

Abstract

The scope of this report was to analyze Covid-19 statistics published by World Health Organization (WHO). The aim was to present a more comprehensive macro-scale depiction of this crisis through visualization of datasets in different Python libraries. The focus is on the global community rather than an individual country or territory. Investigation of this current world-wide situation along with ongoing pandemic changes during the first half of 2020 occurred. The severity of outbreak was measured with several parameters including number of confirmed cases, number of deaths, number of new cases and deaths, as well as number of case and death per population in 100,00. In addition, consideration was made for case fatality rate and two well-known factors of epidemiological analysis. This study is part I of a series dedicated to individual countries devastated by Coronavirus based on the mentioned parameters.

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Introduction

The purpose of this report was to study the current status of the Coronavirus pandemic around the globe as well as its evolution with time. The focus concentrated on reports published by World Health Organization (WHO).

The first WHO daily report was published 20 days after the organization had been informed about related Coronavirus outbreak in China, on 21st Jan 2020. The WHO reports contain statistical information including total and new numbers of confirmed cases, death toll in different countries and territories around the world as well as technical guidelines, recommendations and advice for the public in PDF formats. As the international community struggles to control this pandemic, better understanding can be achieved by analyzing the statistics of this extremely contagious virus.

Data

The WHO's statistical information as well as countries' general information including their population, area, density, continent and geographical coordination is used in this project to visualize and examine Covid-19 pandemic around the world. In the absence of universal credible reference for the basic information about the countries, Wikipedia websites were used to obtain the data within this report. And, the Natural Earth website was used to obtain information regarding the geographical information of each country.

Since this is an active outbreak, WHO, governments, and other health authorities modified report formats and datasets regularly. The availability of datasets to the public often changed as the situation evolved. For instance, access to complete archive and detail information regarding the early days of the outbreak was limited within certain governmental websites.

Moreover, investigating countries' health infrastructure, tourism sectors and border policies can be a significant key to decipher the mystery of unexpected rapid rate of hospitalization and death due to Covid-19 infection in certain communities and nations; nonetheless, the public accessibility to these data were restricted.

Methodology

The procurement of the visualization and examination from published Coronavirus related data by the WHO was performed using several Python libraries including Pandas, Numpy, Matplotlib, PyPlot, Folium, Geopandas, Json, BeautifulSoup, Tabula and PyPDF2. The procedure of this study can be summarized as follows:

- 1- The data from WHO PDF documents were extracted via tabula and PyPDF2 modules and stored as Pandas dataframes. Further information and details can be found in: https://github.com/HodaMYoung/Covid19/WHO1_38.py
- 2- The extracted dataframes were preprocessed before analytical study. Dealing with missing data, data conversion, eliminating unnecessary characters and information as the main part of the preprocessing methodology to keep the accuracy and consistency of dataframes was performed entirely in Pandas and Numpy libraries. It should be noted that formats and datasets of WHO reports have evolved during pandemic. Therefore, preprocessing played a significant role in maintaining the uniformity of the dataframe type and style.
- 3- The countries' basic information was obtained via scraping Wikipedia websites with BeautifulSoup module and stored as Panda dataframe. More information and detail can be found in: <https://gits.github.com/HodaMYoung>
- 4- The extracted data from Wikipedia required further revising before being able to merge the two datasets. For instance, the statistics related to pandemics for three small territories in the Caribbean were presented as a single entity in WHO reports. As a result, the datasets from Wikipedia need to be adjusted. After merging the datasets, new variables like number of cases and death per population in 100,000 for each country were determined.
- 5- The countries' geographical information was obtained from the Natural Earth website in shapefile, i.e. .shp format, to create appropriate GeoJson files. Having the appropriate GeoJson file was the prerequisite step to generate choropleth maps with Folium libraries. Further information can be found in: <https://github.com/HodaMYoung/World-GeoJson-File/CountriesGeoJsonData.py>
- 6- Choropleth maps of current status of Covid-19 in the world were created with Folium and Geopandas libraries. The maps visualize pandemic statistic data like new number of confirmed cases and deaths, total cases and deaths per population in 100,000, and case fatality rate for each territory. More details are available at: <https://github.com/HodaMYoung/Covid19/CurrentChoropleth.py>
- 7- The outbreak evolution in each month and 30 days intervals since the first reported publication of the WHO was investigated and depicted globally and for each continent by using Pandas and Matplotlib, Pyplot modules. Further details are presented in: <https://github.com/HodaMYoung/Covid19/TestGraphBars.py>

Results & Discussion

The results that will be presented here can be divided into major categories: Current Status, Evolution

Current Status

The total confirmed cases and death toll were illustrated in the following choropleth maps, Fig. 1-2. The results indicate that the United States, with more than 2.6 million cases, has been the most affected country in the world, while Brazil with more than 1.4 million and Russia with more than 600,000 rank second and third, respectively. Furthermore, the mortality rate due to Covid-19 in the United States was more than 127,000 people while Brazil, the second most confirmed cases, had approximately 60,000.

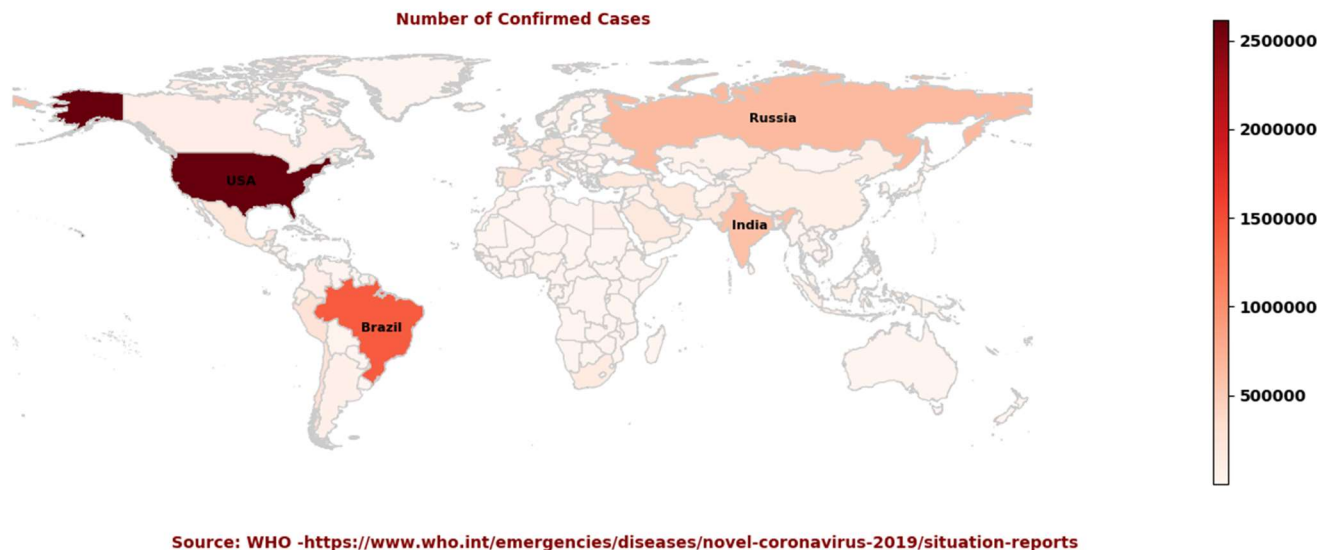


Fig.1. Total globally confirmed Covid-19 cases on July 2nd 2020.

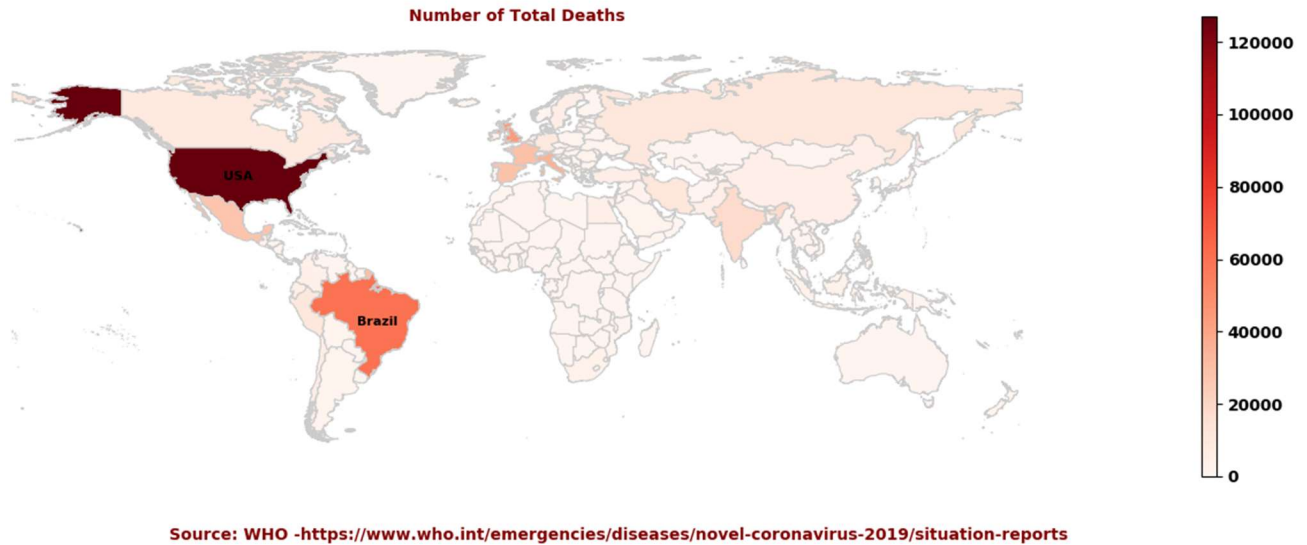


Fig.2. Total Covid-19 death toll on 2nd July 2020.

Additionally, on the July 2nd the United States reported more than 43,000 new cases. The daily confirmed cases for Brazil, India, Russia and South Africa were more than 33,000, 19,000, 8,000 and 6,000, respectively. Fig. 3. Illustrates the total number of cases and Fig. 4. Illustrates the total number of deaths.

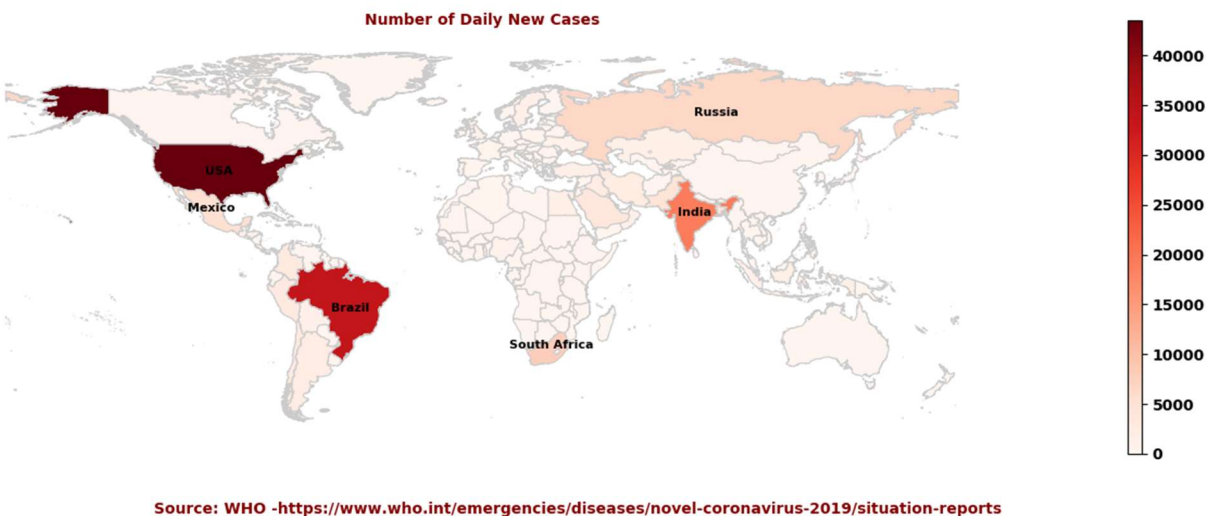
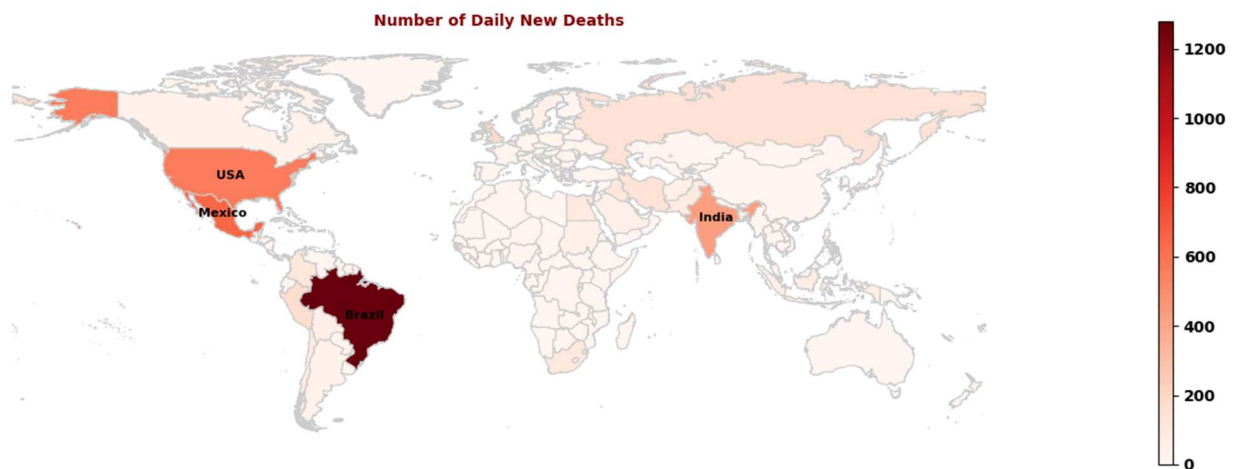


Fig. 3. New reported Covid-19 confirmed cases around the globe on 2nd July 2020.

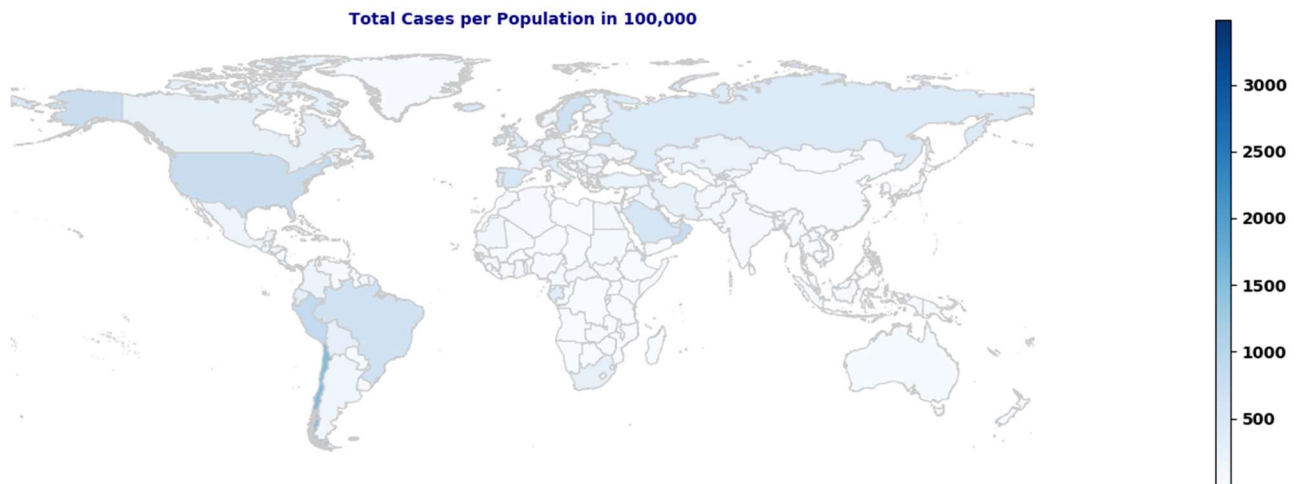


Source: WHO -<https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

Fig. 4. New reported Covid-19 deaths around the globe on 2nd July 2020.

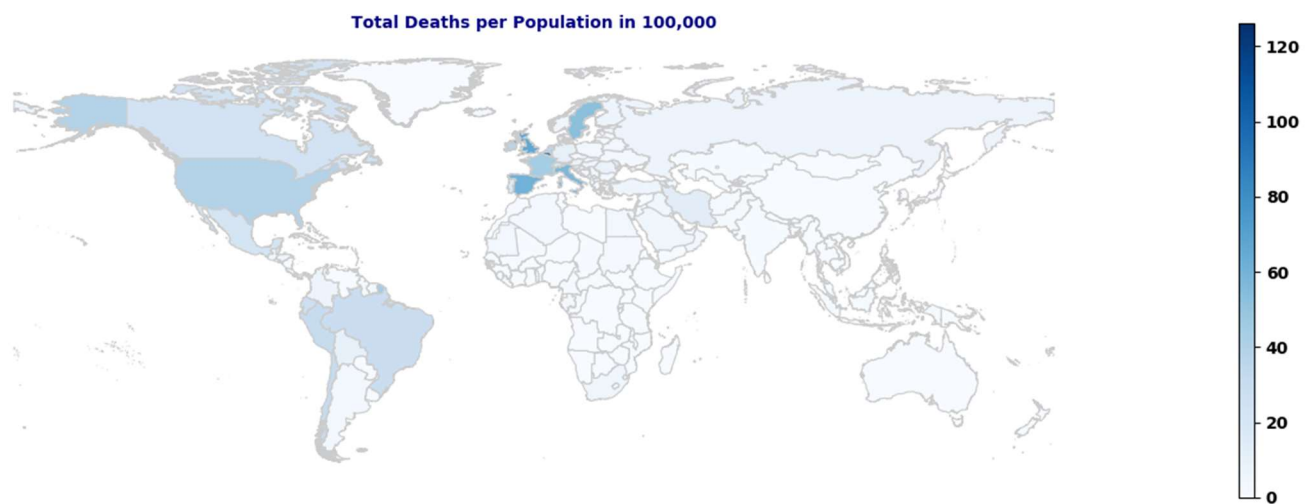
According to the results presented here, the United States, Brazil, Russia and India have been the most impacted countries in terms of total confirmed cases and death toll as well as daily surge in new cases and deaths. Nevertheless, small countries and tiny territories like Qatar, San Marino and Bahrain have had the highest number of infections per population in 100,000, Fig. 5. The USA and Brazil rank 13th and 17th in terms of number of cases per population in 100,000, respectively. Nonetheless, more economically developed countries like Belgium, the UK, Spain, Italy, Sweden, France and the USA are on the top of the list of number of deaths per population in 100,000 after San Marino, Fig. 6.

In order to have a better understanding of the impact of Coronavirus pandemic the case fatality rates (CFR) for each country are visualized in Fig.7. The case fatality rate is defined as the percentage of deceased per total infected cases. The highest CFR was actually observed in Yemen, one of the poorest countries in Middle East with nearly 27% fatality rate. Sint Maarten, France, Belgium, Italy, Hungary, and the UK are showing the highest CFR after Yemen. The United States ranks the 47th with CFR nearly 5%.



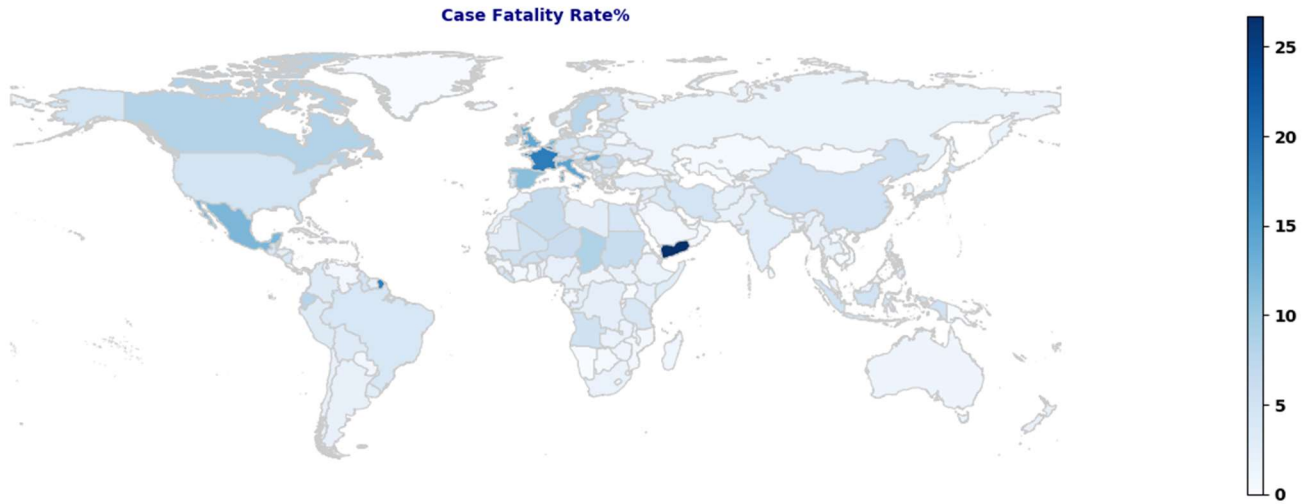
Source: WHO -<https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

Fig. 5. Total Covid-19 cases per population in 100,000 on 2nd July 2020.



Source: WHO -<https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

Fig. 6. Total Covid-19 deaths per population in 100,000 on 2nd July 2020.



Source: WHO - <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

Fig.7 Case Fatality Rate on 2nd July 2020.

Finally, the above results are plotted interactive maps with higher resolutions in Folium libraries, Fig.8. However, the size of these map is often large.

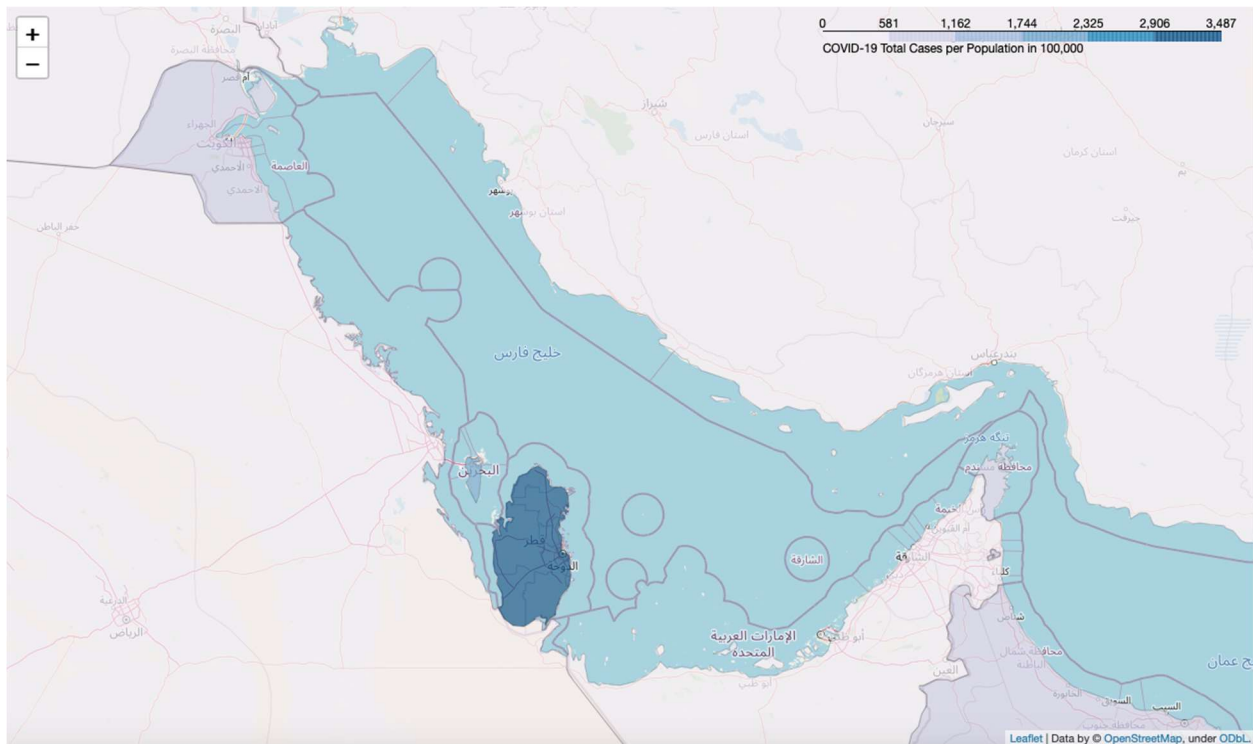


Fig. 8. The interactive folium map of total Covid-19 cases per population in 100,000 on 2nd July 2020.

Evolution

In this part, the changes in statistics of Covid-19 in the first six months of this universal crisis is discussed. The number of countries and territories with Coronavirus cases increased from 54 countries in February to 200 countries in March. This increase in the number of affected countries continued in April until it reached 213 in May and remained constant in June, Fig. 9.

As shown in Fig. 10. in January, Coronavirus cases were the main challenging concern in Asia with no African and South American countries being affected. However, more African and European countries were infected by the end of the June. From January to end of June up to 55 African countries and territories reported Coronavirus cases. More comprehensive depictions of the situation of each continent are presented in Fig.11-12., where, 14 South American affected countries represent 88% of the countries and territories in the continent and accounts for 100% of the continent's population. Similar patterns can be observed for other continents where more than 80% of population has been affected by this international emergency.

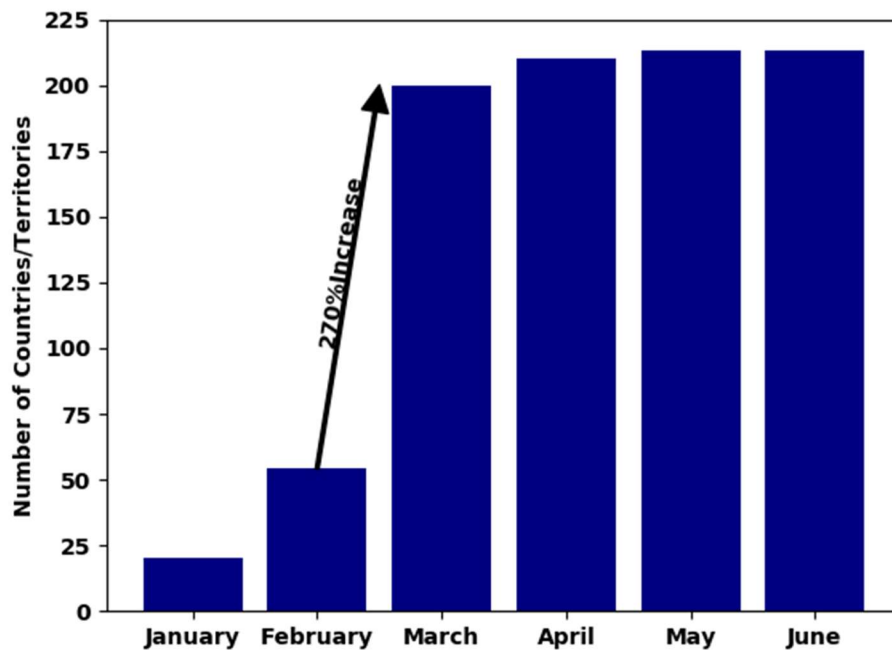


Fig. 9. Number of countries and territories affected by Covid-19.

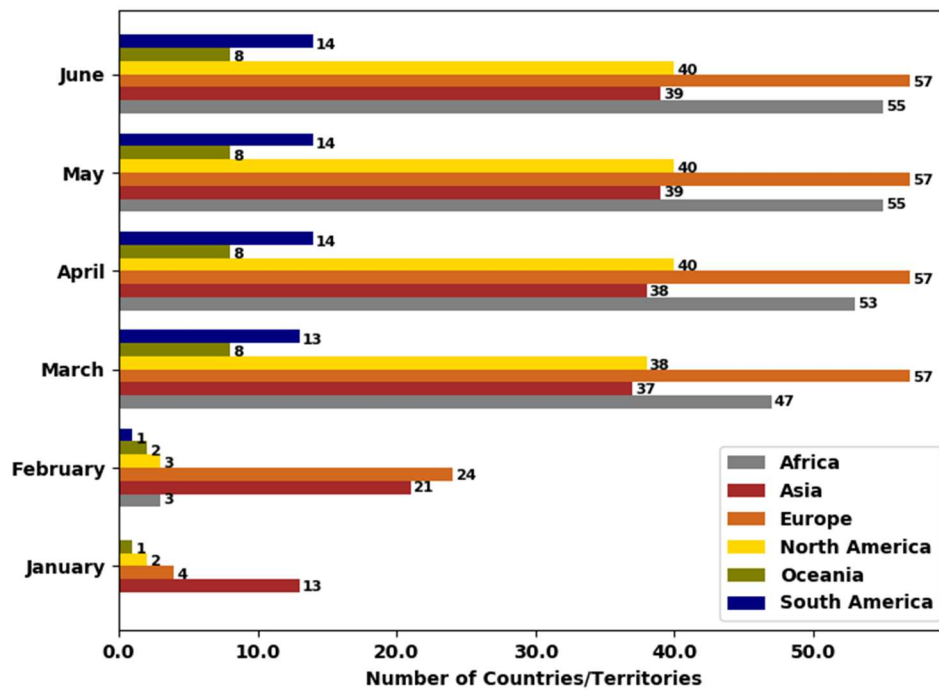


Fig. 10. Number of countries and territories affected by Covid-19 in each continent.

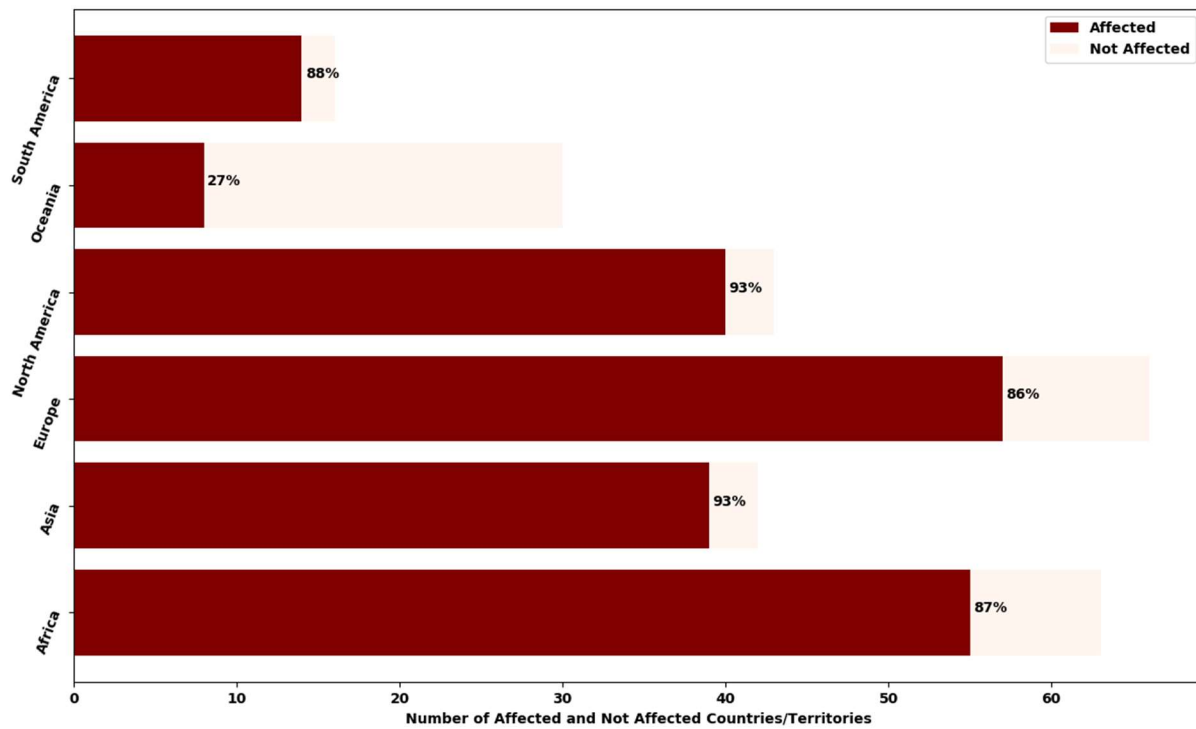


Fig. 11. Number of affected and not affected countries/territories.

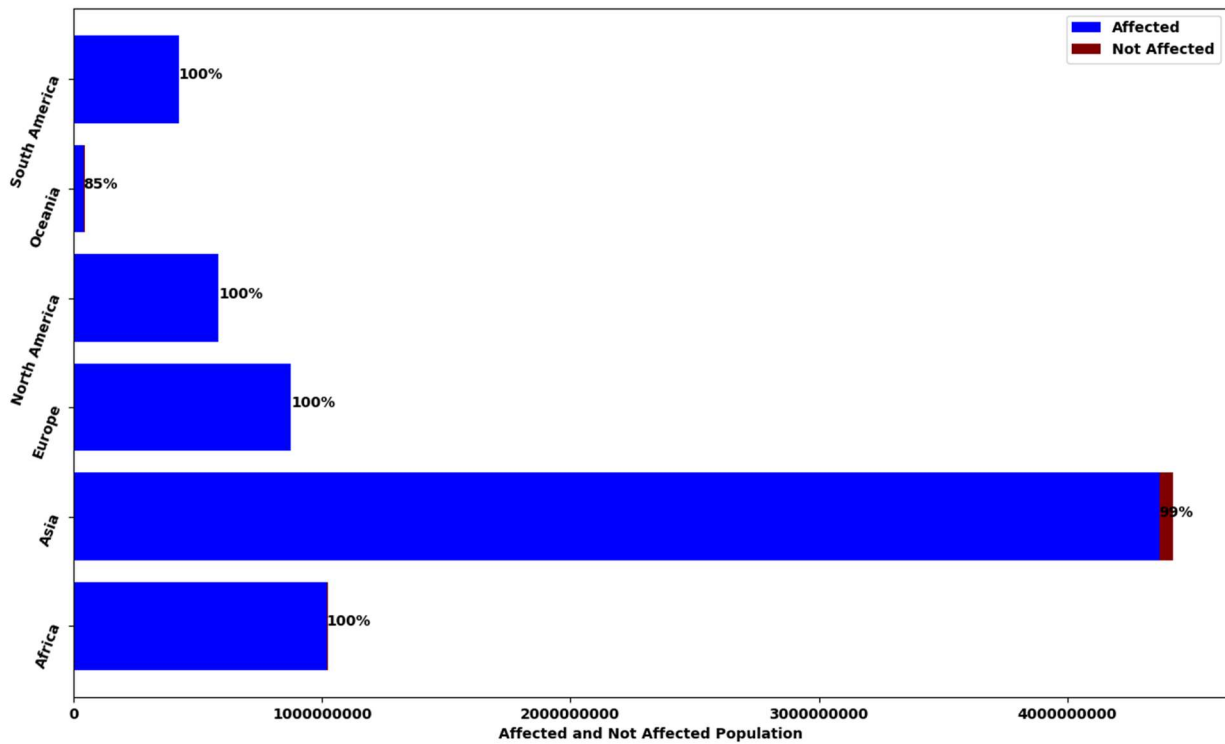


Fig. 12. Affected population by Covid-19 per month.

The change in the number of infections around the world within first six months of 2020 can be seen in Fig. 13. As the global confirmed cases currently passing 10 million, the rate of infection is decreasing without direct correlation between the continents' population and the continents' number of infections, Fig.14-15. While only 12% and 8% of world population lives in Europe and North America, respectively, in Fig.15 they account for more than 25% of confirmed cases. In addition, South America as another severely affected continent with 21% of total confirmed cases is only home to 6% percent of world population. The epicenter of the pandemic has shifted twice.

The first from Asia in January and February to Europe in March; the second from Europe in April to North America in June.

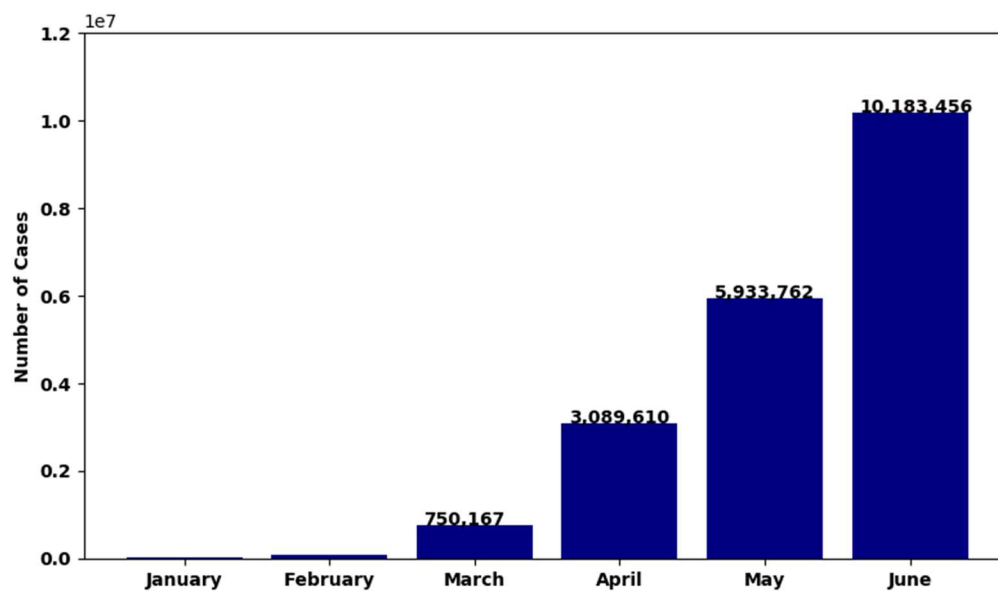


Fig. 13. The number of confirmed cases around the world per month.

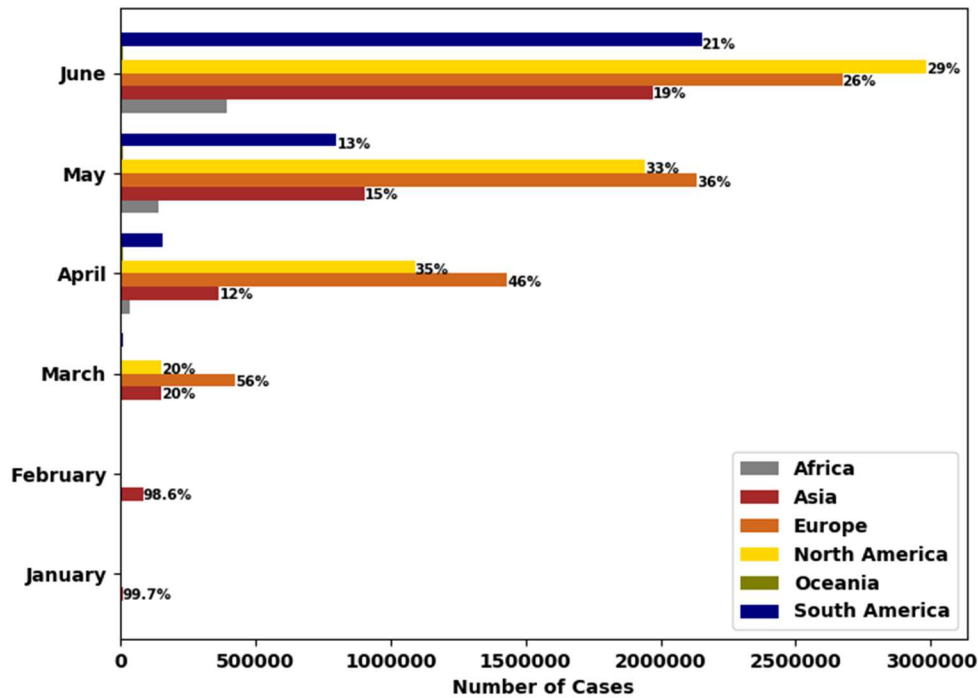


Fig. 14. The number of cases in each continent per month.

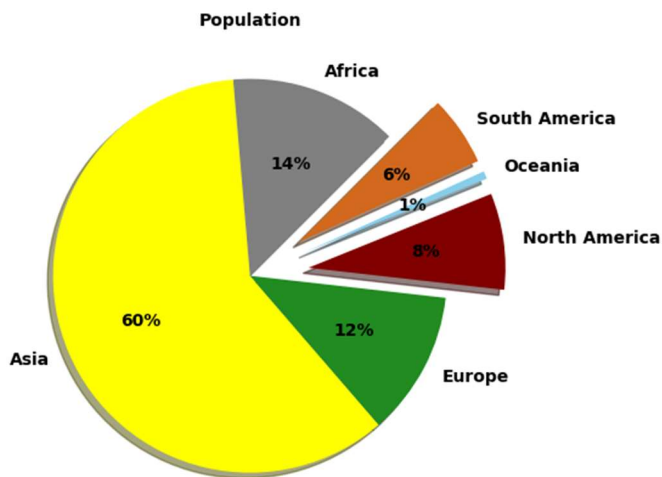


Fig. 15. The world population.

Similar patterns can be observed in the case of death toll globally where highest number of deaths occurred in Asia for the first two months. While in April, 62% of total deaths around the

world took place in Europe with the number decreasing in May and June. North America followed Europe reporting 33% of global deaths in June, Fig. 16-17.

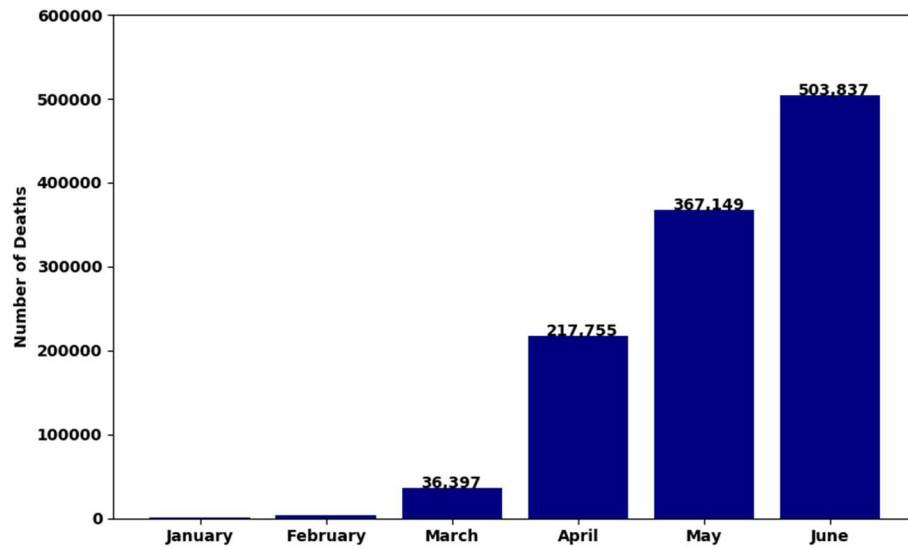


Fig. 16. The number of deaths around the world per month.

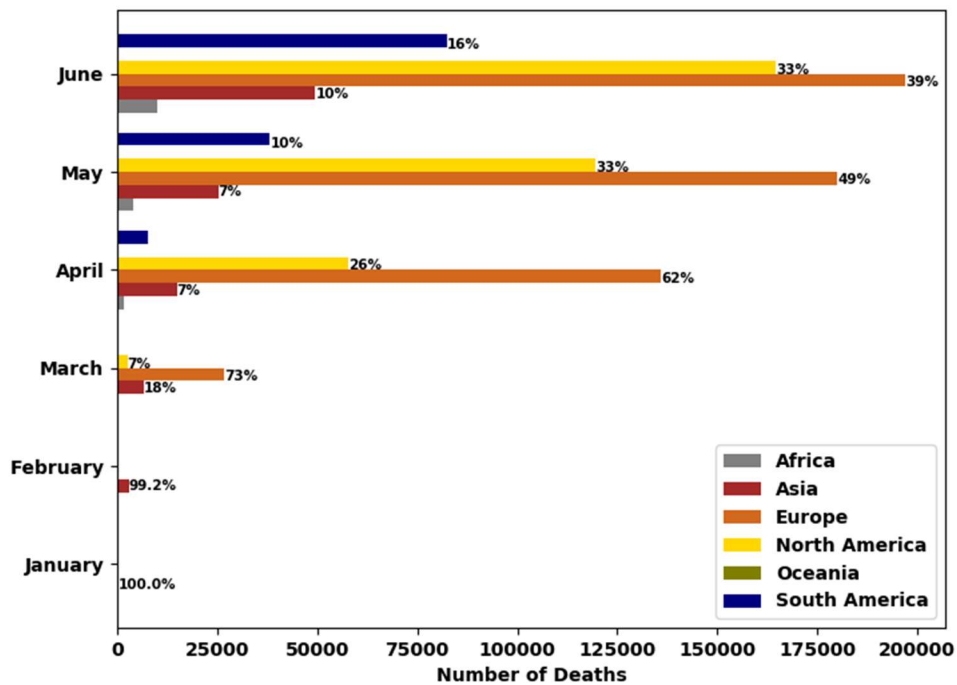


Fig. 17. The number of deaths in each continent per month.

Lists of the most affected and least affected countries/territories around world in terms of confirmed cases and death toll per month are presented in the following table:

Table 1. The most and least affected countries around the world per month.

| Month | Most Affected | Least Affected |
|--------------|---------------------------|--|
| January | China, Japan, Thailand | Cambodia, Sri Lanka, Philippines |
| February | China, South Korea, Italy | New Zealand, Belarus, Lithuania |
| March | USA, Italy, Spain | British Virgin Islands, Northern Mariana Islands, Saint Vincent and Grenadines |
| April | USA, Spain, Italy | Saint Barthelemy, Bonaire, Sint Eustatius and Saba, Yemen |
| May | USA, Brazil, Russia | Bonaire, Sint Eustatius and Saba, Saint Barthelemy, Anguilla |
| June | USA, Brazil, Russia | British Virgin Islands, Bonaire, Sint Eustatius and Saba, Anguilla |

In addition, the list of most affected countries in each continent during the first half of the year are presented in Table 2. Coincidentally, China where the outbreak originated and the most populated country in the world, is not included within the 3 highest Asian countries within the past four months.

Table 2. The most affected countries in each continent per month.

| Month Continent | January | February | March | April | May | June |
|----------------------------|----------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Africa | | Egypt Algeria Nigeria | South Africa Egypt Morocco | South Africa Egypt Morocco | South Africa Egypt Nigeria | South Africa Egypt Nigeria |
| Asia | China Japan Thailand | China South Korea Iran | China Iran South Korea | Iran China India | India Iran China | India Iran Pakistan |
| Europe | France Germany Italy | Italy France Germany | Italy Spain Germany | Spain Italy UK | Russia UK Spain | Russia UK Spain |
| North America | USA Canada | USA Canada Mexico | USA Canada Mexico | USA Canada Mexico | USA Canada Mexico | USA Mexico Canada |
| Oceania | Australia | Australia New Zealand Guam | Australia New Zealand Guam | Australia New Zealand Guam | Australia New Zealand Guam | Australia New Zealand Guam |
| South America | | Brazil | Brazil Chili Ecuador | Brazil Peru Ecuador | Brazil Peru Chile | Brazil Peru Chile |

In this report, the impact of countries' population to determine the pandemic severity was considered. As a result, two well-recognized epidemiological parameters, i.e. cases and deaths per population in 100,000 (CPP, DPP) for each country and continents were calculated. The CPP result for the entire world over the course of the outbreak is shown in Fig. 18. For the past four months, March to June, the increase in CPP around the world has grown more than 10 times. Nevertheless, this significant increase was not distributed proportionally in all continents. South America and North America respectively experienced approximately 10 and 2 times more infections per population in 100,000 for the same time frame, while Oceania was shown the least amount of increase during this period. Fig.19.

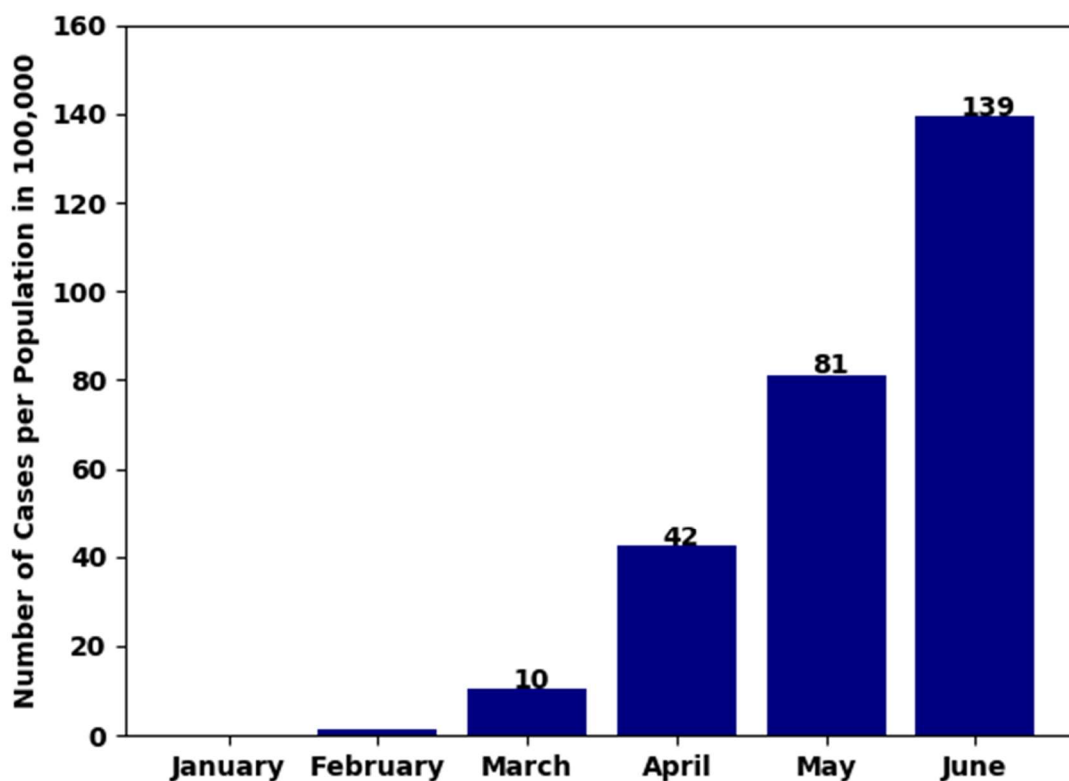


Fig. 18. The number of cases per population in 100,000 globally in each month.

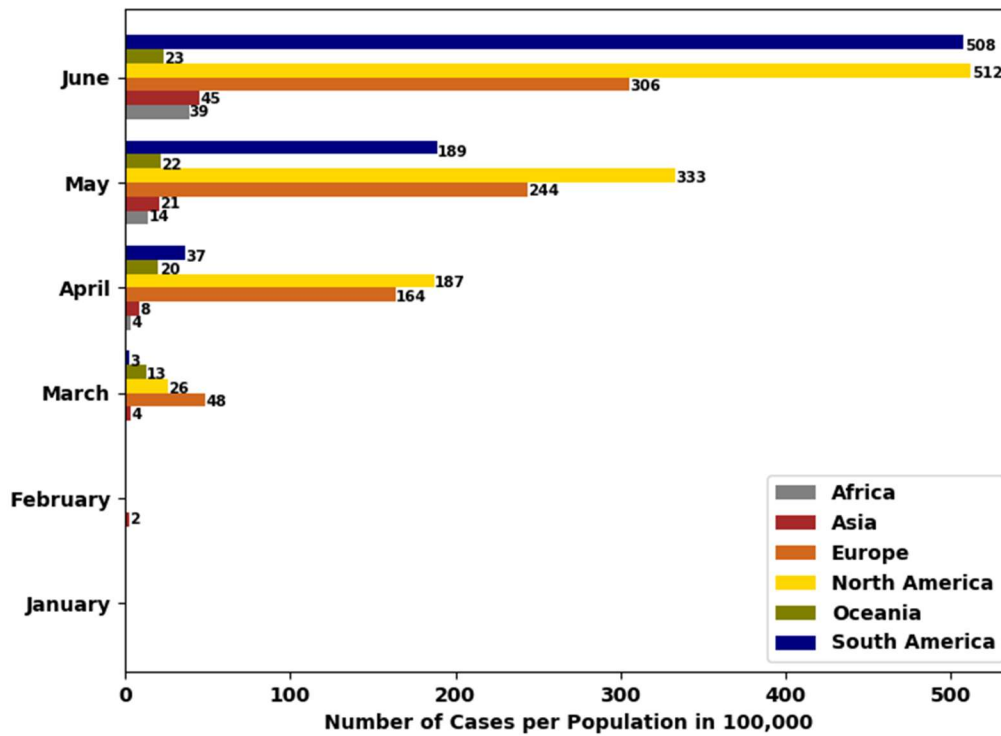


Fig. 19. The number of cases per population in 100,000 in each continent per month.

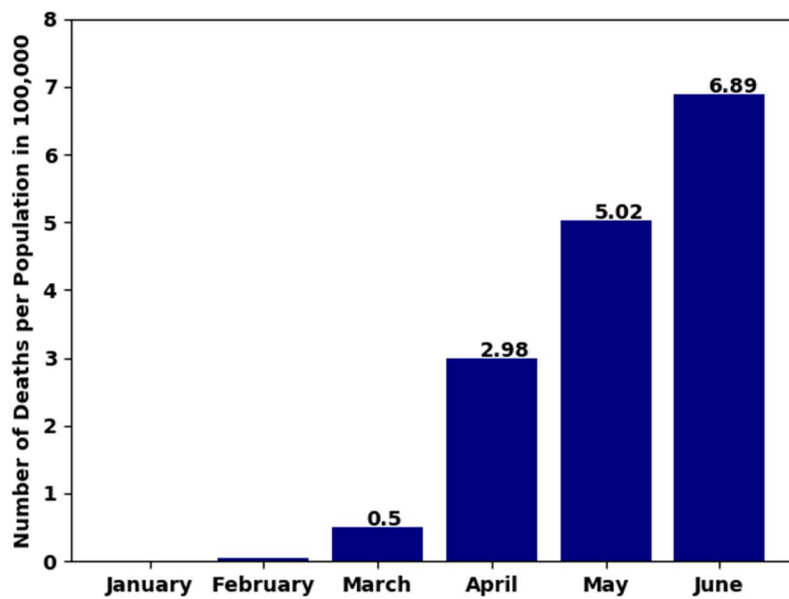


Fig. 20. The number of deaths per population in 100,000 globally per month.

The results for number of deaths per world population in 100,000 are presented in Fig.20. The number of death toll per world population in 100,00 increased from 0.5 in March to almost 7 people per population in June; however, the rate of change decreased in May and June. The trend of global DPP variation during the first half period of 2020, did not reflect on the changes in DPP for each continent for the same time, Fig.21. The highest DPP was observed in North America with 28 DPP reported, Europe with 23 and South America with 19 ranked after in June.

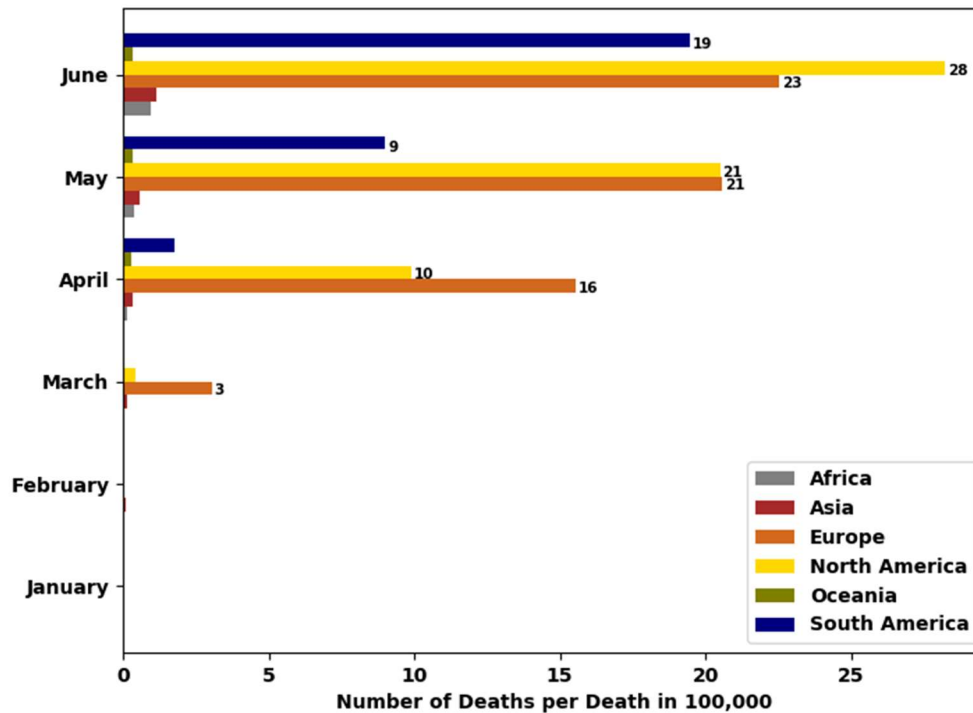


Fig. 21. The number of deaths per population in 100,000 in each continent per month.

Lists of countries with the highest CPP are summarized in Table 3. In the first two month of the year, as expected countries with considerable number of cases like China and South Korea experienced more infection per population in 100,000. Nonetheless, through June and early July, small-sized and least populated countries/territories including Qatar, Bahrain, and San Marino reported the highest number of CPP. Countries with lower number of CPP did not share any distinct characteristics as the pandemic crisis evolved.

Table 3. The most and least affected countries around the world based on CPP per month.

| Month | Most Affected | Least Affected |
|--------------|------------------------------------|------------------------------|
| January | China, Singapore, UAE | Nepal, Italy, USA |
| February | South Korea, China, San Marino | Egypt, Pakistan, Nigeria, |
| March | San Marino, Andorra, Faroe Islands | Sudan, Myanmar, Nepal |
| April | San Marino, Andorra, Luxembourg | Nicaragua, Burundi, Ethiopia |
| May | San Marino, Qatar, Andorra | Myanmar, Vietnam, Laos |
| June | Qatar, San Marino, Bahrain | Cambodia, Myanmar, Vietnam |

Lists of countries with the highest DPP are summarized in Table 4. In January and February, the highest numbers of DPP were detected in China, Japan, Iran, and Italy, a few of the epicenters of this pandemic. As the crisis continues, European countries like Belgium, Italy and Spain experienced more death per population. Additionally, tiny countries like San Marino and Andorra that are surrounded by countries with higher DPP such as Italy and Spain were affected significantly. Nevertheless, countries with lower numbers of DPP did not share any distinct trends as the pandemic crisis evolves.

Table 4. The most and least affected countries around the world based on DPP per month.

| Month | Most Affected | Least Affected |
|--------------|------------------------------|-----------------------------------|
| January | China, Japan, India | Australia, South Korea, Singapore |
| February | China, Iran, Italy | Austria, Croatia, Singapore |
| March | San Marino, Italy, Spain | Senegal, Tanzania, |
| April | San Marino, Belgium, Andorra | Grenada, Laos, Fiji |
| May | San Marino, Belgium, Andorra | Faroe Islands, Mongolia, Cambodia |
| June | San Marino, Belgium, Andorra | Faroe Islands, Namibia, Cambodia |

The list of countries with highest CPP in each continent during the first half of the 2020 year is presented in Table 5. According to this table, smaller size countries and islands were located at the top of the list for all continents by the end of the June except for the United States. Coincidentally, between the months of January and February respectively only 20 and 54 countries around the world detected the virus with countries like China, South Korea, and Australia ranking highest within their corresponding continents.

Table 5. The most affected countries based on CPP in each continent per month.

| Month Continent | January | February | March | April | May | June |
|----------------------------|------------------------------|------------------------------------|---|---|---|---|
| Africa | | Algeria Egypt Nigeria | Mayotte Reunion Seychelles | Mayotte Djibouti Reunion | Mayotte Djibouti Gabon | Mayotte Djibouti Gabon |
| Asia | China Singapore UAE | South Korea China Bahrain | Iran Qatar Bahrain | Qatar Singapore Bahrain | Qatar Bahrain Kuwait | Qatar Bahrain Kuwait |
| Europe | Finland France Germany | San Marino Italy Switzerland | San Marino Andorra Faroe Islands | San Marino Andorra Luxembourg | San Marino Andorra Luxembourg | San Marino Andorra Armenia |
| North America | Canada USA | Canada USA Mexico | Montserrat Saint Barthelemy Sint Maarten | Montserrat Sint Maarten Bermuda | USA Panama Canada | USA Panama Cayman Islands |
| Oceania | | Australia New Zealand Guam | Guam Australia French Polynesia | Guam Australia Northern Mariana Islands | Guam Northern Mariana Islands Australia | Guam Northern Mariana Islands Australia |
| South America | | Brazil | French Guiana Chile Ecuador | Falkland Islands Ecuador Peru | Chile Peru Falkland Islands | Chile French Guiana Peru |

Smaller countries with low populations like San Marino, Andorra, Qatar, Northern Mariana Islands Sint Maarten, and Montserrat that were more often surrounded by the epicenters of pandemic within their corresponding continents ranked the highest in number of DDP particularly in the past four months. Nonetheless, the United States in North America and Brazil in South America have been on the top of DPP tables since March. The United States is home to 56% of North Americans; the second and third most populated countries are Mexico (22%) and Canada (6%). Meanwhile, Iran, the 9th most populated country in Asia, reported one of the highest DDP counts for the months of February to July. A similar trend had been detected for New Zealand in Oceania since March. New Zealand accounts for 10% of Oceania's population while Australia (53%), Papua New Guinea (18%), and Papua (7%) share the majority of the continent's population. In South America, Brazil accounts for 49% of the continent population, Colombia (12%) and Argentina (10%) are the second and third most populated countries in the continent.

Table 6. The most affected countries based on DPP in each continent per month.

| Month Continent | January | February | March | April | May | June |
|----------------------------|----------------------------|------------------------------|--|---|---|---|
| Africa | | | Mauritius Morocco Algeria | Mayotte Algeria Mauritius | Mayotte Sao Tome and Principe Djibouti | Mayotte Sao Tome and Principe Djibouti |
| Asia | China Japan Thailand | China South Korea Iran | Iran South Korea Bahrain | Iran UAE Kuwait | Iran Kuwait UAE | Qatar Iran Kuwait |
| Europe | | Italy France | San Marino Italy Spain | San Marino Belgium Andorra | San Marino Belgium Andorra | San Marino Belgium Andorra |
| North America | | | Saint Martin Cayman Islands Guadalupe | Sint Maarten Montserrat USA | Sint Maarten USA Montserrat | USA Sint Maarten Canada |
| Oceania | | | Guam Australia New Zealand | Northern Mariana Islands Guam New Zealand | Northern Mariana Islands Guam New Zealand | Northern Mariana Islands Guam New Zealand |
| South America | | | Ecuador Guyana Brazil | Ecuador Peru Brazil | Ecuador Brazil Peru | Chile Peru Brazil |

The case fatality rate (CFR) is another useful indicator to measure the severity of pandemic and was widely used in epidemiological analysis that was discussed here. CFR is defined as the percentage of death toll in the number of diagnosed cases. The global CFR variation in the first half of the year was presented in Fig. 22. The fatality rate reached its highest value in April with slightly more than 7% of the confirmed cases resulting in deaths. The rate of change was not uniformly distributed in each continent, Fig.23. All continents except North America experienced a peak in April. North America did not experience its deadliest months until May and June. Europe reported a 9% fatality, the highest among all continents, and experienced the most drastic changes in CFR. Oceanian countries managed to keep their fatality rate less than 2% in all six consecutive months.

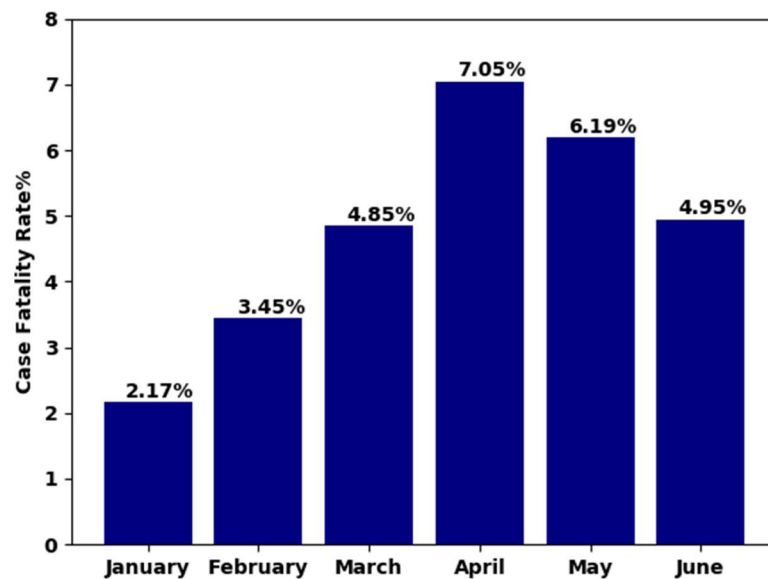


Fig. 22. Changes in CFR Rate around the world in each month.

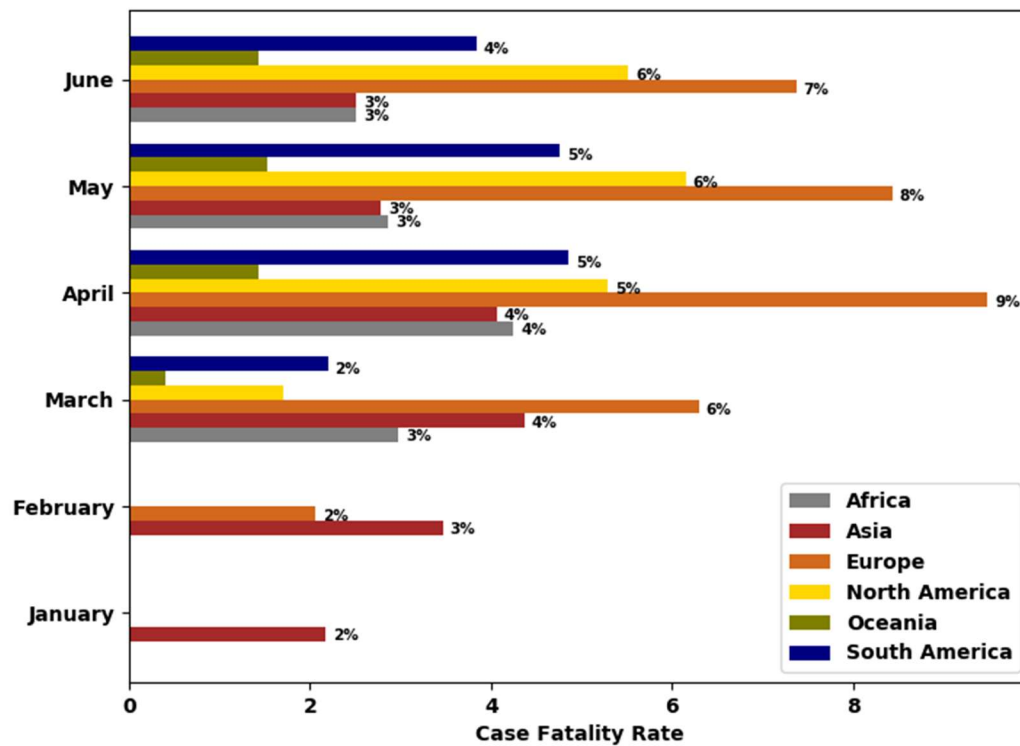


Fig. 21. Changes in CFR in each continent in each month.

Tables 7 and 8 show the list of the most affected countries in terms of case fatality rate globally and in each continent, respectively. As shown in Table 6. only Asia and Europe reported deaths before March, as a result Asian and European countries had highest CFR in the first two months of the year. In general, the combination of smaller-sized countries such as Sint Maarten, the most devastated such as Yemen and Sudan, along with countries like Italy which has one of the highest number of CPP and DPP Italy form the deadliest countries within Tables 6 through 8.

Table 7. The most and least affected countries around the world based on CFR per month.

| Month | Most Affected |
|--------------|---------------------------------|
| January | China |
| February | Philippines, Iran, China |
| March | Sudan, Gambia, Nicaragua |
| April | Nicaragua, France, Sint Maarten |
| May | Yemen, France, Sint Maarten |
| June | Yemen, Sint Maarten, France |

Table 8. The most affected countries based on CFR in each continent per month.

| Month Continent | January | February | March | April | May | June |
|----------------------------------|----------------|------------------------------|---|--|---|---|
| Africa | | | Sudan Gambia Zimbabwe | Mauritania Zimbabwe Algeria | Liberia Chad Algeria | Chad Algeria Niger |
| Asia | China | Philippines Iran China | Syria Bangladesh Indonesia | Indonesia Syria Philippines | Yemen Indonesia Philippines | Yemen China Japan |
| Europe | | France Italy | Italy San Marino Spain | France UK Belgium | France Belgium Italy | France Belgium Italy |
| North America | | | Nicaragua Curacao Cayman Islands | Nicaragua Sint Maarten British Virgin Islands | Sint Maarten British Virgin Islands Antigua and Barbuda | Sint Maarten British Virgin Islands Mexico |
| Oceania | | | Guam Australia New Zealand | Northern Mariana Islands Guam New Zealand | Northern Mariana Islands Guam New Zealand | Northern Mariana Islands Guam New Zealand |
| South America | | | Guyana Bolivia Paraguay | Ecuador Peru Brazil | Ecuador Suriname Guyana | Ecuador Guyana Brazil |

Finally, the attack rates (AR) for each continent and around the world were calculated as the percentage of the ratio of new cases during specific time period over the total population at the

risk of infection. The overall attack rates for the entire population of the world in constant time interval of 30 days and total of 150 days were presented in the following table:

Table 9. Attack Rate in percentage for the first 150 days of pandemic.

| Period | Globally | Africa | Asia | Europe | North America | Oceania | South America |
|--------------------------|----------|------------------|--------|--------|---------------|---------|---------------|
| 1 st 30 days | 0.001 | 10 ⁻⁸ | 0.002 | 5e-6 | 4e-6 | 3.2e-5 | |
| 2 nd 30 days | 0.0021 | 8e-5 | 0.0009 | 0.01 | 0.002 | 0.002 | 0.0004 |
| 3 rd 30 days | 0.027 | 0.002 | 0.004 | 0.11 | 0.13 | 0.015 | 0.017 |
| 4 th 30 days | 0.034 | 0.007 | 0.008 | 0.09 | 0.15 | 0.011 | 0.087 |
| 5 th 30 days | 0.048 | 0.02 | 0.02 | 0.06 | 0.14 | 0.0007 | 0.26 |
| 1 st 150 days | 0.11 | 0.03 | 0.03 | 0.28 | 0.42 | 0.02 | 0.36 |

According to the presented results, the rate of attacks in Asia, Africa and Oceania were more than 70% less than the universal rate. The virus attacked the American continents more aggressively than the rest of the world. North America attack rate was nearly 4 times more than global rate, while South America was affected by almost 3 times the universal rate.

Conclusion

In conclusion, the Covid-19 outbreak has affected more 80% of world population in each continent within the first 3 months of its existence. The international community missed the opportunity to prevent future spread of virus during early months. According to WHO datasets the epicenter of pandemic had shifted from Asia, the origin of the virus, to Europe, then to the Americas. Nevertheless, the number of confirmed cases in Asian countries like India and Iran is surging and three countries after the United States such as Brazil, Russia, and Mexico have been reporting high new daily cases in recent days. In terms of case fatality rate, Europe had experienced the highest fatality rate 9% amongst all continents during the first six months of 2020. The attack rate of virus in North America is 270% more than global value and North America's trend of new cases is very troubling. Nevertheless, the smaller-sized and poor countries in the world like Yemen, Sudan and San Marino recorded highest fatality rate.