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Reports

The profiles of first and second SARS-CoV-2 waves in the top ten COVID-19 affected countries

Jyoti Chhibber-Goel[1], Sumit Malhotra[2], N.M. Anoop Krishnan[3], Amit Sharma[1]

[1] Molecular Medicine, International Centre for Genetic Engineering and Biotechnology, New Delhi, India, [2] Centre for Community Medicine, All India Institute of Medical Sciences, New Delhi, India, [3] Department of Civil Engineering, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India; School of Artificial Intelligence, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, India

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In March 2020, the World Health Organization (WHO) acknowledged the outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) as a "*public health emergency of international concern*." Within a month, coronavirus disease 2019 (COVID-19) was declared a pandemic. As of 21 July 2021, 192.8 million cases and 4.13 million deaths have been attributed to COVID-19 worldwide. Here we discuss the data from top ten COVID-19 affected countries, with an emphasis on the average strolling period of 6 to 8 months between first and second wave in these nations. Our study ascertains that analysis of the data from countries temporally ahead of others during the pandemic gives policymakers the chance to strategize and postpone or mitigate subsequent COVID-19 waves. With governments throughout the globe continuing their immunisation efforts, a study of the key indicators of COVID-19 waves from the top ten countries is critical to preparing the healthcare system to save millions of lives.

In April 2020, the Centre for Infectious Disease Research and Policy (CIDRAP) published a viewpoint titled - "*The future of the COVID-19 pandemic: Lessons Learned from Pandemic Influenza*."[1] Based on previous data and research, the CIDRAP experts proposed three scenarios that the countries worldwide would possibly face based on the measures taken to curb the spread of infection: (i) *Peak and valley waves:* a first wave, followed by repetitive smaller waves that are consistent over a period of one to two years, gradually falling over time; (ii) *fall peak waves:* wherein the first peak is followed by a much severe second peak and subsequent milder peaks; and (iii) *slow burn waves:* where a first severe peak is followed by an on-going spread without a clear wave pattern.[1] The CIDRAP experts had emphasized that the world needs to be prepared to deal with the pandemic for the next 18 to 24 months (i.e., till 2022). Several nations around the world missed this warning, partly attributable to poor lockdowns, opening up of public places, mass gatherings as well as pandemic fatigue and failure to alert and prepare the populace for the upcoming disease waves.

THE SECOND COVID-19 WAVES

It is evident that in the top ten COVID-19 countries, the shape of COVID-19 waves is typical of fall peak waves, i.e., the second wave that is more severe than the first (**Figure 1, *plates A and B***).[2,3] It is widely accepted in the field of infectious diseases that pandemics spread through subsequent waves (as was the case in the 1918 Spanish flu pandemic where second wave was more ferocious compared to first wave), and human behaviour is a major factor for the spike in coronavirus cases rather than the virus diffusion itself.[4–8] In an interview, Dr. Anthony Fauci, Director, National Institute of Allergy and Infectious Diseases (NIAID) opined that the second wave would depend on the capability and effectiveness to monitor and mitigate blips of infection and then to ensure that systems are in place for testing, isolation and contact tracing. A more severe second wave is usually attributed to: (i) appearance of newer and more infectious variants; (ii) opening of the public places; (iii) pandemic fatigue resulting in failure to follow COVID-19 appropriate behaviour in a public place; and (iv) lack of protection in the susceptible population due to inadequate vaccination coverage. The changes in public policies such as reopening businesses and other community activities take a minimum of one or two weeks to show up in terms of COVID-19 cases and six to eight weeks for these numbers to appear in population-level data. This worsens the subsequent wave of infections during a pandemic that reaches a point of no return at the time. In an attempt to explain the taming of the next wave, Cacciapaglia *et al*.[9] have demonstrated that the strolling period between two waves is critical in controlling the pandemic. This strolling period allows the formulation of strategies to prevent the arrival of the next wave.[9] Thus, the strolling period between the two waves: (i) is critical to control the number of new infections to delay the beginning of the new wave; (ii) allow the time to boost the vaccination campaign; (iii) provide an opportunity for the health policymakers to ensure non-pharmaceutical interventions to reduce the impact of second wave; (iv) allow boosting the public health measures to combat the pandemic; and (v) most importantly, prepare for the inescapable upcoming wave.

Among the top ten nations, India ranking second in the

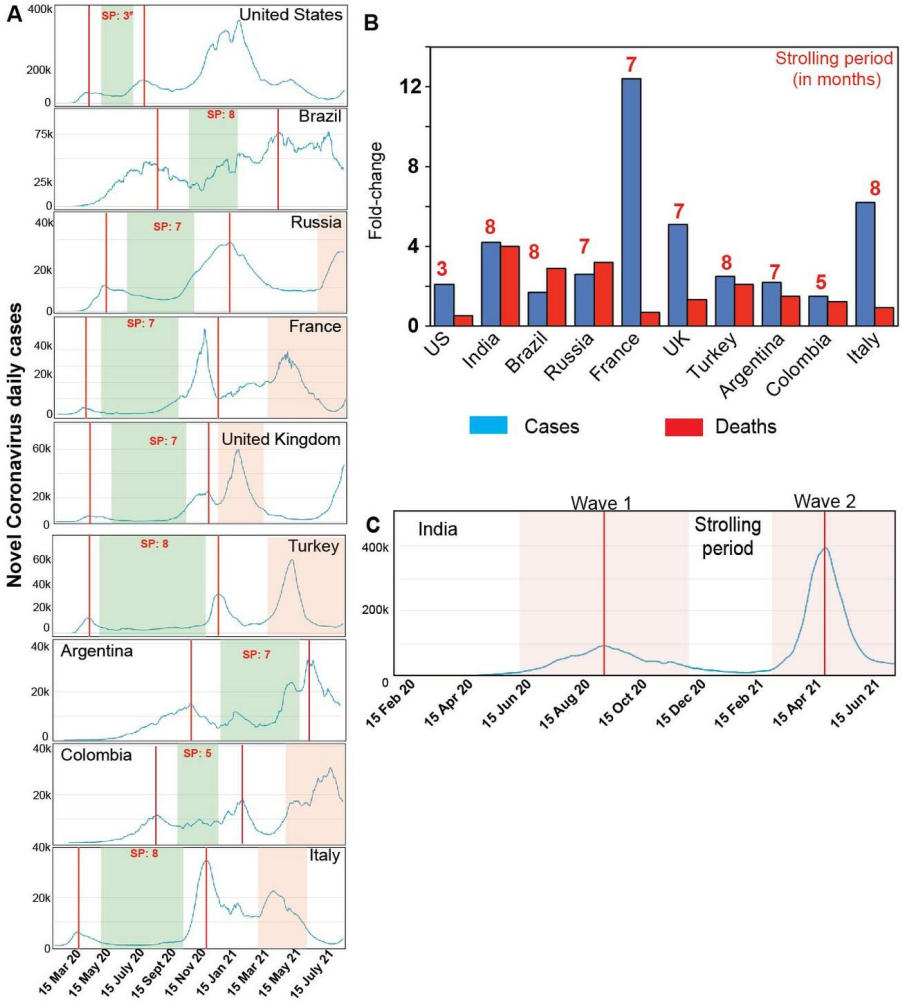

Figure 1. The COVID-19 wave profiles in top ten affected nations.

A. Presented in order of their ranking is shown (except India, which ranks two). The United States (currently experiencing the third wave, with a short strolling period of three months between the first and second waves), and Brazil/Argentina (with a slow burn wave) are shown as the 7-day moving average of the daily cases. The graphs represent the peaks/waves (in red line) faced by the nations, with a low-lying strolling period (SP: duration in months) with minimal or decreased number of reported new cases. Data were obtained from the Worldometers.info.[2]

B. The values on top of the column indicate the number of months between the first and the second COVID-19 waves in each country. The values on top of the bars indicate an ongoing second wave with a strolling period of 6-8 months. # An exception with a short strolling period between first and second wave due to absence of nation-wide lock-downs as previously discussed.

C. Showing a peak in September 2020 and the start of the second wave is shown in red. The strolling period of six months between the two waves and their peaks is marked in green.

number of COVID-19 cases recently encountered second infection wave. In 2020, India was able to delay the first wave with a sudden nation-wide lockdown in April 2020. The highest daily confirmed cases of 67.5 per million on 16 September 2020 (first peak) were reported in India. Further, based on public data and an average strolling period of 6 to 8 months in nations ahead of India temporally in the pandemic (like the UK), the second wave during April to May 2021 (exactly 6 to 8 months from the first peak) was inevitable (**Figure 1**, ***plate C***). Thus demonstrating that an analysis of COVID-19 waves in nations that are ahead in infection waves could easily help predict both the timing and the relative (to the previous wave) intensity of the subsequent waves. It is worth noting that the countries in the northern hemisphere (the United States, France, Turkey, Russia, the United Kingdom, Italy, and Germany) are chronologically ahead of the equatorial or southern countries (Brazil, Argentina, and India) in the epidemic (**Figure 1**, ***plate A***). This may be due in part to the proposed virus's natural periodicity across the world. Despite the spread of COVID-19 in different communities during the first and the second wave, the age and gender distribution has been fairly similar for the countries with available data.[10] Additionally, in terms of the demographics the proportion of COVID-19 deaths remained consistent for the different age categories (**Table 2**).[10,11] As is evident from the incidence

Table 1. The daily new confirmed COVID-19 cases during the first and the second waves in top 10 countries.

Ranking	Country	First wave *(dd.mm.yy)*	Second wave *(dd.mm.yy)*	Fold change during second wave	Strolling period (in months)	Oxford stringency index
1	United States	33047 *(10.04.20)*	70445 *(19.07.20)*	2.1	3	52.3
2	India	93280 *(17.09.20)*	392322 *(08.05.21)*	4.2	8	81.9
3	Brazil	46263 *(30.07.20)*	76738 *(25.03.21)*	1.7	8	56.9
4	Russia	10982 *(12.05.20)*	28934 *(26.12.20)*	2.6	7	46.8
5	France	4537 *(01.04.20)*	56377 *(07.11.20)*	12.4	7	41.2
6	United Kingdom	4990 *(14.04.20)*	25285 *(16.11.20)*	5.1	7	43.9
7	Turkey	12400 *(16.04.20)*	31655 *(07.12.20)*	2.5	8	64.8
8	Argentina	15052 *(21.10.20)*	33172 *(21.05.21)*	2.2	7	75
9	Colombia	11551 *(16. 08.20)*	17857 *(20.01.21)*	1.5	5	70.4
10	Italy	5646 *(26.3.20)*	35289 *(16.11.20)*	6.2	8	75.5

The fold increase during the second wave is shown with respect to first wave. The highest number of new confirmed cases (date-wise) is mentioned in the bracket for each nation where applicable. Oxford stringency index on a scale of 1-100, with 100 being strictest is mentioned.[14] Dates expressed under daily cases as *dd.mm.yr*.

data from the top 10 countries, the fold-increase in the highest daily confirmed cases per million between first and second waves is about 1.5 (Colombia) to 12.4 (France) and the fold increase in number of deaths per million is about 0.5 to 4 fold **(Tables 1 and 2)**. This clearly shows a severe second wave with a strolling period of six to eight months from the first wave **(Figure 1, plates A and B; Table 1)**. An exception to this is the United States of America, with the strolling period between the first and second wave of three months, majorly attributed to the resistance to a nation-wide lockdown during April to May 2020. Thus emphasizing that it is crucial to keep in mind that countries' anti-epidemic tactics differ globally.[12,13]

CONCLUSIONS

Analysis of the data from the top ten COVID-19 afflicted nations that dealt with the coronavirus crisis ahead of other nations on their timelines clearly shows that the first wave of the coronavirus was followed by a six to eight months strolling period. This was followed by a second wave with 1.5 to 12.4 times fold increase in COVID-19 cases. As of 21 July 2021, 192.8 million cases and 4.13 million deaths have been reported worldwide due to COVID-19. Among the top ten nations, India ranking second in the case number and third in deaths due to COVID-19 was recently caught in a devastating second COVID-19 wave that lasted for approximately four months.[2] During the first wave, the COVID-19 testing capacity was extensively boosted in India with government-approved private and government labs all across the nation. During the second wave demand for a country-wide lockdown gained momentum. Thus, several states in India either imposed state-wide/weekend lockdowns, curfews or selected restrictions on the movement of public or curfews based on the number of active cases and the burden on the healthcare system. The lockdown thus resulted in a substantial drop in average weekly fresh cases. As of 21 July, 2021 the test positivity rates is 2% and the R-value that represents the ability of the virus to spread had dropped in most states to 0.97.[15] Mass vaccination of the populace during the on-going strolling period will have substantial effect on the onset of 3rd wave as well as the clinical profile of the COVID-19 cases. Thus, analysis of the epidemiological data from countries temporally ahead and having reached or past their 3rd COVID-19 wave with mass vaccinations provides an opportunity to defer or diminish a possible 3rd wave in most countries. There is time to prepare the healthcare system to save the lives of millions, to mass vaccinate, and to curb the generation of new variants that stem from high transmission rates. Any delay in these steps would result in a slow burn wave pattern of the pandemic, which will be detrimental to its population. While extrapolating severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) wave patterns, it is important to note that the anti-epidemic measures deployed by nations vary globally. These are attributed to socio-economic impact of the mitigation strategies as well as the var-

ied healthcare facilities that play a key role in defining the outcomes during a pandemic. In addition, because of the inherent disparities in healthcare infrastructure, the management and treatment of a variety of other infectious illnesses native to the countries, such as malaria, is hampered. For instance, we have previously suggested that the well-established malaria control facilities in endemic regions be used in part to initiate long-term COVID-19 mitigation strategies.[16] Thus, nations must consider resetting their pandemic mitigation strategies by focusing on providing emergency healthcare support to their populations while being focused on mass vaccination campaigns.[17] In summary, nations temporally behind other countries in the COVID-19 pandemic must track the profiles of COVID-19 across the globe. Thus redirecting their efforts based on data from other nations to maximize immunization and combat the emergence of SARS-CoV-2 variants (tracked through investments in genomic surveillance) that possibly will be able to delay the on-set of the subsequent waves.

Table 2. The daily confirmed COVID-19 deaths during the first and the second waves in top 10 countries.

Ranking	Country	First wave *(dd.mm.yy)*	Second wave *(dd.mm.yy)*	Fold change during second wave	First wave (age distribution %)			Second wave (age distribution %)		
					<50	50-69	>70	<50	50-69	>70
1	United States	2272 *(21.04.20)*	1187 *(04.08.21)*	0.5	2.8	17.4	79.7	2.4	15.9	81.7
2	India	1170 *(21.09.20)*	4684 *(20.05.21)*	4.0	Elderly with co-morbidities			Young adults (30-50 years of age)		
3	Brazil	1081 *(16.07.20)*	3125 *(12.04.21)*	2.9	Elderly with co-morbidities			Young adults (20-59 years of age)		
4	Russia	178 *(03.06.20)*	567 *(30.12.20)*	3.2	-	-	-	-	-	-
5	France	975 *(08.04.20)*	667 *(19.11.20)*	0.7	0.7	6.8	92.5	0.4	4.9	94.8
6	United Kingdom	944 *(13.04.20)*	1250 *(23.01.21)*	1.3	1.0	9.4	89.5	0.8	8.5	90.7
7	Turkey	122 *(22.04.20)*	256 *(29.12.20)*	2.1	-	-	-	-	-	-
8	Argentina	407 *(11.10.20)*	601 *(07.06.21)*	1.5	-	-	-	-	-	-
9	Colombia	324 *(15.08.20)*	391 *(25.01.21)*	1.2	-	-	-	-	-	-
10	Italy	817 *(02.04.20)*	741 *(03.12.20)*	0.9	1.1	13.5	85.4	1.1	12.3	86.6

The fold increase during the second wave is shown with respect to first wave. The date with the highest number of new confirmed deaths and the proportion of COVID-19 deaths categorised by age groups is also shown.[10] Dates expressed under daily deaths as *dd.mm.yr*.

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AUTHORSHIP CONTRIBUTIONS

All authors contributed to the manuscript.

COMPETING INTERESTS

The authors completed the Unified Competing Interest form at www.icmje.org/disclosure-of-interest/ (available upon request from the corresponding author) and declare no conflicts of interest.

CORRESPONDENCE TO:

Jyoti Chhibber-Goel, Molecular Medicine, International Centre for Genetic Engineering and Biotechnology, New Delhi, India.
jyotichhibbergoel@gmail.com

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