the 78th and the 43rd, respectively, in the world. The incidence rate and mortality rate were $6.90/10^5$ and $0.34/10^5$, respectively, ranking 207th and 188th in the world. The case fatality rate was 4.95%, ranking 11th in the world.

Conclusions: The COVID-19 prevalence is still on the rise, and the turning points of incidence and mortality are not yet forecasted. Personal protection, anti-epidemic measures and efforts from public health personnel, medical professionals, biotechnology R&D personnel, effectiveness of the vaccination programs and the governments, are the important factors to determine the future prevalence of this coronavirus disease.

Background

Novel coronavirus pneumonia (COVID-19) has been reported by all countries in the world since the first discovery of a group of unidentified pneumonia cases in China in December 2019 [1, 2, 3]. This disease is the most serious infectious disease after the outbreak of SARS [4, 5]. From 13 to 20 January, 2020, the outbreak of COVID-19 epidemic in Asia, Thailand, Japan and Korea became acknowledged, and then merged in various countries and regions in the Middle East, Europe and the United States [6, 7, 8]. Therefore, the World Health Organization (WHO) announced the global epidemic (pandemic) [9] on 11 March 2020. Since then the COVID-19 became the most dangerous infectious disease of 2020. Throughout the 2020 pandemic seasons of infectious diseases, countries all over the world, no matter

what hemisphere, societal structure and governancy, no matter what folk cultures and what religious beliefs, have been facing immense challenges of public health. Unfortunately, although quarantine, contact tracing, screening, and isolation are effective measures of COVID-19 prevention, particularly whenever integrated together, have been established as effective measures of containment [10], the pandemic of COVID-19 has not been effectively curbed up to now. While effectively suppression in spread and control has been observed in some countries, as WHO has already pointed out [9], many countries are struggling with a lack of capacity, some countries are struggling with a lack of resources, and some countries are struggling with a lack of resolve. COVID-19 is even more prevalent in the world from the current development trends. By the time of this analysis (31st December, 2020, European time), the number of cumulative cases with COVID-19 in the world has exceeded 81,475,053 cases, and the deaths has exceeded 1,798,050 cases [11]; the ability of the virus to spread far beyond these current estimates is certain [5, 12]. No one knows how long such a pandemic will last, but 2020 is destined to be only the first year of this global pandemic.

In order to fully understand the evolution and developmental trends of the COVID-19 epidemic, it is necessary to analyze the dynamic fluxes of the incidence and mortality of COVID-19 in various countries around the world. According to COVID-19 epidemic data released by WHO [11], this paper provides analysis of some of the main indicators of the global COVID-19 epidemic, and provides inferences for the delineating of public health strategies for controlling the pandemic or the spread of epidemic.

Materials And Methods

Data resources

WHO has released daily data since 11 January 2020 (starting from 3rd Jan.) on the daily number of new cases, cumulative cases, daily number of new deaths and number of cumulative deaths from COVID-19 by continent and by country (region or territory) through the WHO website (https://www.who.int*)*. It can be obtained by real-time query [11]. To click the "download map data" button at the right bottom of the webpage to download the data file named "WHO-COVID-19-global-data.csv"; or, click directly to the linkage https://covid19.who.int/WHO-COVID-19-global-data.csv, the following main fields (information) can be obtained from this file: date_reported, country_code, country, who_region, new_cases, cumulative_cases, new_deaths, and cumulative_death.

Indices analyzed

According to the data file downloaded, the 4 commonly used epidemic indices for COVID-19 are obtained directly, that is, the daily number of new cases, the cumulative number of cases, the daily number of new deaths, and the cumulative deaths. Based on these 4 figures, we can also calculate the following indicators:

Fatality rate (%) = (cumulative deaths / cumulative cases) X 100%;

Incidence rate ($1/10^5$) = (cumulative cases / national population) X 100,000;

Mortality ($1/10^5$) = (cumulative deaths / national population number) X 100,000.

The population of each country comes from the global population statistics in 2020 (https://www.phb123.com/city/renkou/rk.html*)* [12].

Statistical methods

According to the above data and statistical indicators, the incidence rate, mortality rate, and fatality rate of COVID-19 for 237 countries (regions or territories) in the world are can be calculated. The cumulative numbers of cases and deaths were listed for the top 30 countries in the world (Top 30) from high to low, on the number of cumulative cases. The incidence rate, mortality rate and fatality rate by country (region) of COVID-19 are also ranked and compared among the main countries.

Patient and public involvement

This research does not contain any personal or medical information about an identifiable individual. Data are available in a public, open access repository from the WHO.

Results

Global pandemic situation

From Jan. 1st to Dec. 31st, 2020, of the 7.585 billion people in the world, the cumulative number of reported cases was 81,475,053, and the cumulative number of deaths was 1,798,050. Among them, the population (3.822 billion) of 30 countries (Top 30) with the most cases accounted for 50.38% of the total population in the world; and their cumulative incident cases (69,827,269) and the cumulative deaths (1,584,166) accounted for 85.70% and 88.18% of world values, respectively. The 10 countries with the most cumulative cases, in rank, were the United States (19,346,790 cases), India (10,266,674), Brazil (7,563,551), Russia (3,159,297), France (2,556,708), The United Kingdom (2,432,892), Italy (2,083,689), Spain (1,893,502), Germany (1,719,737), and Colombia (1,614,822), respectively. The Top 10 countries with the most cumulative deaths were the United States (335,789 cases), Brazil (192,681), India (148,738), Mexico (123,845), Italy (73,604), The United Kingdom (72,548), France (64,004), Russia (57,019), Iran (55,095), and Spain (50,442), respectively. The epidemic indices of COVID-19 in the Top 30 countries are list as Table 1.

Trends of the epidemic in major countries

China The epidemic of COVID-19 in China started in the beginning of Jan., the total number of cases exceeded 100 on Jan. 19, over 1,000 on Jan. 25, over 10,000 on Feb. 1, over 50,000 on Feb. 13 and over 80,000 on March 2. Since then, the epidemic has been largely controlled and stabilized at a plateau level of cases between 90,000 and 100,000. At the end of 2020, it reached to 96,673 cases, ranking the 78th in the world. The first death case in China reported on Jan. 11, over 10 cumulative deaths reported after Jan.

23, and 100 deaths reported on Jan. 28. More than 1,000 deaths on Feb. 11, 2000 deaths on Feb. 19, and 3000 deaths on March 5 were reported, successively. On March 17, the cumulative deaths exceed to 4600, and after that the deaths were kept under 4800 until the end of the year. The total deaths due to COVID-19 in China were 4788 cases in 2020, ranking 43rd in the world. The outbreak and deaths in China in 2020 are shown in Fig. 1A.

The United States Based upon the WHO's data, the first case reported in the United States (US) was on Jan. 19. The total number of cases exceeded 100 on March 3, more than 1,000 on March 13, 10,000 on March 19, and 100,000 on March 29 (at this point, the total number of cases had overtaken the total number of cases in China). Since then, cases continued to rise. By April 30, there had been more than 1 M cases; on June 13 and July 10 milestones of 2 M and 3 M cases were reached, respectively. There were more than 5 M cases on Aug. 12, 10 M in Nov. 12, and 15 M on Dec. 11. As of Dec. 31, the total number of cases of COVID-19 in US in 2020 was 19,346,790, ranking first in the world. The first two deaths reported in the US were on March 3, 2020. Thereafter the total number of deaths exceeded 100 on March 18, 1,000 on March 28, 10,000 on April 8, 100,000 on May 29, 200,000 on Sept. 25, and 300,000 on Dec. 17. As of Dec. 31, the number of cumulative deaths of COVID-19 in the US at the end of 2020 was 335,789, also ranking first in the world. The outbreak and deaths in US are shown in Fig. 1B.

Indian India's epidemic ranks second to that of the US. The first case (5 cases) was reported on Jan. 30, and no more than 3 cases were reported until March 2. The total number of cases reached 100 on March 15, 1,000 on March 30, 10,000 on April 14, and 100,000 on May 19. Cases reached 500,000 on June 27, 1 M on July 17, and then continued to 2 M on Aug. 7, 3 M on Aug. 23, and 5 M on Sept. 16. On Dec. 19, the total number of cases reached 10 M. As of Dec. 31, 2020, the number of cumulative cases of COVID-19 in India in 2020 was 10,266,674. India reported its first death on March 13. The total number of deaths reached 100 on April 6, 1,000 on April 29, 10,000 on June 17, and 100,000 on Oct. 3. As of Dec. 31, the number of cumulative deaths from COVID-19 in India in 2020 was 148,738, ranking the third in the world. The outbreak and deaths in India in 2020 are shown in Fig. 1C.

Brazil The total number of COVID-19 cases in Brazil ranks third only behind the US and India. Its time of first case report (Feb. 26) was later than that of China, the US, and India. The cases were more than 10 on March 5, more than 100 on March 14, 1,000 on March 24, 10,000 on April 6, and 100,000 on May 5. It reached to 1 M on June 21, 2 M on July 18, and 3 M in Aug.10. The number of cumulative cases was 5 M on Oct. 9, and at the end of 2020, 7,563,551. Brazil reported its first death on March 18, 2020. Then deaths exceeded 1000 on March 30, 1,000 on April 12, 10,000 on May 11, and 100,000 on Aug. 10. As of Dec. 31, the total number of cumulative deaths of COVID-19 in Brazil in 2020 was 192,681, ranking second in the world. The outbreak and deaths in Brazil in 2020 are shown in Fig. 1D.

Cumulative cases in Russia, The United Kingdom, France, Italy, Spain, Germany, and Colombia

The numbers of cases of COVID-19 in 2020 from Russia, the United Kingdom, France, Italy, Spain, Germany, and Colombia are shown in Fig. 2A.

Russia The total number of cases ranks fourth globally. Its first case (2 cases) was reported on Jan. 31, over 100 cases on March 18, 10,000 on April 9 and 1 M cases on Sept. 1. The number of cumulative cases in 2020 was 3,159,297.

France The total number of cases ranks fifth, and its first case (3 cases) was reported on Feb. 24. It reached 100 cases on March 1, 10,000 on March 20, and 1 M on Oct. 24. The number of cumulative cases in 2020 was 2,556,708.

The United Kingdom The total number of cases in the United Kingdom (UK) ranks sixth, and its first case (2 cases) was reported on Feb 1. It reached 100 cases on March 4, 10,000 on March 24, and 1 M on Nov. 1. The number of cumulative cases in 2020 was 2,432,892.

Italy The total number of cases in Italy ranks seventh. Its first case (2 cases) was reported on Jan. 29. There were more than 100 cases on Feb. 24, 10,000 cases on March 31, and 1 M on Nov. 12. The number of cumulative cases in 2020 was 2,083,689.

Spain The total number of cases ranks eighth. Its first case (4 cases) was reported on Feb. 2. There were more than 100 cases on March 3, 10,000 on March 16, and 1 M on Oct. 19. The number of cumulative cases in 2020 was 1,893,502.

Germany The total number of cases ranks ninth. Its first case was reported on Jan. 28. There were over 100 cases on March 1, 10,000 on March 20, and 1 M on Nov. 27. The number of cumulative cases in 2020 was 1,719,737.

Colombia The total number of cases ranks tenth. Its first case (5 cases) was reported on March 3. There were 100 cases on March 18, 10,000 on May 24, and 1 M on Oct. 21. The number of cumulative cases in 2020 was 1,614,822.

Cumulative deaths in Mexico, Italy, The UK, France, Iran, Russia, and Spain

The numbers of cumulative deaths of COVID-19 in 2010 from Mexico, Italy, the UK, France, Iran, Russia and Spain are shown in Fig. 2B.

Mexico The total number of deaths ranks fourth in the world. The first death was reported on March 19, 2020. It exceeded 100 deaths on April 8, 1,000 on April 25, 10,000 on June 3, and 100,000 on Nov. 21. As of Dec. 31, the total number of deaths of COVID-19 in Mexico was 123,845.

Italy The total number of deaths ranks fifth. The first death (2 cases) was reported on Feb. 23, over 100 deaths on March 5, 1,000 on March 13, 10,000 on March 29, and 50,000 on Nov. 24. As of Dec. 31, the number of cumulative deaths of COVID-19 in Italy was 73,604.

The UK The total number of deaths ranks sixth. The first death was reported on March 7, exceeded 100 deaths on March 19, 1,000 on March 28, 10,000 on April 11, and 50,000 on Nov. 12. As of Dec. 31, the

number of cumulative deaths of COVID-19 in the UK was 72,548.

France The total number of deaths ranks seventh. The first death was reported on Feb. 15, reaching 100 deaths on March 16, 1,000 on March 25, 10,000 on April 8, and 50,000 on Nov. 26. As of Dec. 31, the number of cumulative deaths of COVID-19 in France was 64,004.

Russia The total number of deaths ranks eighth. The first death (2 cases) was reported on March 26,reaching 100 deaths on April 11, 1,000 on April 30, 10,000 on July 4, and 50,000 on Dec. 19. As of Dec. 31, the number of cumulative deaths of COVID-19 in Russia was 57,019.

Iran The total number of deaths ranks ninth. The first death (2 cases) was reported on Feb. 19, 2020, was over 100 deaths on March 5, 1,000 on March 18, 10,000 on June 26, and 50,000 on Dec. 6. As of Dec. 31, the number of cumulative deaths of COVID-19 in Iran was 55,095.

Spain The total number of deaths ranks tenth. The first death was reported on Feb. 13, reaching 100 deaths on March 13, 1,000 on March 20, 10,000 on April 2, and 50,000 on Dec. 24. As of Dec. 31, the number of cumulative deaths of COVID-19 in Spain was 50,442.

Incidence, mortality and fatality rates in major countries

Incidence rate The incidence rate of global COVID-19 in 2020 was 1074.13/10 per 100,000 population (10^5). According to the population-based incidence rate by country, the ten highest incidence rates of countries were, in rank, Andorra (10,373.86/10^5), Luxembourg (7,861.99/10^5), Montenegro (7,615.79/10^5), San Marino (6,952.35/10^5), Czechia (6,763.71/10^5), The US (5,920.67/10^5), Bahrain (5,898.24/10^5), French Polynesia (5,894.86/10^5), Georgia (5,820.64/10^5), and Slovenia (5,753.25/10^5), respectively. The incidence rate of COVID-19 in China was 6.90/10^5, ranking 207th in the world. The rank order of the top 30 countries with the highest incidence rates is shown in Fig. 3A.

Mortality rate In 2020, the average mortality rate of COVID-19 worldwide was 23.70 /10^5. The ten countries with the highest mortality rate from COVID-19 were, in rank, San Marino (175.82/10^5), Belgium (169.07/10^5), Slovenia (128.86/10^5), Italy (121.70/10^5), North Macedonia (119.33/10^5), Bosnia & Herzegovina (115.60/10^5), Peru (115.43/10^5), Andorra (109.16/10^5), Czechia (108.99/10^5), and the UK (108.97/10^5). The mortality rate of COVID-19 in China was 0.34%, ranking 188th in the world. The rank of the top 30 countries with the highest mortality rates is shown in Fig. 3B.

Fatality rate In 2020, the total number of COVID-19 cases was 81,475,053, and the number of cumulative deaths was 1,798,050 in the world, so the global average fatality rate of COVID-19 cases (at the end of the year) was 2.21%. Yemen, in Asia, had the highest case fatality rate, being 29.08% (611/2,101); Mexico, in Northern America, ranked second with a rate of 8.84% (123,845 /1,401,529); Montserrat (the UK overseas territory) ranked third with a rate of 7.69% (1/13). The countries (territories) in the fourth to tenth ranks are Isle of Man (6.68%, 25/374), Ecuador (6.63%, 14,023/211,512), Sudan (6.30%, 1,468/23,316), Syrian Arab Rep. (6.21%, 704/11,344), Bolivia (5.82%, 9,135/156,887), Egypt (5.54%, 7,576/136,644), and

Chad (5.01%, 104/2,077) (Fig. 3C). The case fatality rate in China was 4.95% (4,788/96,673), ranking 11th in the world.

Discussion

The pneumonia (COVID-19) caused by new coronavirus (SARS-COV-2) has become the most serious and influential pandemic since the SARS epidemic in 2003 [4, 5, 6], and indeed now far exceeds it public health impact. WHO has repeatedly called on all sectors of the world to unite and cooperate to fight against this coronavirus pneumonia. The past 12 months of 2020, fully demonstrated the impact of anti-epidemic practices on the development and changes in epidemic situations under different social systems, social backgrounds and different public health concepts [3, 7, 13, 14].

We use the WHO's open access data is not only for analyzing the global epidemic status, but also for delineating the development trends of the pandemic of COVID-19. Through the basic epidemic data provided by WHO and the analysis within this paper, we can fully show the ups and downs of the epidemic situation, the "track" or even the "unexpected" situation of the spread of this disease. One can find from this article that due to the great pathogenicity and infectivity of SARS-COV-2, the whole world has been heavily attacked by the virus, regardless of social and political systems, regardless of the size of the country's wealth, regardless of ethnic and religious habits [7]. According to WHO, COVID-19 has been reported in 222 of 237 countries (regions or territories) in the world at this point of 2020/12/31 [11].

China is the first country reported the unknown-pneumonia at the very beginning of the outbreak of new coronavirus infection [1, 2, 3]. Since the epidemic first appeared in China, it mandated a needfor understanding of the epidemic rhythm, etiological and clinical features [4, 7]. The novel coronavirus pneumonia has took 2 weeks from the early suspicion of discovery (Dec. 31, 2019) to a rough “understanding" of the viral-disease; from "unknown cause" to the determination of the "human transmission" epidemic process. Then it took another week to take protection, isolation, and lockdown measures [3], resulting in the rapid control (containment) of epidemic within a short period of month (2 incubation periods)[10]. Looking back to analyze the development of the epidemic situation in China, we find that it took only 6 days from the emergence of more than 100 cumulative cases to 1000 cases; and took 7 days from 1,000 cases to 10,000 cases; and took 12 days from 10,000 cases on Feb. 1 to 50,000 cases on Feb. 13. After another 18 days, the cumulative cases reached 80,000 on March 2. The subsequent epidemics have been fully prevented and controlled [3, 4], and the effects are fully demonstrated on the curves in Fig. 1A.

The US is one of the countries that has been affected by the epidemic later. When 80,000 people in China suffered from COVID-19 in early March, the number of reported cases in US was less than 100. However, when the number of cases in US exceeded 100 on March 3, the number of cumulative cases increased in a speed of exponential growth rate exceeding 1,000, 10,000 and 100,000 cases within every 10 days. From 100,000 cases on March 29 to more than 1 M cases on April 30, taking only one month. In the

period of May, the daily COVID-19 new cases seem to be following a downward trend in the US. However, perhaps due to the crowd gathering of “work resumption” [15] and the campaign of social justice (“BML”, black lives matter) [16], the epidemic of COVID-19 reemerged as a serious outbreak, resulting in excess of 2 M cases on June 13, and over 4 M cases on July 25. From mid-Sept., the epidemic curves in the US have continued to climb upwards, and the daily number of new cases has risen from 30,000–40,000 to more than 100,000 on Nov. 6, and even more than 200,000 a day after Dec. 5. The daily deaths due to COVID-19 exceeded 1,000 after mid-Nov., with a maximum of 3,443 a day on Dec. 19. Based upon these available data, we may conclude that the daily increase in the number of new cases and deaths of COVID-19 in the US have not yet shown any dampening in the upward epidemic trends.

The epidemic in India began at the end of Jan., with no new cases reported during the most days of Feb., 2020. New cases appeared again in early March, and the number increased sharply at the end of March. Then the number of cumulative cases increased from 1,000 to 10,000 in two weeks; to 100,000 in five weeks, and to 1 M in the eight subsequent weeks on July 17. After that, the number of new cases per day has continued to rise, with a highest number of 97,994 cases per day, and the number of cumulative cases of more than 5 M in mid-Sept. Thereafter, the number of new cases gradually declined, and by the end of the year, the number of daily new cases fluctuated around 2,000. This may reflect the measures such as the effort of “lockdown” in India [13]. The trend curves of the number of daily deaths and cumulative deaths in India were similar to the curves of the number of daily new cases and the number of cumulative deaths. The COVID-19 epidemic in India seems to have been gradually contained, if this trend can be maintained.

Brazil is another country where the epidemic developed very rapidly [17], starting after the epidemic situation in China has been controlled. Since the first case reported at the end of Feb., it took less than 25 days to cross three logarithmic levels of 100 cases, 1,000 cases and 10,000 cases. Since May 2, it has surpassed the number of cumulative cases reported from China at that period, reaching 85,380. The number of cases continued to rise in the period of May to July, until reached to a peak of 69,074 cases daily on July 31. After that the number kept on declining slightly until early of Nov., and then rose again. By Dec. 18, the daily number of new cases reached a peak of 70,574 for the year. The curves of daily deaths and cumulative deaths in Brazil were similar to the curves of daily new cases and cumulative cases, respectively. According to the present trends, in general, the second epidemic peak of the COVID-19 in Brazil will appear within the next two months. It is likely to become the third country with cumulative number of more than 10 M cases.

Figure 2A shows the incidence rates of COVID-19 in other major countries. Russia’s COVID-19 epidemic developed slowly before March. However, since April, the epidemic has developed relatively fast, reaching a level of more than 10,000 cases per day in early May, and the cumulative deaths were increasing rapidly, resulting in high a case fatality rate [18]. These trends appeared to be slowing down between June and Oct. But after Oct. 4, a trend of increasing by 10,000 cases every day appeared again. By Dec. 21, it

reached the level of 29,350 cases a day, becoming the fourth country in the world in terms of cumulative cases in 2020, and the epidemic trend is not optimistic at present.

The epidemic of COVID-19 in France grew at a relatively rapid rate from early March to April. However, it experienced a relatively slow plateau from May to Aug. The increase in case numbers between Sept. and Nov. was relatively fast, reaching a high level [19]. The prevalence of COVID-19 in the UK was roughly the same as that in France from early March to April, but soon surpassed France, mainly because of the delayed “social distancing” policy, or the prevailing concept of "herd immunity" [20] seen in some European countries. After mid-Sept., the number of cumulative cases surpassed by that of France, but at a still faster rate. The UK has become the sixth most prevalent country in the world. Italy is one of the European countries where the COVID-19 epidemic occurred earliest (March). The increase in case numbers before May was relatively rapid. The epidemic was relatively stable from June to Sept., and increased from Sept. to Oct. After Oct. 17, it accelerated sharply again, with the number of new cases on Nov. 14 being 40,902. After Dec. 11, the total number of cases ranked seventh in the world.

Spain was not an early epidemic country in Europe. The initial epidemic situation of COVID-19 was similar to Italy [21], but after March it rapidly became the country with the most severe disease in the European countries. It was relatively stable after mid-May, and accelerated again from July to Oct., becoming the country second only to the incidence of Russia. It was surpassed by France in late Oct. and by Italy and the UK after Dec. 6, ranking eighth in the world. The COVID-19 epidemic at the initial period in Germany was similar to that in France [21]. Before Aug., it was similar to that of France but slightly higher than that of the UK. After Aug. 27, it was overtaken by France again, and the subsequent epidemic trend was similar to Italy but the number of cases was lower. The increase in the daily number of new cases and the cumulative case accelerated after later Oct., indicating that its incidence peak has arrived. At the end of 2020 it ranked 9th in the world. Colombia is a country in South America with a high incidence second only to Brazil, but its outbreak started late. After the cases appeared in March, they showed a pulse-like onset, and a steady lower trend observed in early May [22]. The number of cumulative cases rose rapidly after July, surpassing France, Germany, Italy, the UK, and Spain. It was surpassed by Spain and France in late Oct., by the UK in early Nov., by Italy in mid-Nov. and by Germany in mid-Dec. Colombia ranked 10th globally in the total number of COVID-19 cases in 2020.

The above data analysis shows that for COVID-19 the increments of cumulative growth from 100 cases, to 1,000 cases, to 10,000 cases and to 100,000 cases, in the absence of effective control mechanisms and policies, are about ten days for each 10-fold increase in magnitude. If there were quarantine measures, namely, intervention or exercising social distancing mandatese, the time of growth of this magnitude would be lengthen; if there were no control measures, the time to 10-fold increase in magnitude would be significantly shorter. For example, in the early stage of China's epidemic development, as the cumulative number of cases was less than 1,000 (before Jan. 25), the 10-fold increase in magnitude was very short; after strengthening prevention and control, then the time of case increase from 1,000 cases to 10,000 cases became longer; and so far there were no more than 100,000 of

cumulative cases in China. In contrast, in countries with no containment measures of prevention and control, such as in the US, the time of 10-fold increment from 100 cases to 1,000 cases, to 10,000 cases, and to 100,000 cases, were less than 10 days! This may reflect the COVID-19 epidemic severity and regularity under the "natural condition", and the basic reproduction numbers [21]. On the other hand, it told us that the effective prevention and intervention can contain the epidemic; and China's prevention and control measures for the COVID-19 were prompt and reasonable [3].

An important indicator for assessing the severity of an epidemic is the cumulative number of deaths. However, the number of cumulative deaths will be affected by the number of cumulative cases, and by the size of the country's population. Therefore, while caring about the total number of cumulative cases and cumulative deaths in a defined period, we must mention the case fatality rate that is the ratio of cumulative deaths to cumulative number of cases; and also we must care about the incidence and mortality rates which are based on the national or regional population size. General speaking, the case fatality reflects how many people (cases) die of the disease from patients (the denominator is the sick) [23], demonstrating the hazard degree of disease to life. In the epidemiological sense, the incidence (mortality) rate is concerned about how many patients have suffered or died of the disease in the population (the denominator is the total population), reflecting the epidemic (death) degree or range of a disease. Assume that 200 cases are from a 1 M population and 8 died, making incidence rate of 20 per 100,000 (200/1 M), mortality rate of 0.8 per 100,000 (8/1 M), and the case fatality of 4% (8/200), telling us, obviously, the different implications clinically and epidemiologically.

COVID-19 incidence, mortality, and fatality rates are calculated based on the WHO data and the population data by country. The results show that in the year of 2020, the Top 30 countries with the largest number of cumulative cases account for more than 1/2 (50.38%) of the global population, but the cumulative cases account for 85.70%, and the cumulative death cases account for 88.18% of the global total deaths of COVID-19. The incidence rate and mortality rate of Top 30 countries were 1827.17/10^5 and 41.45/10^5, respectively, being higher than the total incidence rate and mortality rate of 1074.13/10^5 and 23.70/10^5 all over the world. The US with high number of cumulative cases surely had high an incidence rate, but was not the country with the highest incidence rate. Its incidence and mortality rates were 1,023.60/10^5 and 41.33/10^5, respectively, ranking 6th and 14th, respectively, in the world. Table 1 shows that although the number of cumulative cases in Czechia is listed as only 21st, the incidence rate of 6,763.71/10^5 was the highest among the Top 30 countries, due to its small population of less than 1 M. In fact, when considering the incidence rates of COVID-19 from all countries in the world, we would find that many so-called small countries (territories or regions) were also on the list. Figure 3A shows that the highest incidence rate of COVID-19 is found to be in Andorra (10,373.86/10^5), followed by Luxembourg (7,861.99/10^5), and Montenegro (7,615.79/10^5), although their cumulative cases are not listed in the TOP 30 countries.

The cumulative cases (96,673) and cumulative deaths (4,788) in China were ranked at the 79th and 43rd, respectively, but the incidence rate (0.33/10^5) and mortality rate (0.33/10^5) ranked only 207th and 188th,

respectively, simply because of its huge population but relative fewer cases (deaths). Based on this situation, although the COVID-19 had the first break out in China in the first quarter of the year 2020, it was also the first to be controlled in the world, due to its rapid, appropriate and effective measures [3, 4, 10]. It has set a convincing example for global prevention and control of this pandemic.

Fatality is an important indicator of disease control management, medical treatment and prognosis. For that of COVID-19, someone [24, 25] argued the way of calculation because of the estimation of the denominator, but in this paper, that would be no real impact on estimation of the rate. The overall case fatality rate of COVID-19 in 2020 was 2.21%; while the rate in the Top 30 countries was slightly higher than the global level, being 2.27%. There were no real distinction for fatality rates of COVID-19 between the developed and less developed countries, as shown in Fig. 3C. This may be related to the fact that COVID-19 is an emerging disease, and its clinical outcome not only depends on the clinical treatment itself, but depends on many factors such as the extent of the epidemic in each country, emergency treatments, the availability of medical resources and others [8, 10]. In China, for instance, which was the first to bear the brunt of the outbreak, exhibited a fatality rate that gradually increased from about 2% at the beginning to 5.52% at the peak on April 17, and then steadily decreased with an average rate of 4.95% at the end of the year (4,788/96,673). In the US, the first death cases was reported on March 3, and soon, the case fatality rate reached up to 6.77% (9/133) on March 6, then began to decline to 1.27% (402/31,573) on March 23; and rose again to 6.18% (67,637/1,093,880) on May 3, after that steadily decreased to 1.74% (335,789/19,346,790) at the end of the year. It can be seen from Fig. 1B that the high fatality rate in May in the US may be related to the first outbreak peak in April, and may be also related to the failure of patients to receive possible emergency treatment due to the crowding out of medical resources [23]. In Europe, the fatality rate was very high in the early outbreak countries, as was it high in early period in China [26]. In France, for example, it was reported that in the first three months of the epidemic, due to lack of validated COVID-19 treatment, the fatality rate in some medical institutions reached up to 44% [27].

Why with so many countries facing the outbreaks of COVID-19, were there big differences in incidence, mortality, and fatality? The answer is likely involve many factors [5,8,10, 23,26,28–31]: 1) In countries with earlier outbreaks, due to lack of knowledge, of prevention and control measures, the epidemic developed rapidly; 2) Because the novel coronavirus was not recognized initially by the symptoms, development or prognosis [5, 28], the clinicians faced to the shortage of medical treatment, to the crowding of medical equipment [23]; 3) Due to the relatively high proportion of an aging population [32], such as in Europe and America, elderly people were more easily infected with the coronavirus and to die from the disease; 4) Because there was no proven drug treatment, fatality from COVID-19 was not essentially different between large and small countries, between developed and less developed countries. 5) Personal self-protection (mask wearing and hand washing), community isolation, and social distance are important factors and even decisive factors affecting the disease epidemic [10], although a report showed no significant benefits on case growth of more restrictive non-pharmaceutical interventions [33].

The length of time that the number of cases doubled may be one of the important and sensitive indicators to evaluate whether the disease is effectively controlled or not. Due to the diversity of the global society and the complexity of social systems, and the cultural differences in the cognition of diseases, individual behavior will be crucial to control the spread of COVID-19. Personal behavior, rather than government action, in western democracies might be the most important issue. Early self-isolation, and social distancing are key. Government actions to ban mass gatherings [10] would be essentially important.

According to the current epidemic situation and trends, the global burden of COVID-19 is not slowing down. So far the initial, novel coronavirus vaccines in the world have achieved good results in early trials, and the current COVID-19 vaccine candidates are safe, tolerated, and immunogenic [34], but their shorter or long term efficacy or the extent of protective effect need to be verified in different populations [35]. Dissemination to all people of the global community remains an enormous challenge. Therefore, strict isolation, social distance, even lockdowns may be still the best vaccine [36] before effective virus vaccine immunization With the vaccines can be broadly administered.

From the analysis of this paper, it is evident that COVID-19 will be still on the rise in the US for months to come. If the current prevention and control measures and capabilities can't be effectively changed (if the effect of the vaccine is uncertain), it may reach at least the level of 50 M cumulative cases in the year 2021. Assuming its low case fatality rate of 1.6% is sustained despite the emergence of more infectious variants, the number of cumulative deaths due to COVID-19 will reach to 800,000. For India, if new peak of outbreak does appear, its number of cumulative cases will be contained within 40 M, with a number of cumulative deaths of over 500,000. While the number of new cases in Brazil, if no second peak wave in 2021, the cumulative number of cases may rise to 30 M. Its cumulative number of deaths may reach to 700,000, due to its relatively high case fatality rate. The numbers of cumulative cases from only these 3 countries will exceed 120 M, that will be far over some estimation of 80 M in 2021 worldwide [37]. From a global perspective, countries and regions where epidemic prevention measures were in place, community isolation, public health supervision, and government regulation were better, the epidemic trends could be seen to have slowed down [8, 10, 19]. For the past hard year, China's local prevention and control has undoubtedly handed in excellent answers [3, 4], but at present, it still needs to be vigilant and prevent imported cases.

To curb the COVID-19 pandemic worldwide, the prevention and control efforts from public professionals, treatment capacity from medical workers, development capacity from biotechnological researchers, and the attitude and measures of various countries' governments, and the public's awareness, cooperation in self protection, and the overall effectiveness of the vaccination programs [31–36, 38] will be the important factors to decide whether the COVID-19 will continue to be epidemic or become contained. COVID-19 control would be possible only if the whole society embraces the challenges, and learned more from failure in prevention [39]. But, there is a long way to go.

Conclusions

Based on WHO's global open access report data, 81,475,053 cases and 1,798,050 deaths were reported worldwide with an incidence of 1074.13, mortality of 23.70 per 100,000 population, and case fatality rate of 2.21%. The US, India, and Brazil were the worst affected countries; and the US, Brazil, India, had the highest number of deaths. The highest case fatality rate was found in Yemen, Mexico, and Montserrat. By comparing the major indices of the epidemic, Covid-19 has been demonstrated as a global public health hazard regardless of social and political systems, regardless of the size of the country's wealth, regardless of ethnic and religious habits. Personal self-protection, social distance, community isolation or even lockdown, might be the important factors and even decisive factors affecting the disease epidemic in various countries. The current situation is described, the developmental trends of the epidemic are predicted, and the factors influencing the outcome of COVID-19 pandemic are evaluated. So far, there is no sign that the global pandemic of COVID-19 has eased. The global anti-epidemic efforts must not be neglected and relaxed.

Abbreviations

COVID-19: Novel coronavirus disease 2019; SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2; WHO: World Health Organization; US: the United States; UK: the United Kingdom.

Declarations

Ethics approval and consent for participant

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

Data are available in a public, open access repository. All data and code used for this article is available in WHO open access repository (*https://covid19.who.int/WHO-COVID-19-global-data.csv*). The data and code are accessible for public use.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

HZC and BC contributed equally to this work. JGC is guarantor of the article and participated in conceptualization and design of the study, performed the data collection and analysis, and wrote and edited the manuscript. HZC and BC participated in the data collection, performed the analysis, and wrote the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1. Epidemic indices of COVID-19 in Top 30 countries with the most cumulative cases

(2020.01.01 – 2020.12.31)

Country*	Population	Cumulative cases	Cumulative deaths	Fatality (%)	Incidence (10^5)	Mortality (10^5)
United States	326766748	19346790	335789	1.74	5920.67	102.76
India	1354051854	10266674	148738	1.45	758.22	10.98
Brazil	210867954	7563551	192681	2.55	3586.87	91.38
Russian	143964709	3159297	57019	1.80	2194.49	39.61
France	65233271	2556708	64004	2.50	3919.33	98.12
The United Kingdom	66573504	2432892	72548	2.98	3654.44	108.97
Italy	60482200	2083689	73604	3.53	3445.13	121.70
Spain	46397452	1893502	50442	2.66	4081.05	108.72
Germany	82293457	1719737	33071	1.92	2089.76	40.19
Colombia	49464683	1614822	42620	2.64	3264.60	86.16
Argentina	46397452	1602163	43018	2.68	3453.13	92.72
Mexico	130759074	1401529	123845	8.84	1071.84	94.71
Turkey	81916871	1379934	20642	1.50	1684.55	25.20
Poland	38104832	1294878	28554	2.21	3398.20	74.94
Iran	82011735	1218753	55095	4.52	1486.07	67.18
Ukraine	44009214	1055047	18533	1.76	2397.33	42.11
South Africa	57398421	1039161	28033	2.70	1810.43	48.84
Peru	32551815	1010496	37574	3.72	3104.27	115.43
Netherlands	17084459	787797	11330	1.44	4611.19	66.32
Indonesia	266794980	735124	21944	2.99	275.54	8.23
Czechia	10625250	718661	11580	1.61	6763.71	108.99
Belgium	11498519	644242	19441	3.02	5602.83	169.07
Romania	19580634	627941	15596	2.48	3206.95	79.65
Chile	18197209	605950	16499	2.72	3329.91	90.67
Iraq	39339753	594442	12808	2.15	1511.05	32.56
Canada	36953765	565506	15378	2.72	1530.31	41.61
Bangladesh	166368149	512496	7531	1.47	308.05	4.53

Pakistan	200813818	477240	10047	2.11	237.65	5.00
Philippines	106512074	472532	9230	1.95	443.64	8.67
Switzerland	8544034	445715	6972	1.56	5216.68	81.60
Total of the Top 30	**3821557890**	**69827269**	**1584166**	**2.27**	**1827.19**	**41.45**
Worldwide	**7585204179**	**81475053**	**1798050**	**2.21**	**1074.13**	**23.70**

*Ranking by the cumulative cases.

Figures

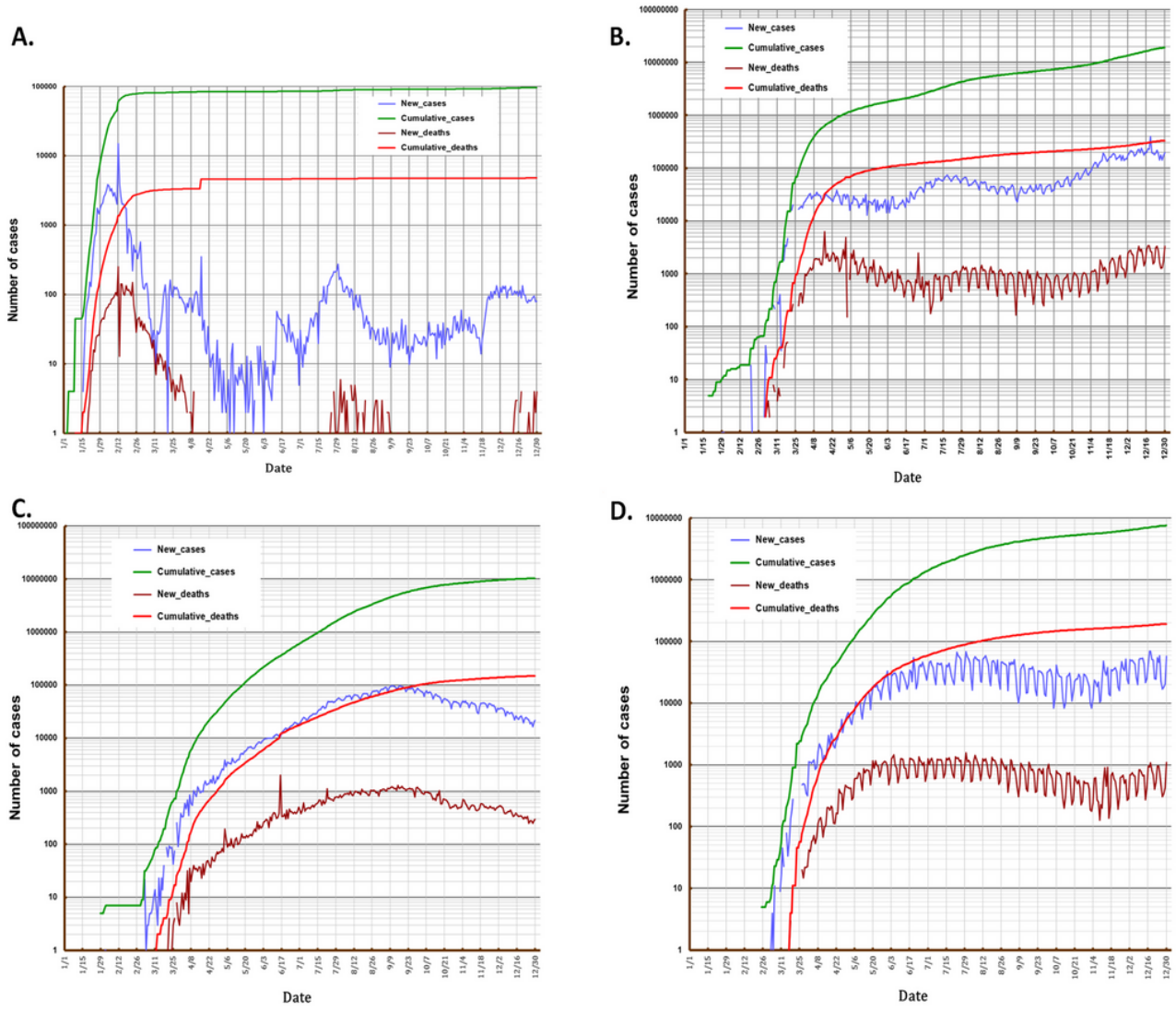

Figure 1

Epidemic trends of COVID-19 in China, the US, India, and Brazil in 2020 Number of cumulative cases, number of cumulative deaths, daily new cases, and daily new deaths in China (A), the US (B), India (C), and Brazil (D).

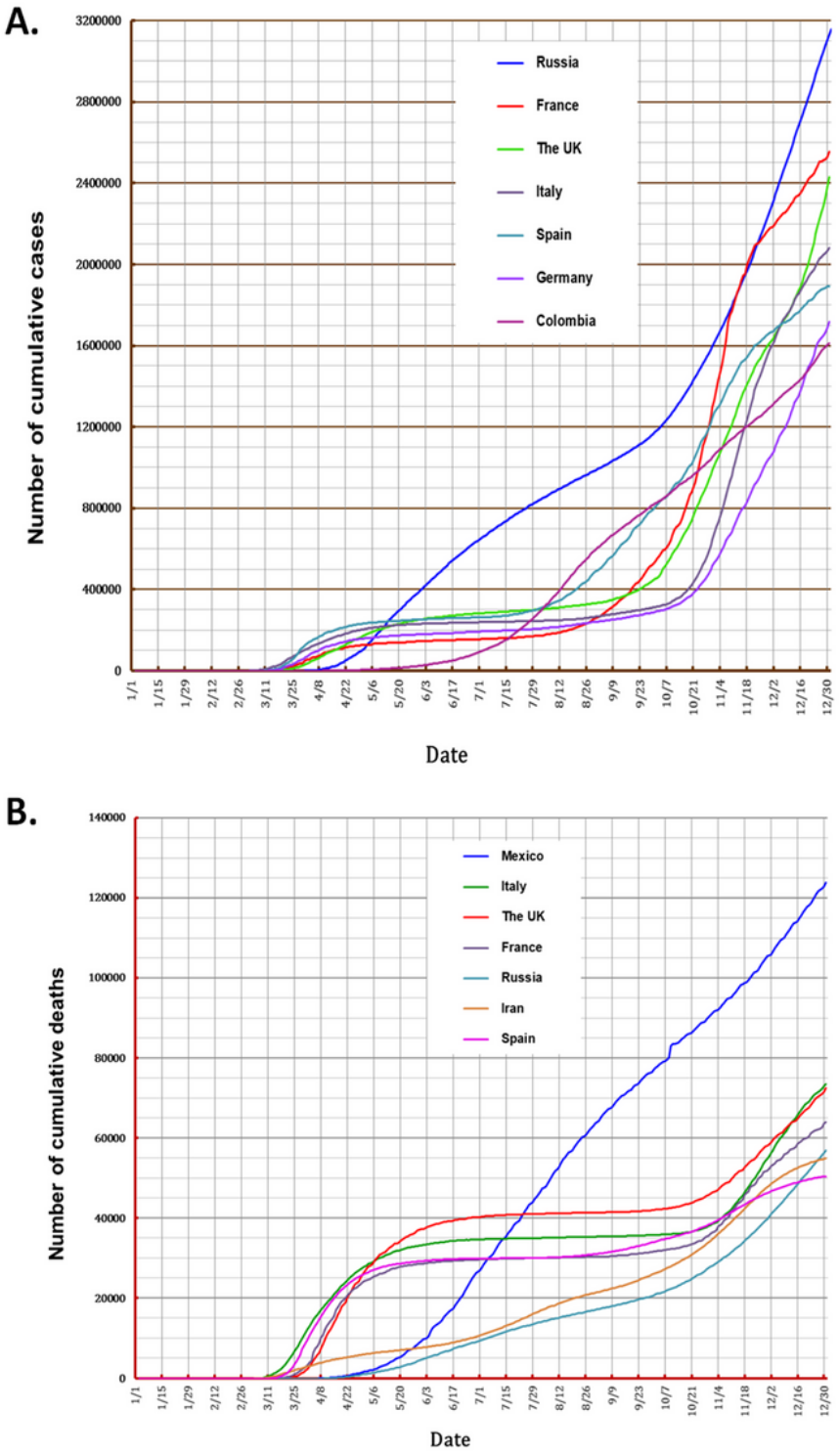

Figure 2

Trends of cumulative cases and cumulative deaths of COVID-19 in major countries in 2020 A. Number of cumulative cases; B. Number of cumulative deaths.

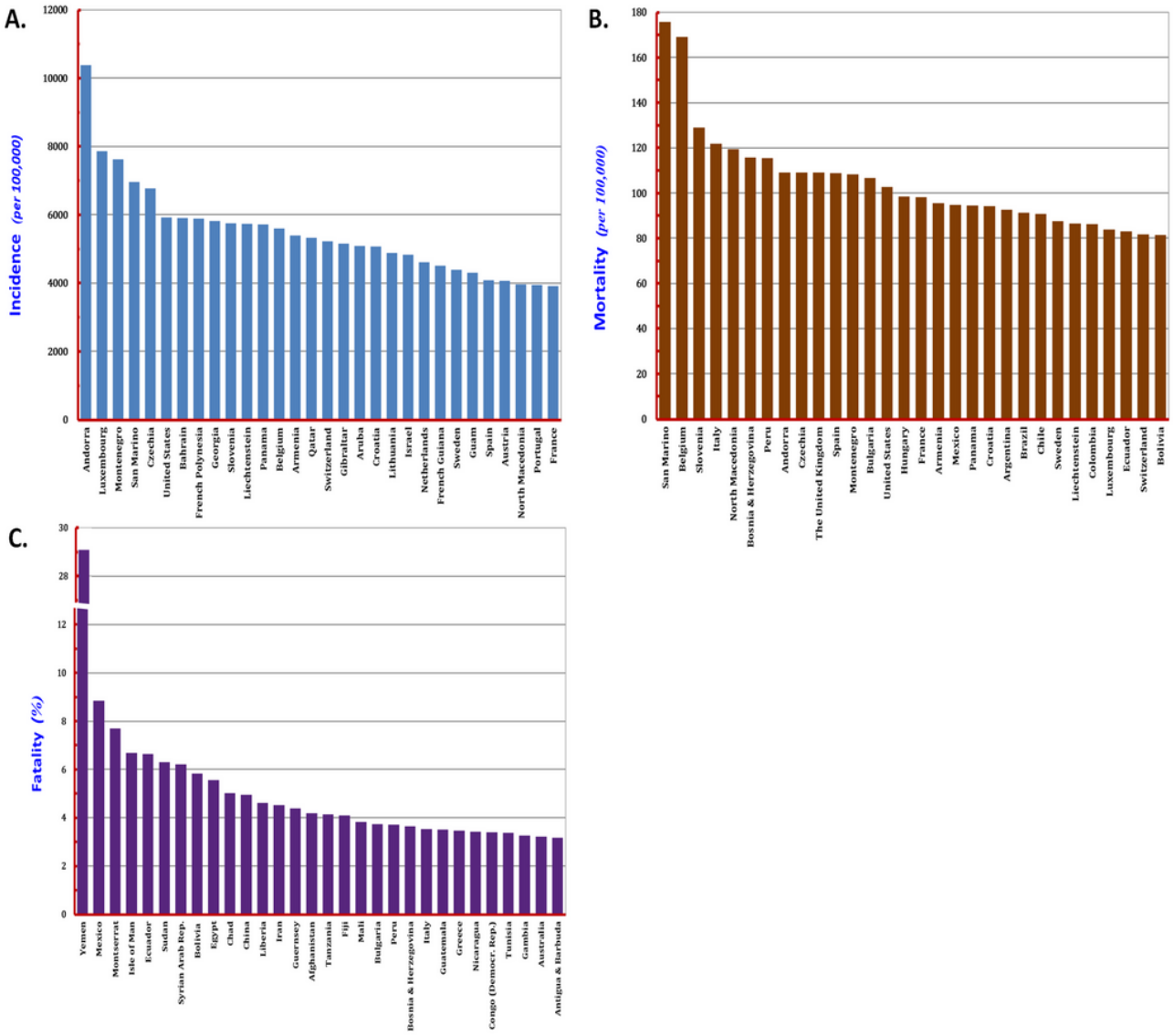

Figure 3

Incidence rates, mortality rates and fatality rates of COVID-19 in Top 30 countries in 2020 A. Incidence rates; B. Mortality rates; C. Fatality rates.