

ORIGINAL ARTICLE

# Trends in case-fatality rates of COVID-19 in the world, between december, 2019 and august, 2020

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## Abstract

**Introduction:** CoV infections can potentially cause from a simple cold to a severe respiratory syndrome, such as the Severe Acute Respiratory Syndrome and the Middle East Respiratory Syndrome (MERS-CoV). The COVID-19 created a new reality for global healthcare delivery models.

**Objective:** To evaluate trends in case-fatality rates of COVID-19 in the world.

**Methods:** We conducted a population-based time-series study using public and official data of cases and deaths from COVID-19 in Argentina, Australia, Brazil, Chile, China, Colombia, France, Germany, India, Iran, Italy, Japan, Mexico, Morocco, New Zealand, Nigeria, Peru, Saudi Arabia, South Africa, South Korea, Spain, Switzerland, United Kingdom, United States and Russia, between December, 2019 and August, 2020. Data were based on reports from the European Centre for Disease Prevention and Control. COVID-19 was defined according to the International Classification of Diseases, 10th revision (U07.1). A Prais-Winsten regression model was performed and the Daily Percentage Change (DPC) determined rates as increasing, decreasing or flat.

**Results:** During the study period, trends in case-fatality rates in the world were flat (DPC = 0.3; CI 95% [-0.2: 0.7];  $p = 0.225$ ). In Africa, Morocco had decreasing trends (DPC = -1.1; CI 95% [-1.5: -0.7];  $p < 0.001$ ), whereas there were increasing trends in South Africa ( $p < 0.05$ ) and flat trends in Nigeria ( $p > 0.05$ ). In the Americas, Argentina showed a decreasing trend in case-fatality rates (DPC = -0.6; CI 95% [-1.1: -0.2];  $p = 0.005$ ), the U.S. had flat trends ( $p > 0.05$ ) and all other countries in the Americas had increasing trends ( $p < 0.05$ ). In Asia, Iran had decreasing trends (DPC = -1.5; CI 95% [-2.6: -0.2];  $p = 0.019$ ); China and Saudi Arabia showed increasing trends ( $p < 0.05$ ), while in India, Japan and South Korea they were flat ( $p > 0.05$ ). European countries had mostly increasing trends ( $p < 0.05$ ): Germany, Italy, Spain, the UK and Russia; France and Switzerland had flat trends ( $p > 0.05$ ). Finally, in Oceania, trends in case-fatality rates were flat in Australia ( $p > 0.05$ ) and increasing in New Zealand ( $p < 0.05$ ).

**Conclusion:** World trends in case-fatality rates of COVID-19 were flat between December 31, 2019 and August 31, 2020. Argentina, Iran and Morocco were the only countries with decreasing trends. On the other hand, South Africa, Brazil, Canada, Chile, Colombia, Mexico, Peru, China, Saudi Arabia, Germany, Spain, United Kingdom, Russian and New Zealand had increasing trends in case-fatality rates. All the other countries analyzed had flat trends. Based on case-fatality rate data, our study supports that COVID-19 pandemic is still in progress worldwide.

**Keywords:** COVID-19, Trends, Case-Fatality, Epidemiology.

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## Authors summary

### Why was this study done?

- COVID-19 created a new reality in terms of global healthcare models.
- The scientific evidence so far available are not enough to meet the demands of the pandemic.
- Epidemiological studies are relevant to trigger public health strategies for spread control.

### What did the researchers do and find?

- We conducted a population-based time-series study using public and official data of cases and deaths from COVID-19 in Argentina, Australia, Brazil, Chile, China, Colombia, France, Germany, India, Iran, Italy, Japan, Mexico, Morocco, New Zealand, Nigeria, Peru (33538625), Saudi Arabia, South Africa, South Korea, Spain, Switzerland, United Kingdom (UK), United States (U.S.) and Russia, between December, 2019 and August, 2020.
- Trends in case-fatality rates were decreasing only in three countries among twenty-six analyzed: Argentina, Iran and Morocco. It was more significant in Iran.
- Nigeria, the U.S., India, Japan, South Korea, France, Switzerland and Australia had flat trends in case-fatality rates due to COVID-19.
- All the other countries analyzed in our study had increasing trends in case-fatality rates, with more significant results among countries of America and Europe.

### What do these findings mean?

- Increasing trends in case-fatality rates were higher between countries of Americas and Europe, suggesting a greater severity of the disease in those continents.
- Decreasing trends in case-fatality rates found in Argentina, Iran and Morocco should attract international attention in order to guide public health policies to reduce COVID-19 case-fatality.
- Based on case-fatality data, our study supports that COVID-19 pandemic is still in progress worldwide.

## INTRODUCTION

The coronaviruses (CoV) are a large family of viruses, so named because of surface spikes that resemble a crown (corona, Latin)<sup>1</sup>. The CoV infections can potentially cause from a simple cold to a severe respiratory syndrome, such as the Severe Acute Respiratory Syndrome (SARS-CoV) and the Middle East Respiratory Syndrome (MERS-CoV)<sup>1,2</sup>. The COVID-19 is a new variant of the coronaviruses, first isolated in China. The novel coronavirus differs from the others because of its high impact in public health and the huge number of new cases reported in a short time-period<sup>2,3</sup>.

The COVID-19 created a new reality for global healthcare delivery models<sup>1,2</sup>. The scientific evidence so far available are not enough to meet the demands to face the pandemic, since data about specific treatment and vaccines are insufficient (WHO)<sup>4</sup>, which forces governments to recommend social distancing as the principal effective strategy to contain the spread of the disease.

Pandemic scenarios require information in order to promptly (re)organize health practices and to provide health care, such as prevention and treatment, control and rehabilitation, since they are essential for health care managers and providers<sup>5</sup>. To address this demand, epidemiological studies are relevant to trigger public health strategies to control the spread of the virus.

Furthermore, this global scenario suggests that nobody can now be protected from an emerging and poorly known infectious disease. It would be unwise to make specific predictions about the natural history of the disease or efforts to contain SARS-CoV-2 outbreaks, but it is possible to make some incipient conclusions and to protect the most vulnerable from the virus<sup>6</sup>.

Health research<sup>7</sup> is designed to develop reliable data on problems and needs that are important to the individual/community, with a particular focus on guiding practitioners. In line with that, findings about social distancing are probably effective to reduce case-fatality,

since they are suitable to prevent and control the extensive spread of COVID-19<sup>8</sup>.

There is a lack of population-based studies assessing the trends in case-fatality rates in different countries in the world, which is crucial information to understand the pandemic dynamic, the severity of the disease and to elaborate global public health policies<sup>5</sup>. The traditional cumulative case-fatality rates may possibly underestimate the real case-fatality, since each region of the world is experiencing a different stage of the pandemic<sup>9</sup>. Case-fatality rates are not static. Rather, they tend to be dynamic and change over time. Thus, we aimed to evaluate trends in case-fatality rates of COVID-19 around the world.

## METHODS

This a population-based time-series study of public and official data available on the website of the European Centre for Disease Prevention and Control (<https://www.ecdc.europa.eu/en>).

Data were collected on August 31, 2020, by household address for COVID-19 reported cases. Population data were extracted from the Country Meters website (<https://countrymeters.info/en>), and included the following countries: Argentina (45,757,489 inhabitants), Australia (2,594,452 inhabitants), Brazil (217,040,683 inhabitants), Chile (18,944,479 inhabitants), China (1,410,334,120 inhabitants), Colombia (50,697,280 inhabitants), France (65,790,781 inhabitants), Germany (81,466,451 inhabitants), India (2,195,755,104 inhabitants), Iran (84,341,761 inhabitants), Italy (60,016,386 inhabitants), Japan (125,901,152 inhabitants), Mexico (136,136,481 inhabitants), Morocco (36,833,644 inhabitants), New Zealand (4,695,515 inhabitants), Nigeria (208,242,721), Peru (33,538,625 inhabitants), Saudi Arabia (35,457,606 inhabitants), South Africa (57,581,898), South Korea (51,472,090 inhabitants), Spain (45,690,902 inhabitants), Switzerland (8,770,577

inhabitants), United Kingdom (66,679,096 inhabitants), United States (333,487,241 inhabitants), and Russia (146,590,156 inhabitants).

The study analyzed cases and deaths reported between December 31, 2019 and August 31, 2020. New cases and deaths were collected according to day of reporting.

### Study population, inclusion and exclusion criteria

The World Health Organization assigned the emergency ICD-10 code of “U07.1 COVID-19, virus identified” to a disease diagnosis of COVID-19 confirmed by laboratory testing.

Data collection started in different dates in each country according to the reporting of new cases. In Argentina, it started on March 03; in Australia, on January 25; in Brazil, on January 26; in Canada, on January 26; in China, on January 21; in Chile, on March 03; in Colombia, on March 07; in France, on January 25; in Germany, on January, 28; in India, on January 30; in Iran, on February 20; in Italy, on January 31; in Japan, on January 21; in Mexico, on February 29; in Morocco, on March 03; in New Zealand, on February 28; in Nigeria, on February 28; in Peru, on March 07; in Saudi Arabia, on March 03; in South Africa, on March 06; in South Korea, on January 21; in Spain, on February 02; in Switzerland, on February 26; in the United Kingdom, on January 31; in the United States, on January 21; and in Russia, on February 01.

All confirmed cases and deaths of COVID-19 were included. They were registered according to the 10th Revision of the International Classification of Diseases (ICD-10) as COVID-19, virus identified (U07.1).

### Data Collection Procedures

Data were extracted from the public and official data system of the European Centre for Disease Prevention and Control (ECDC), section “Latest situation update, epidemiological curve and global distribution.” The ECDC is closely monitoring the outbreak, providing risk assessments and public health guidance.

Confirmed cases and deaths were collected from national health information systems responsible for registering, analyzing and publishing official country health data. The data were transferred to the European Centre for Disease Prevention and Control, which updated it daily.

Data about the resident population of each country was obtained from the Country Meters website and we projected population from January to August, 2020. The population data account for the total country population as of January 01, 2020.

In order to minimize possible discrepancies, the data were extracted by two different researchers independently.

### Statistical analysis

The COVID-19 incidence (new cases / population) and mortality (deaths / population) rates were calculated, per 1,000,000 inhabitants, and case-fatality (total deaths / total cases) rates, as daily percentage, between January and May 2020.

For trend analyses, we used methods proposed by Antunes and Cardoso (2015)<sup>10</sup>. Time-series rates were calculated using a Prais-Winsten regression model, which allowed first-order autocorrelation corrections on values by time. Thus, the following values were estimated: angular coefficient ( $\beta$ ) and respective probability ( $p$ ), considering a significance level of 95% confidence interval (CI 95%).

The data modeling process included transforming rates (dependent variable = Y value) into a base 10 logarithmic function. The independent variable (X value) was days of historical series. We also used the Durbin–Watson test to measure the existence of a first-order autocorrelation of the time series of the daily coefficients, and to verify if the correlation was compatible with the random regression residuals hypothesis<sup>11</sup>.

The logarithm rates results ( $\beta$ ) of Prais-Winsten regression allowed to estimate the Daily Percent Change (DPC) in each country, with the respective confidence intervals (95% CI)<sup>10</sup>:

$$\text{DPC} = [-1+10^\beta]*100\%$$

$$\text{IC } 95\% = [-1+10^{\beta_{\text{min}}}] * 100\%; [-1+10^{\beta_{\text{max}}}] * 100\%$$

This procedure made it possible to determine rates as increasing, decreasing or flat, and to quantify percent change in daily<sup>12</sup> incidence, mortality and case-fatality rates. The trend was considered to be flat when the coefficient was not significantly different from zero ( $p > 0.05$ ).

To facilitate the visualization of the trends in case-fatality rates, we reduced the random variation in the graph using the five-order moving average technique<sup>11</sup>.

We used the Stata 15.1 statistical software to conduct statistical analyses (College Station, TX, U.S. 2018).



**Table 2:** Prais-Winsten regression estimates and Daily Percent Change (DPC) of case-fatality, incidence and mortality rates due to COVID-19, according to countries of Africa and Americas. Jan-Aug, 2020.

Continent / Countries	DPC (CI 95%) Case-Fatality	p Value	Case-Fatality Trend	DPC (CI 95%) Incidence	p Value	Incidence Trend	DPC (CI 95%) Mortality	p Value	Mortality Trend
World	0.3 (-0.2 : 0.7)	0.225	Flat	4.9 (2.0 : 7.8)	0.001	Increasing	3.9 (1.5 : 6.5)	0.002	Increasing
Africa									
Morocco	-1.1 (-1.5 : -0.7)	< 0.001	Decreasing	3.1 (2.4 : 3.9)	< 0.001	Increasing	1.3 (0.6 : 2.1)	0.001	Increasing
Nigeria	-0.2 (-0.5 : 0.2)	0.371	Flat	3.4 (2.0 : 4.8)	< 0.001	Increasing	0.6 (0.1 : 1.1)	0.031	Increasing
South Africa	1.5 (0.4 : 2.6)	0.007	Increasing	4.9 (3.2 : 6.5)	< 0.001	Increasing	3.4 (3.0 : 3.9)	< 0.001	Increasing
Americas									
Argentina	-0.6 (-1.1 : -0.2)	0.005	Decreasing	4.5 (3.9 : 5.0)	< 0.001	Increasing	2.8 (2.7 : 3.0)	< 0.001	Increasing
Brazil	1.3 (0.1 : 2.6)	0.036	Increasing	5.8 (2.1 : 9.6)	0.002	Increasing	3.0 (1.0 : 5.1)	0.003	Increasing
Canada	1.0 (0.2 : 1.9)	0.015	Increasing	3.5 (1.4 : 5.6)	0.001	Increasing	-0.02 (-1.6 : 1.6)	0.985	Flat
Chile	1.8 (0.9 : 2.7)	< 0.001	Increasing	3.8 (0.9 : 6.8)	0.010	Increasing	2.5 (1.7 : 3.2)	< 0.001	Increasing
Colombia	1.2 (0.1 : 2.2)	0.028	Increasing	5.4 (4.3 : 6.6)	< 0.001	Increasing	3.5 (3.2 : 3.8)	< 0.001	Increasing
Mexico	1.5 (0.5 : 2.5)	0.004	Increasing	4.1 (1.1 : 7.2)	0.008	Increasing	3.6 (2.3 : 4.8)	< 0.001	Increasing
Peru	0.8 (0.4 : 1.1)	< 0.001	Increasing	4.3 (2.7 : 5.9)	< 0.001	Increasing	2.6 (1.8 : 3.3)	< 0.001	Increasing
United States	0.3 (-0.4 : 1.0)	0.367	Flat	6.0 (2.8 : 9.3)	< 0.001	Increasing	2.2 (-0.01 : 4.5)	0.051	Flat

DPC – Daily Percent Change (%); CI 95% – Confidence Interval 95%; p Value – probability of statistics significance

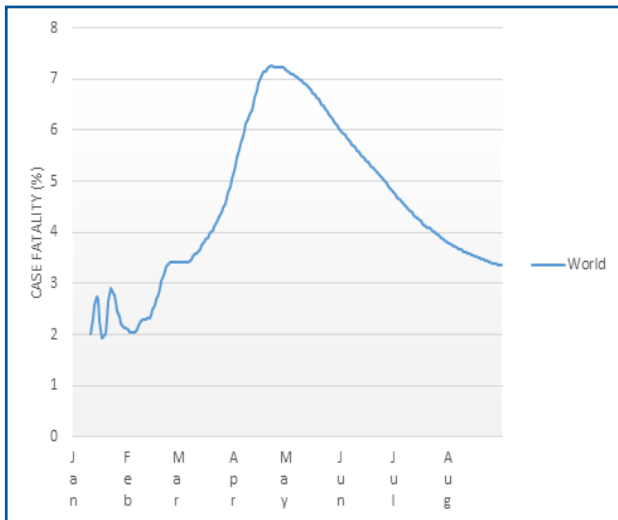
Source: Cases and Deaths data from the European Centre for Disease Prevention and Control (ECDC). Population data from the countrymeters.info.

**Table 3:** Prais-Winsten regression estimates and Daily Percent Change (DPC) of case-fatality, incidence and mortality rates due to COVID-19, according to countries of Asia, Europe and Oceania. Jan-Aug. 2020.

Continent / Countries	DPC (CI 95%) Case-Fatality	p Value	Case-Fatality Trend	DPC (CI 95%) Incidence	p Value	Incidence Trend	DPC (CI 95%) Mortality	p Value	Mortality Trend
<b>Asia</b>									
China	0.4 (0.3 : 0.6)	< 0.001	Increasing	-0.2 (-1.5 : 1.1)	0.753	Flat	-0.5 (-1.5 : 0.4)	0.281	Flat
India	0.01 (-0.3 : 0.4)	0.060	Flat	6.2 (5.0 : 7.4)	< 0.001	Increasing	4.5 (3.5 : 5.5)	< 0.001	Increasing
Iran	-1.5 (-2.6 : -0.2)	0.019	Decreasing	1.7 (0.5 : 3.0)	0.007	Increasing	1.5 (0.8 : 2.1)	< 0.001	Increasing
Japan	-0.1 (-0.8 : 0.6)	0.727	Flat	2.7 (2.0 : 3.4)	< 0.001	Increasing	0.3 (-0.4 : 0.9)	0.432	Flat
Saudi Arabia	1.4 (0.3 : 2.4)	0.013	Increasing	3.0 (1.0 : 5.1)	0.004	Increasing	1.9 (1.3 : 2.4)	< 0.001	Increasing
South Korea	0.5 (-0.1 : 1.0)	0.08	Flat	2.2 (1.0 : 3.4)	< 0.001	Increasing	-0.7 (-1.0 : -0.4)	< 0.001	Decreasing
<b>Europe</b>									
France	0.2 (-0.7 : 1.1)	0.627	Flat	3.6 (2.0 : 5.2)	< 0.001	Increasing	0.9 (-0.9 : 2.8)	0.319	Flat
Germany	1.8 (0.7 : 2.9)	0.001	Increasing	3.5 (0.7 : 6.5)	0.015	Increasing	-0.4 (-1.8 : 1.0)	0.530	Flat
Italy	0.8 (0.1 : 1.6)	0.022	Increasing	2.6 (-0.3 : 5.6)	0.077	Flat	-0.6 (-2.4 : 1.1)	0.465	Flat
Spain	1.8 (0.05 : 3.5)	0.044	Increasing	4.0 (2.0 : 6.0)	< 0.001	Increasing	-1.4 (-3.1 : 0.2)	0.090	Flat
Switzerland	0.7 (-0.1 : 1.6)	0.071	Flat	1.0 (-0.6 : 2.7)	0.227	Flat	-1.0 (-1.8 : -0.1)	0.026	Decreasing
United Kingdom	2.0 (0.6 : 3.4)	0.005	Increasing	3.5 (0.1 : 6.9)	0.045	Increasing	0.5 (-2.0 : 3.0)	0.707	Flat
Russia	1.2 (0.5 : 2.0)	0.001	Increasing	4.4 (1.9 : 7.0)	0.001	Increasing	1.7 (0.6 : 2.8)	0.004	Increasing
<b>Oceania</b>									
Australia	-0.2 (-1.2 : 0.7)	0.629	Flat	2.6 (1.4 : 3.8)	< 0.001	Increasing	0.6 (0.6 : 1.6)	< 0.001	Increasing
New Zealand	1.3 (0.1 : 2.5)	0.04	Increasing	-0.3 (-1.4 : 0.7)	0.533	Flat	-0.7 (-2.6 : 1.3)	0.462	Flat

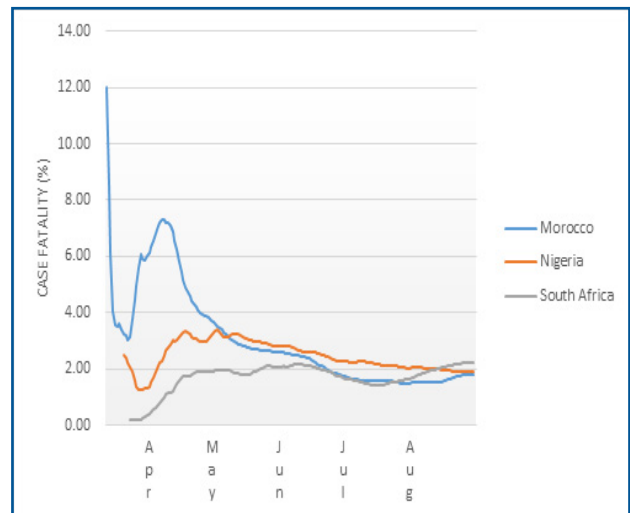
DPC – Daily Percent Change (%); CI 95% – Confidence Interval 95%; p Value – probability of statistics significance

Source: Cases and Deaths data from the European Centre for Disease Prevention and Control (ECDC). Population data from the countrymeters.info.



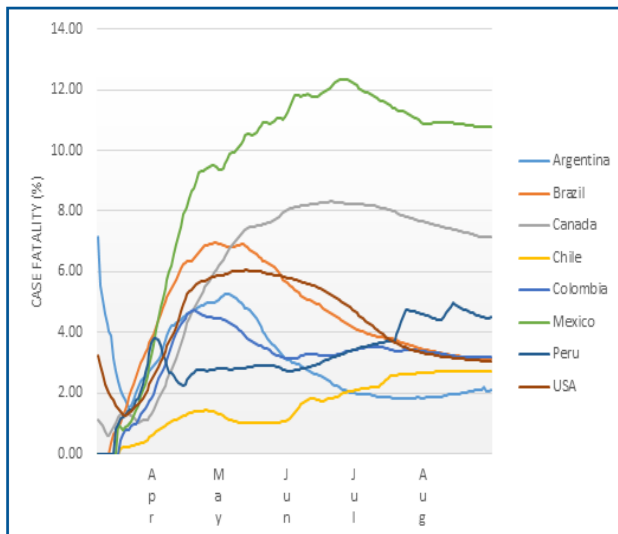
**Figure 1:** Temporal trend of case-fatality rates (%) of COVID-19 in the World. December, 2019 - August 2020.

Source: Cases and Deaths data from the European Centre for Disease Prevention and Control (ECDC). Population data from the Country Meters.



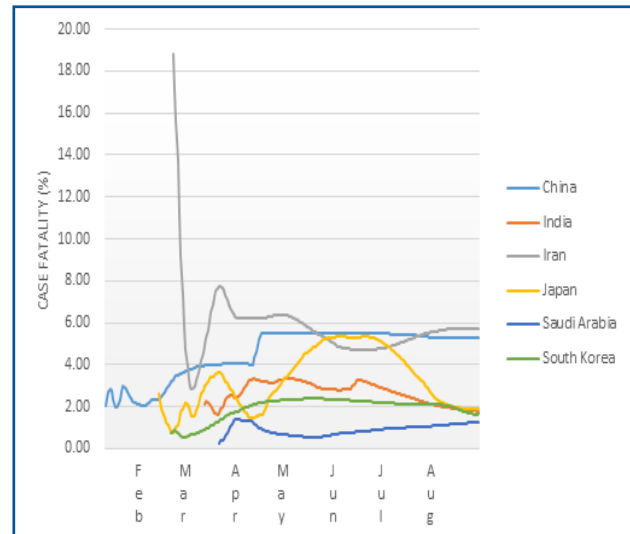
**Figure 2:** Temporal trend of case-fatality (%) of COVID-19, according to countries of Africa, December, 2019 - August 2020.

Source: Cases and Deaths data from the European Centre for Disease Prevention and Control (ECDC). Population data from the Country Meters.



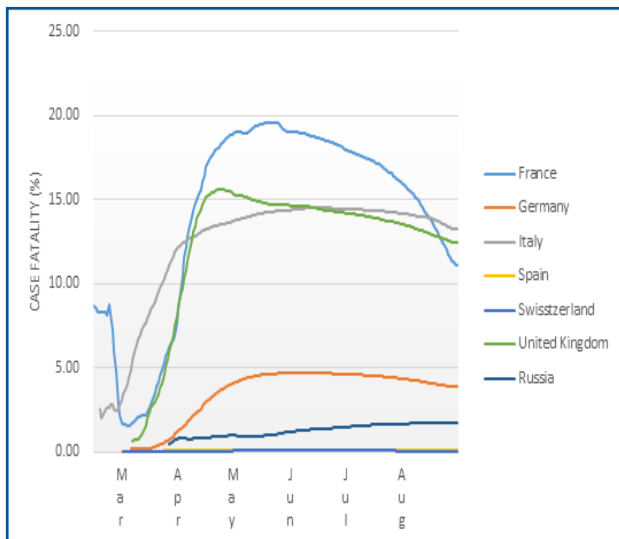
**Figure 3:** Temporal trend of case-fatality (%) of COVID-19, according to countries of Americas, December, 2019 - August 2020.

Source: Cases and Deaths data from the European Centre for Disease Prevention and Control (ECDC). Population data from the Country Meters.



**Figure 4:** Temporal trend of case-fatality (%) of COVID-19, according to countries of Asia, December, 2019 - August 2020.

Source: Cases and Deaths data from the European Centre for Disease Prevention and Control (ECDC). Population data from the Country Meters.



**Figure 5:** Temporal trend of case-fatality (%) of COVID-19, according to countries of Europe, December, 2019 - August 2020.

Source: Cases and Deaths data from the European Centre for Disease Prevention and Control (ECDC). Population data from the Country Meters.

**Case-fatality Rates**

Between December 31, 2019, and August 3, 2020, the case-fatality rate due to COVID-19 in the world was 3.4%.

In Africa, among countries analyzed, the highest case-fatality rates was found in South Africa (2.2%), followed by Nigeria (1.9%) and Morocco (1.8%). Similar results were found in Oceania: Australia (2.4%) and New Zealand (1.6%) (Table 1).

In the Americas, Mexico had the greatest case-fatality rate: 10.8%, which represents the fourth country with the highest percentage. Canada also showed high case-fatality rate: 7.1%. In countries in America, we found similar percentages in case-fatality rates, except Chile, where it was 0.5%, the lowest rate between all countries (Table 1).

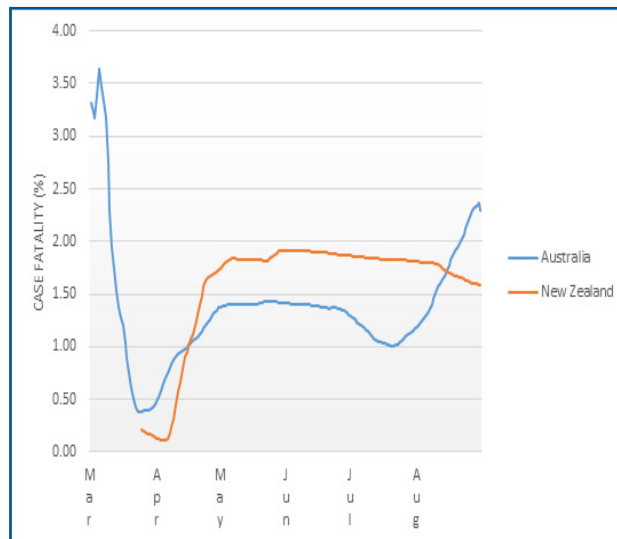
Asia had two different profile of groups: China and Iran had case-fatality rates above 5.0%, while the rest of Asian countries showed rates below 2.0% (Table 1).

Europe had the most heterogeneous results compared with other continents. Italy, France and United Kingdom had case-fatality rates above 10.0%. Spain and Switzerland show intermediary rates among European countries, while German and Russia were the countries with the lowest rates in case-fatality in the continent. (Table 1).

**Trends in case-fatality rates**

Trends in case-fatality rates in the world were flat (DPC = 0.3; CI 95% [-0.2 : 0.7]; p = 0.225) in the study period (Table 2, Fig. 1).

Morocco was one of the three countries in which the case-fatality rate was decreasing (DPC = -1.1; CI 95% [-1.5 : -0.7]; p < 0.001). In Nigeria, the case-fatality rate was flat, while in South Africa it was increasing (Table 2, Fig. 2).



**Figure 6:** Temporal trend of case-fatality (%) of COVID-19, according to countries of Oceania, December, 2019 - August 2020.

Source: Cases and Deaths data from the European Centre for Disease Prevention and Control (ECDC). Population data from the Country Meters.

In the Americas, Argentina had decreasing trends in case-fatality rates (DPC = -0.6; CI 95% [-1.1: -0.2]; p = 0.005), while all other countries had increasing trends. The United States, on the other hand, had flat rate trends. (Table 2, Fig. 3).

With regard to Asian countries, Iran showed decreasing trends in case-fatality rates (DPC = -1.5; CI 95% [-2.6: -0.2]; p = 0.019). China and Saudi Arabia had increasing trends, while India and South Korea showed flat tendency (Table 3, Fig. 4).

In Europe, France and Switzerland had flat trends in case-fatality rates, but all the other countries had increasing tendency (Table 3, Fig. 5).

Finally, in Oceania, Australia had flat tendency, while New Zealand had increasing trends in case-fatality rates due to COVID-19 (Table 3, Fig 6).

**DISCUSSION**

We estimated trends in case-fatality rates by calculating the Daily Percent Change in case-fatality rates, which allows the understanding of the dynamic of the pandemic better than simply analyzing rates<sup>9</sup>. Between December 31, 2019 and August 31, 2020, trends in case-fatality rates due to COVID-19 in the world remained flat. Argentina, Iran and Morocco were the only countries that had decreasing trends in case-fatality rates. Nigeria, United States, India, Japan, South Korea, France, Germany, Switzerland and Australia had flat tendency. All other countries showed increasing trends, which can indicate progressive severity of the disease around the five continents.

Our findings showed case-fatality rates in the world similar to Zhao *et al.* study, who found a rate of 3.1% after analyzing 30 studies with 53.000 patients<sup>12</sup>. Another study estimating case-fatality rates showed expected rates for this pandemic ranging from 2.9% to 3.0%<sup>9</sup>. As we already



pointed out, case-fatality rates are not static, but rather dynamic. Our statistical analyses of world trends suggest a flat tendency ( $p > 0.05$ ).

### Increasing Case-Fatality Rate Trends

South Africa, Brazil, Canada, Chile, Colombia, Mexico, Peru, China, Saudi Arabia, Germany, Italy, Spain, United Kingdom, Russia and New Zealand had increasing trends in case-fatality rates due to COVID-19. Among all of them, Canada, Mexico, Peru, Germany, Italy, Spain and United Kingdom had case-fatality rates above the world's rate, which can possibly indicate an highest severity of the disease in those nations. Germany, Spain and United Kingdom showed the greatest Daily Percent Change, indicating that Europe still is the continent most affected by COVID.

With regard to Canada, our results contrasts with Abdollahi *et al.* findings, who found a case-fatality rate of 1.6% (CI 95% 0.7%–3.1%) on April 22, which is significantly lower than ours<sup>13</sup>. It demonstrates that COVID-19 has substantially increased over the past 4 months. Therefore, it is noteworthy that Canada had a high severity of the disease, which is still in progress.

Regarding Europe, we found the same behavior for case-fatality rates pointed by Pachetti *et al.*, who described a significant lower rate for Germany (0.31% CI 95% [0.29; 0.33]) compared to the other nations, on April 30<sup>14</sup>. Although the estimation of case-fatality rates are not high in Germany, this country had the second increasing Daily Percent Change in case-fatality rates among all 26 countries analyzed. Aside from Germany, Russia had low case-fatality rates, but it had also increasing trends. The United Kingdom had the highest case-fatality rate and upward trend among the nations analyzed in our study.

### Flat Case-Fatality Rate Trends

Nigeria, United States, India, Japan, South Korea, France, Switzerland, Australia had flat tendency in case-fatality rates due to COVID-19. France and Switzerland were the only nations with rates above the world's, which suggests the hypothesis that Europe is not in a regression phase of the pandemic.

With respect to Australia, Chin *et al.* already noted signs that pandemic was under control. They identified case-fatality rates raging 0.4% to 3.0%, tending to decrease after March 29<sup>15</sup>. This decrease may be attributed to timely implementation and strict enforcement of bans on travel and social gatherings, as well as concerted diagnostic and management strategies.

The United States also showed signs of controlling the spread of COVID-19. On April 22, Abdollahi *et al.* reported a case-fatality rate of 6.1% (CI 95% 5.4%–6.9%)<sup>13</sup>, which corresponds to approximately twice our results. This finding suggests that case-fatality rates might have decreased in the previous 4 months and a new flat trend emerged.

### Decreasing Case-Fatality Rate Trends

Morocco, Argentina and Iran showed decreasing trends in case-fatality rates of COVID-19. In spite of that, Iran was the only country in which case-fatality rates were above the estimate of the world's rate.

As of May 13, 2020, Ouchetto *et al.* reported a case-fatality rate of 5.26% in Morocco<sup>16</sup>, almost 3 times greater than our findings, supporting the hypothesis that the pandemic is tending toward control in this nation.

Regarding Iran, we have to interpret the results with parsimony, since according to studies, cases reported in official statistics at the beginning of the epidemics were likely to grossly underestimate the total of actual cases. Thus estimating the actual case-fatality rates due to COVID-19 is currently impossible<sup>17</sup>.

It is important to highlight that our analysis was based on public and official secondary data from the European Centre for Disease Prevention and Control. Even considering unknown underreporting, these are the best available data to formulate public health policies. The analysis of incidence, mortality, case-fatality rates and their respective trends allowed for measurement of risk, severity, and magnitude, which are defining indicators to understand the dynamics of pandemics<sup>6</sup>.

The time-series regression model used in this study allowed to estimate the existence the Daily Percent Change (DPC) in case-fatality rates, which made it possible to measure the dynamic variation of the pandemic among 26 countries around the five continents worldwide.

## CONCLUSIONS

Trends in case-fatality rates of COVID-19 in the world were flat between December, 31 and August, 31. Argentina, Iran and Morocco were the only countries with decreasing trends. On the other hand, South Africa, Brazil, Canada, Chile, Colombia, Mexico, Peru, China, Saudi Arabia, Germany, Spain, United Kingdom, Russian and New Zealand had increasing trends in case-fatality rates. All other countries analyzed had flat trends. Based on case-fatality rates data, our study provides evidence that the COVID-19 pandemic is still in progress worldwide.

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## Resumo

**Introdução:** As infecções por CoV podem causar desde um simples resfriado até uma síndrome respiratória grave, como a Síndrome Respiratória Aguda Grave e a Síndrome Respiratória do Oriente Médio (MERS-CoV). O COVID-19 impôs uma nova realidade em termos de modelos globais de saúde.

**Objetivo:** Avaliar as tendências das taxas de letalidade do COVID-19 no mundo.

**Método:** Estudo de séries temporais de base populacional usando dados públicos e oficiais de casos e mortes por COVID-19 na Argentina, Austrália, Brasil, Chile, China, Colômbia, França, Alemanha, Índia, Irã, Itália, Japão, México, Marrocos, Nova Zelândia, Nigéria, Peru, Arábia Saudita, África do Sul, Coreia do Sul, Espanha, Suíça, Reino Unido, Estados Unidos (EUA) e Rússia, entre dezembro de 2019 e agosto de 2020. Os dados foram baseados nos relatórios do Centro Europeu de Prevenção e Controle de Doenças. COVID-19 foi definido pela Classificação Internacional de Doenças, 10ª revisão (U07.1). Para análise estatística, foi realizada a regressão linear de Prais-Winsten, a partir da qual foi possível calcular a variação percentual de mudança diária (DPC) das taxas, classificadas como crescentes, decrescentes ou estacionárias.

**Resultados:** Durante o período do estudo, as taxas de letalidade no mundo permaneceram estacionárias (DPC = 0,3; IC 95% [-0,2; 0,7];  $p = 0,225$ ). Na África, Marrocos teve tendência decrescente (DPC = -1,1; IC 95% [-1,5; -0,7];  $p < 0,001$ ), enquanto na África do Sul houve tendência crescente ( $p < 0,05$ ) e estável na Nigéria ( $p > 0,05$ ). Em relação às Américas, a Argentina revelou tendência decrescente nas taxas de letalidade (DPC = -0,6; IC 95% [-1,1; -0,2];  $p = 0,005$ ), os EUA demonstraram tendência estável ( $p > 0,05$ ) e todos os outros americanos os países demonstraram tendências crescentes ( $p < 0,05$ ). Na Ásia, o Irã apresentou tendência decrescente (DPC = -1,5; IC 95% [-2,6; -0,2];  $p = 0,019$ ); China e Arábia Saudita apresentaram tendências crescentes ( $p < 0,05$ ), enquanto Índia, Japão e Coreia do Sul mantiveram tendência estacionária ( $p > 0,05$ ). A maioria dos países europeus apresentaram tendências crescentes ( $p < 0,05$ ): Alemanha, Itália, Espanha, Reino Unido e Rússia; França e Suíça demonstraram tendências estacionárias ( $p > 0,05$ ). Por fim, na Oceania, a tendência nas taxas de letalidade na Austrália foi estável ( $p > 0,05$ ) e aumentou na Nova Zelândia ( $p < 0,05$ ).

**Conclusão:** A tendência nas taxas de letalidade por COVID-19 no mundo permaneceu estável entre 31 de dezembro e 31 de agosto. Argentina, Irã e Marrocos foram os únicos países com tendências decrescentes. Por outro lado, África do Sul, Brasil, Canadá, Chile, Colômbia, México, Peru, China, Arábia Saudita, Alemanha, Espanha, Reino Unido, Rússia e Nova Zelândia apresentaram tendências crescentes de letalidade. Todos os outros países analisados demonstraram tendências estacionárias. De acordo com dados de letalidade, nosso estudo confirma que a pandemia de COVID-19 ainda está em fase de progressão em todo o mundo.

**Palavras-chave:** COVID-19; Tendência; Letalidade; Epidemiologia.

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