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Analysing the behaviour of doubling rates in 8 major countries affected by COVID-19 virus

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ABSTRACT

Background and aims: Sars-CoV2 is a novel coronavirus that is transmitted to humans through zoonosis and characterised by mild to moderate pneumonia-like symptoms. The outbreak began in Wuhan, China, and has now spread on a global scale. Doubling time is the amount of period taken for a particular entity (that tends to grow over time) to double its size/value. This study's prime target is to develop relationships between the variation in the doubling time of the number of cases of COVID-19 virus and various socio-economic factors responsible for them. These frameworks focus on the relationships instead of relational data, so here in graph structures, we have generated different patterns of doubling rates and drawn the inferences.

Methods: Only significant countries affected by the COVID-19 virus are studied, and accordingly, collected datasets of growth of cases in the form of spreadsheets. The doubling rate is determined by calculating the doubling time for each day and then plotting these datasets in graphical form.

Results: The doubling time of various countries is vastly affected by the preventive measures taken and the lockdown implementation's success. Higher testing rates helped identify the hosts of the virus; thus, countries with mass testing have lower doubling rates. Countries, where the virus spread started earlier, had less time to prepare themselves, and they were in initial stages, the doubling time suffered. A sudden dip in doubling time is due to a large gathering of people or not effective lockdown; thus, people's attitude contributes to an essential role in affecting the doubling time.

Conclusion: The relationships between the spread of the virus and various factors such as dissimilarities in ethnic values, demographics, governing bodies, human resources, economy, and tourism of major countries are carried out to understand the differences in the virus's behaviour. This fast-moving pandemic has shown various defects and weaknesses in our healthcare systems, political organisations & economic stability and gives numerous lessons on how to enhance the ways that the global societies address similar epidemics. There is also a component that may share the same denominator is the necessity for requisite healthcare systems and medical staff. Still, the shortage of this component does not certainly mean that taking necessary steps would be ineffective. Transmission of COVID-19 to humans by zoonosis reveals that the global community is required to be observant concerning similar pandemics in the future.

1. Introduction

In December 2019, an outbreak with pneumonia-like symptoms broke out in Wuhan, China. The natural hosts of this virus are considered to be bats, yet other species are also regarded as sources. There has not been enough information accumulated by the epidemiologists to conclude how the virus spreads and affects the patients' bodies on a cellular level, but the figures indicate that the disease's reproduction number lies between 2 and 3. COVID-19 was the name announced of this new virus on February 11, 2020, and the virus is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). Although similar relations were seen with SARS-CoV and MERS-CoV after genomic characterisation was done, the novel virus was more aggressive than other coronaviruses.\textsuperscript{1}

Since so far, confirmed cases are touching 20 million, with more than 0.7 million deaths worldwide. Preliminary data from the EU/EEA show that around 20–30% of confirmed COVID-19 patients are hospitalised, and 4% are in severe conditions. For patients aged above 60 or

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those having other medical conditions, there is an increase in the hospitalisation rates.2,3 The incubation period for the disease is around 14 days, with a high possibility of symptoms showing 11.5 days.4 The COVID-19 outbreak is putting a massive strain on societies due to the considerable mortality and morbidity, the profound impact on healthcare and the societal and economic harm included with the physical distancing measures.5

Different countries have variation in the geography, economy, culture, tourism, healthcare, education, leadership; thus, several such factors are responsible for altering doubling rates, which can explain why the outbreak in a few countries has been at an alarming rate.6 The developing countries have an immense amount of air traffic (easing foreign diseases to spread inside the country) but have overpopulated cities and underfunded healthcare systems. Thus, in the long term, these countries may observe a slight increase in the doubling rates and show an exploding number of cases.7–10 The measures taken by the governing bodies are also an essential factor in coronavirus's behaviour in countries. We intend to add value to this discussion by analysing doubling rates of 9 major countries and drawing inferences that can act as a resource for containing the outbreak of COVID-19 virus.

2. Problem definition and research objectives of the paper

Here, the main focus of this paper is identifying the doubling rate of several COVID-19 positive cases. This analysis aims to assess the relationship between the variations in the doubling rates in various countries with factors such as geography, culture, government, economy and tourism. Our objective is to identify these relations, draw patterns and accumulate the ones which seem effective worldwide.

3. Scope of the paper

The study focuses on drawing insights on publicly available datasets and statistics. The data considered for the study is the number of cases of COVID-19 positive patients for each country, and spreadsheets are used to accumulate the data on a single platform. The study's depth is limited to analysing the current factors responsible for altering doubling rates through graphical representation and will not cover and sort of data forecasting.

The study's depth will be limited to some exploratory data analysis, data analysis for correlation and cause-and-effect relationships, bivariate analysis, and data visualisation, this study focuses on prediction. It will not cover any kind of data forecasting. The datasets used in the study are publicly available and taken for eight major countries.

4. Research tools

4.1. Tools used

Microsoft Excel is used to gather the data on a single platform. The programming language used for converting the data in graphical form is R (used explicitly for statistical computing and graphics).

4.2. Data used

www.worldometers.info/coronavirus is used as the data source for accumulating the datasets for each country.

5. Analysis of doubling rates of main countries

In our study, epidemic doubling time refers to the sequence of intervals in which the cases of COVID-19 doubles in value. It is an important factor in determining the rate at which the virus is multiplying in various countries.

5.5. Brazil

Fig. 1 shows that after 20 days, when the first infected patient was registered, the doubling rate was still at an alarming rate of 54 h. On 21st March, the State of São Paulo issued a complete lockdown, and all sort of non-essential services were closed down for two weeks starting from 23rd March. This lockdown somewhat helped to improve the doubling rate from 2 days to 4.5 days as the maximum cases were in the state of Sao Paulo only.

However, as the cases spread, the doubling time suffered as the country's health system is underfunded. President Jair Bolsonaro is strictly against lockdown, which is seen on the graph as a numerous rise and dips. The increase in the doubling time is simply due to the citizens' precautions, but the country may suffer in the long term. The country's test positivity rate is 33%, which shows that the increase in doubling time may be false due to less testing done.

5.2. China

Initially, the government did not act quickly enough and even punished doctors who sounded the alarm, which caused initial lower rates of doubling time and also spread of the virus.

Fig. 2 shows the rapid improvement in the doubling time in China from Day 30. This increase can be attributed to the government's vigorous measures to reallocate a vast chunk of its healthcare system to respond to the outbreak's centre and build new facilities specifically for the patients. The government also made testing free of charge even if the results were negative. It took quick actions to alert the public about infection symptoms and isolate confirmed cases and track their closer contacts to find the origins of infection clusters. On Day 70, China updated its data with new 14,108 cases which can be seen as a sharp dip in the graph. Being the epicentre, China has the most knowledge and experience in dealing with the virus, which also acts as an essential factor in the doubling time's steady rise. China has now successfully contained the epidemic, with the doubling time reaching more than 100 days.

5.3. Germany

Germany recorded its first case earlier than Italy, but its doubling time was far better than other European countries, as seen in Fig. 3. The initial low value of doubling time is due to German Carnival, a hotspot for the virus's early spread. However, comprehensive mass testing & associated quality healthcare system is the main reason behind the
success of improving the doubling rate.

Germany has successfully kept the doubling rate low through a well-thought-out strategy and adequately funded healthcare system with strong top leadership support. The country has tested far more people than other countries that have allowed authorities to slow the transmission of the disease by isolating known cases while they are infectious. Therefore, health officials understood the situation early on and took the required measures. It can be seen as a steady increase in the graph from Day 40. Germany has a building block of strong public trust and smoothly functioning leaders. The improvement in doubling time of several cases also displays the significance of governing bodies and transparent data in controlling the virus’s extent. Thus, the country managed to increase its doubling time at a significant rate.

5.4. India

Earlier, the country was only testing citizens with travel history, which then broadened to only symptomatic cases. Thus, not adopting extensive testing (which helps find mild and asymptomatic cases) led the virus to spread in the country’s vast majority. On Day 32, the Government of India issued a nationwide lockdown. As we can see from Fig. 4, starting from day 38, there has been an improvement in the doubling time, i.e. from the 25th March. It is directly related to the lockdown issued by the government and adding the incubation period. The lockdown was placed when the number of positive COVID-19 cases in India was around 500. Lockdown slowed the pandemic rate by 6th April to a rate of doubling every six days, and by 18th April, to a rate of doubling every eight days.

Another factor responsible for mass spreading is massive economic migration in the country. The migrants in lockdown were forced to return to their homes (many on foot). Although the lockdown was implemented early on, the governing bodies took slower actions in developing an effective strategy to contain the virus spread. The slow response can worsen the situation as mass testing and contact tracing is not being adopted on a mass scale. Poor health infrastructure has also contributed to the lowering of the doubling rate.

5.5. Iran

As seen in Fig. 5, the starting 15 days of the coronavirus spread show no improvement in the doubling time mostly due to the government’s light response and the country held nationwide parliamentary elections on 21st February. The president called it a conspiracy by enemy countries to shut down the nation, showing no sign of declaring lockdown until the conditions got out of hand. After the cases hit more than 11,000, the country went under lockdown.

It showed a slight improvement in the doubling rate from day 20 to day 30. The country again suffered the second wave of corona cases due to people disobeying the Nowruz holiday restrictions. Thus, starting from day 45, there was a steady improvement in the doubling time with doubling time of 45.5 days. The initial doubling rates also display the significance of governing bodies and transparent data in controlling the virus’s extent.

5.6. Italy

The initial 30 days show an exponential growth of corona cases as the doubling time graph tends to alter from 1 day to 6 days, as shown in Fig. 6.
A large number of people in Northern Italy showed pneumonia-like symptoms and thus becoming sites of infection. There is a high possibility that there were already people infected with the virus long before the first registered case appeared. The country had less time to prepare for the massive explosion that took place in various cities. In mid-February, the doubling time was on the lower side; still, no norms and rules limiting the population’s movement were taken.

On 10th March, the whole country went under lockdown, and strict measures were taken, and movement in and out of areas was prohibited. Thus, the graph showed a steady upward trend starting on Day 30.

5.7. United Kingdom

The majority of cases in the country came due to people travelling from Spain, France and Italy. The government initially adopted the mitigation approach, where it tried not to react and let the outbreak continue with only minor measures. Finally, enough people are supposed to get infected and create herd immunity to permanently reduce the R (Reproduction number) below 1. Due to this reason, the cases multiplied quickly until 30 days, as seen in Fig. 7. On 16th March, the government changed its approach and started promoting social distancing and self-isolation. Furthermore, later in March, the country went into lockdown slowly, there was an upward trend in the doubling time of no. of cases.

5.8. United States of America

The country earlier adopted reactive testing, i.e. prioritising testing of people showing severe symptoms. Thus, those are not actively seeking out the tests, and people with mild or no symptoms were left out. The initial 40 days show the country’s conditions worsening with doubling rate altering between 3 and 7 days, as seen in Fig. 8. This condition can be reflected due to the slow response towards the pandemic and 400,000 people travelling to the country from China and no virus testing of those people done. Social distancing precautions were taken in mid of March when the cases over flowed, and mass testing was carried out. No improvement in the doubling rate was also due to cultural issues with the people and the top leadership’s poor role. This country has one of the best healthcare systems, but there has been a large number of residents have not following social distancing. The country has shown the highest number of COVID-19 positive cases, but the governing bodies have shown improvement in doubling rate.

After 40 days, the doubling time started to increases due to mass testing being done, and social distancing being implemented. As of 2nd April, 90% of the population was under lockdown, which is reflected in Day 40 till Day 80. The doubling time further increased as more testing was done, and preventive measures were taken.

6. Results and discussion

Three different analyses are carried out for eight major countries, and results are drawn. The doubling time of various countries is vastly affected by the preventive measures taken, top leadership role with lockdown implementation and attitude of its citizens. Countries such as Brazil where the lockdown has still not been enacted, the cases have
risen steadily. Higher testing rates helped identify the hosts of the virus; thus, countries with mass testing have higher doubling time. The doubling time graph can also help countries where doubling time is low address the fact that increased medical staff and healthcare facilities are needed, including extra testing centres and PPE kits in countries with high cases. In terms of doubling rates, the worst affected countries are the developing countries due to their weak healthcare system covering an overpopulated expanse. If the conditions are not controlled, this may pose a severe threat to the country.

The country with a weak economy suffered more due to underfunded health system and economic migration (causing the virus to spread to more regions). Unemployment recession and unstable jobs also cause incapable individuals to disobey the lockdown to meet their daily needs to survive. The concerned government plays the most crucial role. Thus, the need is for early and rapid actions for all the governments to control the virus's outreach. Therefore, countries such as China that acted quickly to contain virus spread did not have an explosion of cases, whereas Iran and Brazil lack acting swiftly. Countries such as Brazil where the political assemblies did not take necessary actions and ignored the importance of lockdown and social norms suffered heavily. The strategy of contact tracing and aggressive testing is not easier to replicate in countries with large populations, thus usually countries with high population density will show lower doubling rates (China being the outlier).

7. Limitations of the study, tool, data

The barrier to increasing the number of people getting tested is the limited number of testing facilities, medical staff, and healthcare facilities. The test positivity rate of countries such as Brazil and the United Kingdom is high, which shows that several other people suffer from the virus that is not getting tested. Thus, inadequate information may be available for a large extent of areas. Some governments' failure to provide transparent, up-to-date information about the spread of disease poses a barrier to precise results. There are specific patterns or sequence where the length of the path is unknown upfront, so it is hard to express with absolute certainty the outcome of the growth in the doubling time of the number of coronavirus positive cases. Analysis of COVID-19 pandemic requires multilayered parameters, here we have chosen an elementary model that could include the fundamental aspects of the dissimilarities in the doubling rate of cases of COVID-19 only. Another factor for possible bias is that the data used does not cover all the periods and countries from when the first case was recorded, thus making it tough to study homogenously about the outcomes.

8. Future research implications

Understanding the study done of COVID-19 outbreak can help the authorities take new healthcare measures and other systems to more successfully take necessary action on other diseases lurking in the current time and prepare ourselves more efficiently any future outbreaks. The datasets can be used in conjunction with other systems such as analytics cloud or machine learning. These data sets' patterns give insights on what further measures can be taken by the governing bodies to combat the deadly virus. The possibility of horizontal scalability is there such that no matter what amount of data is there, one can add more resources to the infrastructure and carry out further analysis. The COVID-19 outbreak reveals the significance of rapid actions and strategies in terms of containing the diseases to prevent any further pandemics. The lessons of this study can be learning for others and in dealing with multiple cases of outbreaks. The evolution of healthcare systems, scientific research and medical institutions with strong government support over the past years are important factors that could prove significant in containing any future diseases that may get spread on a global scale.

9. Conclusion

This fast-moving pandemic has shown various defects and weaknesses in our healthcare systems, political organisations & economic stability and gives numerous lessons on how to enhance the ways that the global societies address similar epidemics. There is also a component that may share the same denominator is the necessity for requisite healthcare systems and medical staff. Still, the shortage of this component does not certainly mean that taking necessary steps would be ineffective. Transmission of COVID-19 to humans by zoonosis reveals that the global community must be observant concerning similar pandemics in future. From what we have observed and from the inference that we have drawn, we can say that government response to the pandemic plays a vital role in affecting the virus's doubling time. Mass testing can help identify hosts of the virus and prevent the virus from spreading to other regions. Countries, where the virus spread early, had less time to be prepared and thus in initial stages, the doubling time suffered and vice versa. The people's attitude towards the government and the lockdown also alters the rate at which the doubling time increases. Thus countries such as Germany and South Korea did far better than the United States of America and Iran. The healthcare system and the economic conditions also affect the doubling time, where countries such as Peru and Brazil are immensely affected. The developing countries are the worst hit due to overpopulation and underfunded healthcare system and must take strictest measures to contain the virus spread.

Declaration of competing interest

None.

References

1. https://www.ecdc.europa.eu/en/covid-19/questions-answers.
2. "Naming the Coronavirus Disease (COVID-19) and the Virus that Causes it'. World Health Organization (WHO).
3. Emergency Committee Regarding the Outbreak of Novel Coronavirus (2019-nCoV). Statement on the Second Meeting of the International Health Regulations. https://www.ecdc.europa.eu/sites/default/files/documents/covid-19-rapid-risk-assessment-coronavirus-disease-2019-ninth-update-23-april-2020.pdf; 2005.
4. https://www.cdc.gov/coronavirus/2019-ncov/hcp/clinical-guidance-management-
patients.html.
5. https://www.ecdc.europa.eu/en/covid-19/questions-answers.
6. www.worldometers.info/coronavirus.
7. Wang Y, Zhang D, Du G, et al. Remdesivir in adults with severe COVID-19: a randomised, double-blind, placebo-controlled, multicentre trial. Lancet. 2020;395(10236):1569–1578.
8. Park M, Cook AR, Lim JT, Sun Y, Dickens BL. A systematic review of COVID-19 epidemiology based on current evidence. J Clin Med. 2020;9(4):967.
9. Bianconi A, Marcelli A, Campi G, Perali A. Ostwald growth rate in controlled Covid-19 epidemic spreading as in arrested growth in a quantum complex matter. Condens. Matter. 2020;5(2):23.
10. Tsang TK, Wu P, Lin Y, Lau EH, Leung GM, Cowling BJ. Effect of changing case definitions for COVID-19 on the epidemic curve and transmission parameters in mainland China: a modelling study. Lancet Public Health. 2020;5(5):289–296.