SURENDRANATH COLLEGE MICROBIOLOGY DEPARTMENT

JULY 2021

COVID-19

ORIGIN, 1ST AND 2ND WAVE IN INDIA

BE SAFE, WASH HANDS, ALWAYS USE MASK, AVOID GATHERING

CONTEXT

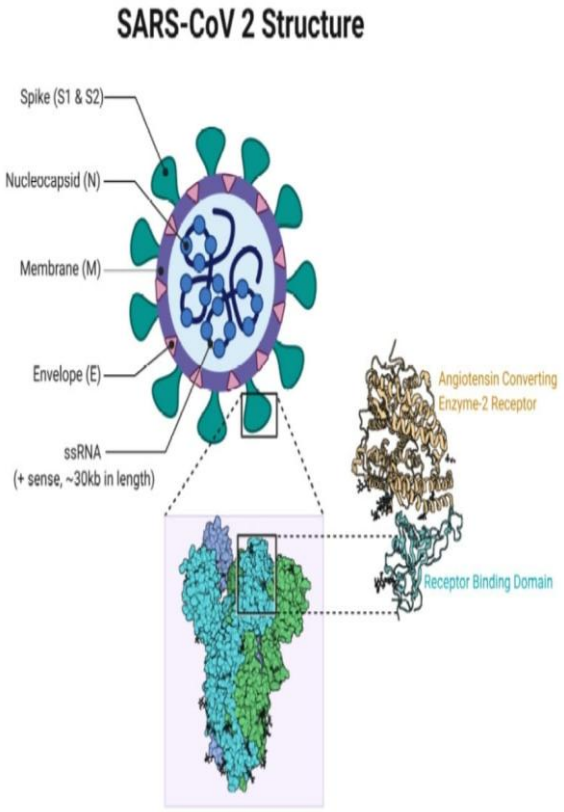
BE SAFE, WASH HANDS, ALWAYS USE MASK, AVOID GATHERING

BASIC CONCEPTS OF SARS-COV 2 AND COVID-19

-By Syed Sohan Ali, Nagiri Lalitya Rao, Ateka Wajahat, Saman Mehboob

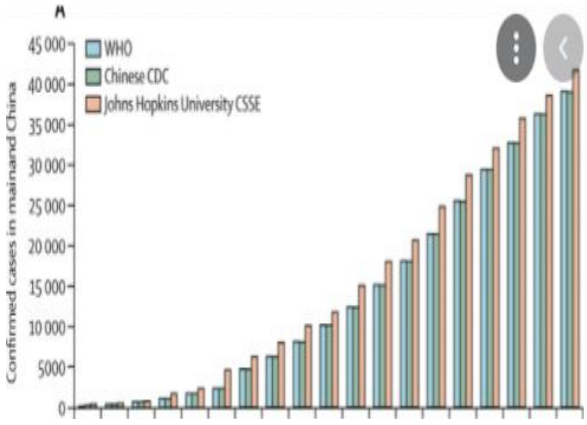
VIRUS STRUCTURE

SARS-CoV-2 contains four structural proteins(S, E, M AND N) and sixteen non-structural (nsp1-16) Nsp1 mediates RNA processing and replication. Nsp2 modulates the survival signalling pathway of host cell Nsp8 and Nsp9 binds to the 7SL RNA which locates at the single recognition particle to disrupt Protein trafficking to the cell membrane followings are some SARS-CoV-2 proteins which may potentially serve as antiviral drug targets on their structures.



ORIGIN

SARS-CoV 2 is a disease with **severe acute respiratory syndrome**, related coronavirus. The first known infections from Wuhan, China in December, 2019. The disease has spread worldwide resulting in a zoonotic origin and close genetic similarity to bat coronavirus. Suggesting it emerged from a bat-borne virus. the early infected of the virus were workers at the Wuhan to be the origin. the figure below shows the active cases in china in 2019.



SPREAD

Respiratory infections can be transmitted through droplets of different sizes: when the droplets particles are>5-10nm in size they referred to as respiratory droplets. Droplet transmission occurs when a person is in close contact with someone who has respiratory symptoms and is therefore at risk of having his/her mucus or conjunctiva exposed to potentially infective respiratory droplets. Transmission may also occur through Fomites in the immediate environment. Airborne transmission is different from droplet transmission which is generally considered to be particles.

IMPACT ON HUMANS

A cross section shows immune cells crowding an inflamed Alveolus, whose walls breakdown during attack by the virus, more effort to break the immune system in overdrive and drugs given to fight the virus may be causing the damage. The virus may attack kidney directly.

CONCLUSION

WHO declared the COVID-19 epidemic a pandemic and the future is going to take horrible forms.

BE SAFE, WASH HANDS, ALWAYS USE MASK, AVOID GATHERING

Emergence of 1st COVID WAVE IN INDIA

-By Abir kundu, Sreejita Pal, Manisha Gangopadhyay

How corona virus spread in INDIA:

In the beginning, Coronavirus cases in India happened due to the abroad connection rather than transmission within the country. The first three infection cases occurred on 30th January and 3rd February in Kerala as they returned from Wuhan China. Within a month later on 3rd March, two more cases were reported where one patient had a travel history from Italy while the other in Hyderabad visited Dubai. On 22nd March

Controlling COVID in INDIA:

Indian government encouraged people to follow 14 hrs of Janata curfew in India. On 24th March first phase of 21 days lockdown started in India. Due to this lock down, mobility in grocery and pharmacy, recreation and retail, transit to station visits to parks, and workplaces reduced by 64.2%, 70.51%, 65.6%, 46.17 and 60.03% respectively. Due to the growing number of infestation from COVID-19, on 14th April, Indian government declared an extended 2nd phase lockdown till 3rd May which was further lengthened till 17th May and later imposed till 31st May.

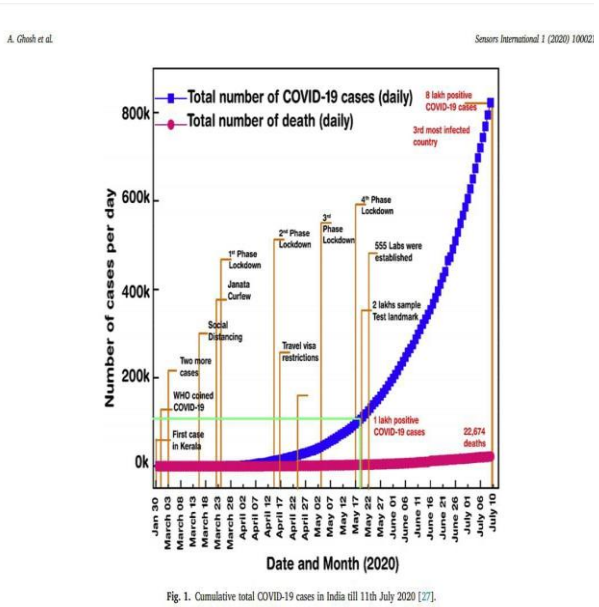


Fig. 1. Cumulative total COVID-19 cases in India till 11th July 2020 [27].

Explaining graph:

After the first confirmed case been reported on 30th January, the total number of confirmed patients reached 107 by 15th March, and since then, the number of positive cases is incessantly increasing. Within 15 days (15th to 30th March), confirmed cases of COVID-19 in India multiplied by 10 times. As of 30th March, India crossed more than 1071 cases with 29 deaths. at the end of all lockdown phases, India experienced a total of 1,90,648 confirmed case including 5407 deaths due to this disease Cities like Ahmedabad, Bangalore, Bhopal, Chennai, Delhi, Hyderabad, Indore, Jaipur and Kolkata were identified as the COVID-19 hotspots with four major metropolitan cities accounted for nearly 40% of the COVID-19 cases in India. India is experiencing exponential growth in the number of COVID-19 cases. As of 11th July 2020, India is the 3rd most COVID-19 infected country with currently 2,922,58 active cases, along with 5,34, 620 patients being cured and discharged (recovery rate of 60.86%) followed by the demise of 22,674 COVID-19 infected patients.

Terrible condition in Maharashtra, Mumbai:

Mumbai (18.93N, 72.83E), the capital of Maharashtra state also known as the business centre of India is renowned for its large number of slums. It is estimated that 9 million people live in Mumbai slums where houses are fairly 10 ft by 10 ft and under such conditions obeying social distancing is a questionable issue. In return, it can also be seen that in India number of COVID-19 cases are maximum in Maharashtra (37,136 cases by 20th May; 75995 cases by 1st July) and particularly high in the city.

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Effectively control COVID 19, In KERALA:

The Indian state of Kerala is celebrated for its efficient response to COVID-19. Built on decades of investment in rural health, education, decentralized administrative systems, and a huge network of women's groups, Kerala has created a health care model that prioritizes empathy and responsiveness. This strong social and administrative fabric has made Kerala a prime example of how other states and countries could respond to the pandemic.

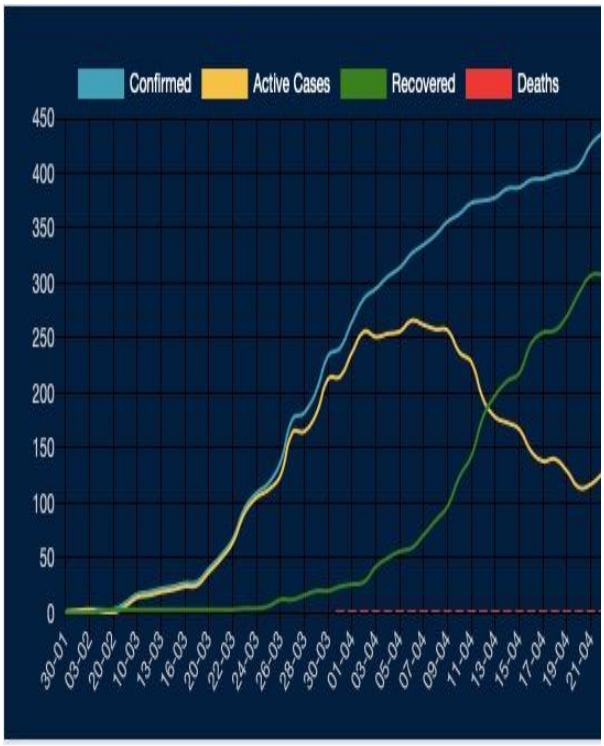


Fig: Growth curve

Table 1

Total Covid-19 infections in different Indian states and Union Territories as of 1st July 2020 [28].

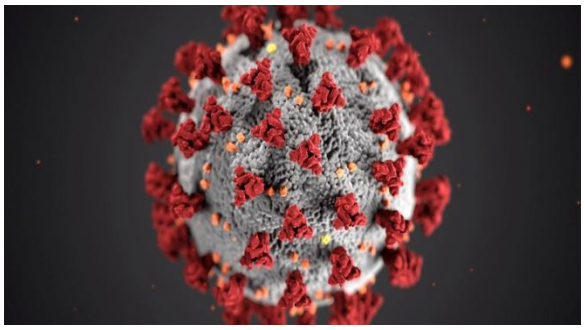
States	Active cases	Cured/ discharged	Deaths	Total confirmed cases
Andaman and Nicobar	47	50	0	97
Andhra Pradesh	7897	6511	187	14595
Arunachal Pradesh	128	62	1	191
Assam	2568	5647	12	8227
Bihar	2289	7687	67	10043
Chandigarh	70	364	6	440
Chhattisgarh	597	2250	13	2860
Dadra and Nagar Haveli Daman Diu	131	83	0	213
Delhi	26270	58348	2742	87360
Goa	716	596	3	1315
Gujrat	7049	23662	1846	32557
Haryana	4340	9972	236	14548
Himachal Pradesh	363	580	10	953
Jammu and Kashmir	2674	4722	101	7497
Jharkhand	591	1884	15	2490
Karnataka	7078	7918	246	15242
Kerala	2112	2306	24	4442
Ladakh	324	648	1	973
Madhya Pradesh	2626	10395	572	13593
Maharashtra	75995	90911	7855	174761
Manipur	681	553	0	1234
Meghalaya	9	42	1	52
Mizoram	38	122	0	160
Nagaland	291	168	0	459
Odisha	1851	5189	25	7065
Puducherry	430	272	12	714
Punjab	1557	3867	144	5568
Rajasthan	3381	14220	413	18014
Sikkim	37	52	0	89
Tamil Nadu	38892	50074	1201	90167
Telangana	8785	7294	260	16339
Tripura	301	1086	1	1388
Uttarakhand	609	2231	41	2881
Uttar Pradesh	6711	16084	697	23492
West Bengal	5761	12130	668	18559

MUTATION OF SARS- CoV 2 VARIANTS IN INDIA

- By RISHAV KUNDU & SHUBHRA JYOTI DAS

INTRODUCTION

Initially reported in mid-December 2019 in the Chinese city of Wuhan, the newly emerged **Severe Acute Respiratory Syndrome Virus** (SARS-CoV-2) is a single-stranded RNA beta-corona virus with a compact **29,903 nucleotides-long genome**. This virus causes a serious disease known as **Corona virus** Disease 2019 (COVID-19), which has spread in over 210 countries in <4 months, counting more than 10 million confirmed cases and almost 500,000 deaths reported worldwide as of June 28, 2020 (source: World Health Organization). A difference in case fatality rates across countries was observed, possibly due to a diverse demographic composition and the type of measures that have been taken in different countries to limit viral spreading (Dowd et al., 2020).



MUTATION

Definition: a change in the basic (genetic) structure of a living or developing thing

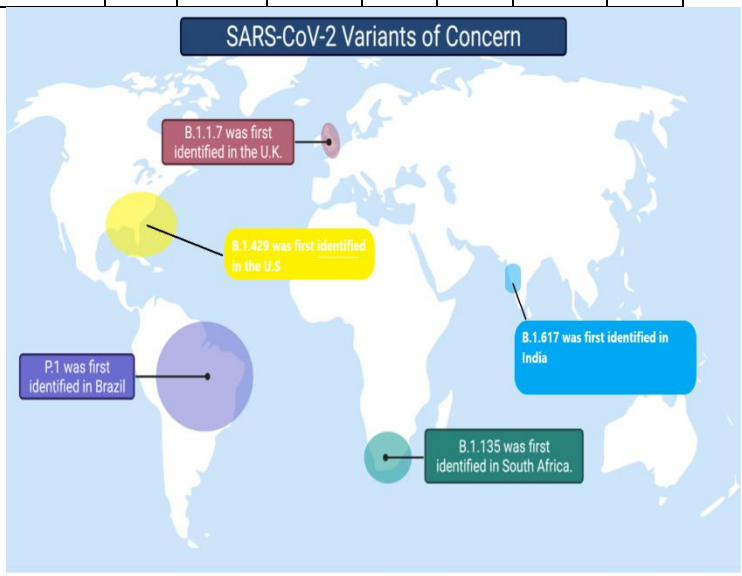
Cause: Most of the mutations that we think matter to evolution are "naturally-occurring". Mutations can also be caused by exposure to specific chemicals or radiation. These agents cause the DNA to break down. This is not necessarily unnatural — even in the most isolated and pristine environments, DNA breaks down. Nevertheless, when the cell repairs the DNA, it might not do a perfect job of the repair. So the cell would end up with DNA slightly different than the original DNA and hence, a mutation.

MUTATION OF SARS CoV-2

Cause: Viruses mutate to be effective in the host cell, to disguise from the immune system.

Basic mutant variants of Sars CoV-2: There are basically 7 deadly mutant variants found in Sars CoV-2, till date

Name Of the variant	B.1.1.7	B.1.1.318	B.1.351	B.1.429	B.1.617	B.1.1.525	P.1
Origin	U.K	U.K	S. Africa	U.S	India	Denmark	Brazil



B.1.617 (Indian Variant)

Basic Mutation: It has mutation in the gene encoding the SARS CoV-2 spike protein causing the substitutions **T478K, P681R** and **L452R** which are known to affect transmissibility of the virus as well as weather it can be neutralized by antibodies for previously circulating variants of COVID-19.

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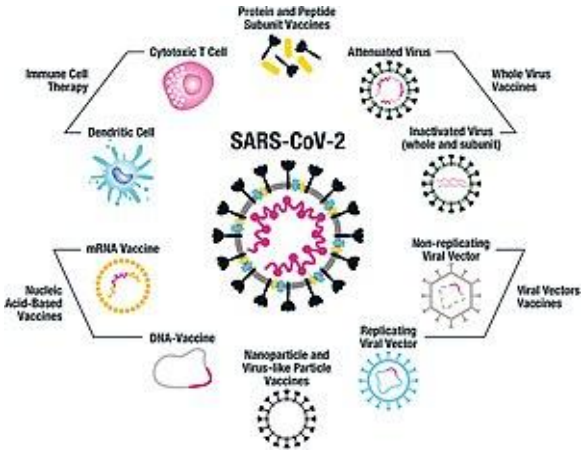

T478K mutation: The T478K mutation constitutes the exchange of the non-charged amino acid **threonine(T)** with the positively charged **lysine(K)** at position 478 and **roughly encompasses amino acids 350 to 550** of the SARS-CoV-2 spike protein. The exchange of amino acids at this position facilitates the presentation of a different electrostatic surface that can be further altered by co-occurring mutations, potentially interacting with receptors, antibodies, and drugs more strongly or weakly.

P681R mutation: The name of the mutation, P681R, refers to an exchange whereby the **proline (P)** is replaced by **arginine(R)** at position 681.

L452R mutation: The name of the mutation, L452R, refers to an exchange whereby the **leucine (L)** is replaced by **arginine(R)** at position 452. L452R, some studies show, could even make the coronavirus resistant to T cells that are class of cells necessary to target and destroy virus-infected cells. They are different from antibodies that are useful in blocking coronavirus particles and preventing it from proliferating.

The two mutations are found in the virus's spike protein. The spike protein helps the virus to bind itself to the human cell's receptors and gain entry into a host cell.

The **P681R** mutation is similar to E484K, a mutation found in the United Kingdom (lineage B.1.1.7) and South Africa (B.1.351) variants of the coronavirus.

The L452R mutation has been found in fast spreading variants in California (B.1.427 and B.1.429). It can increase the binding power of spike proteins with ACE2 receptors on human cells, making it more transmissible. L452R can also potentially enhance viral replication.

Together, E484Q and L452R are more infectious, and can evade antibodies.

TIME OF MUTATION

It was first reported from Maharashtra. In January, 19 samples from various districts were sequenced, and B.1.617 was found in four. In February, 234 samples were sequenced from 18 districts, and 151 samples — from at least 16 districts — had this variant. And in March, as many as 65 of 94 samples had it.

So far, Amravati, Nagpur, Akola, Wardha, Pune, Thane, Aurangabad, and Chandrapur districts have presented strong evidence of the presence of B.1.617. Fewer samples were sequenced in other districts, and the variant was found in some.

The unlock process of the Lockdown was started after the first wave of Covid graph started to lower a little bit time by time. This time political and religious gatherings were taking place often as well the election of 4 state aseembly were declared without considering the second wave. At this time the virus mutated itself to be super contagious as well fit for the Host body and cause more and severe damage.

CONCLUSION

Mutation is the key character of virus. And wave is a feature of pandemics, the 1918 **Spanish Flu** had three waves. As per predictive studies some scientists say the COVID Pandemic may have more or less seven waves. So the people must maintain physical distancing for their own good and the government should also take proper steps to make the virus spread less.

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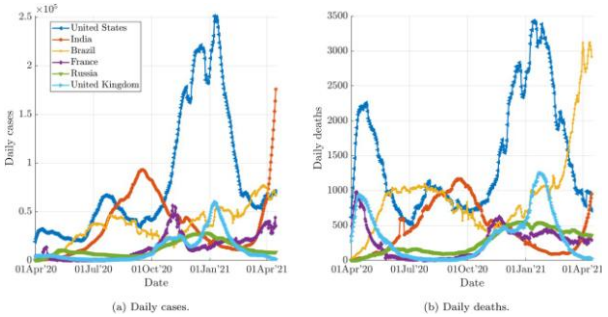
CHARACTERIZATION OF THE SECOND WAVE OF COVID IN INDIA

- by RISHAV KUNDU & SHUBHRAJYOTI DAS

THE BEGINNING

For India, as seen in figures 1(a) and (b), the first and second waves are separated by about 5 months. The peak of the first wave was in September 2020 with the daily cases of around 0.1 million. The daily cases decreased until mid-February after which it exhibited a sharp increase. The end of the first wave was likely a result of a combination of factors – effective implementation of government interventions, increase in awareness, and most importantly, the experience gained by medical professionals in treating the disease over the initial months.

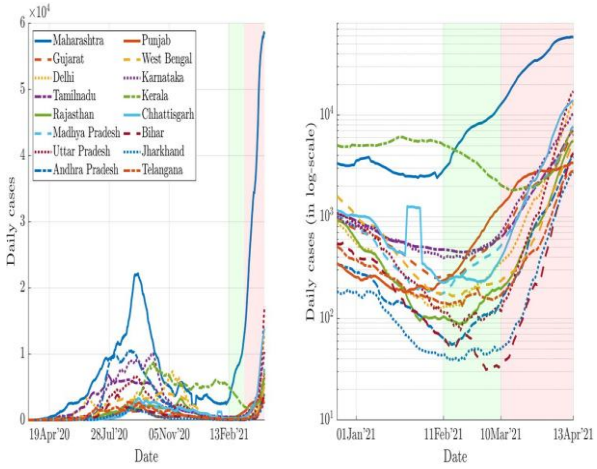
On April 15, 2021, the number of new cases was about 0.2 million which is already more than double of the first peak value. The sudden surge in the number of cases after a relatively long 'cooling' time is baffling although it may be attributed to highly infectious double mutant variant of SARS-CoV-2 (B.1.617 lineage), to negligent behavior of the population, and to the relaxation of interventions (Xu and Li 2020). The number of daily deaths is also rising recently, but the CFR is low compared to the first wave; this aspect will be further discussed later. Note that the study on B.1.617 mutant is limited and there is no clear evidence on whether the mutant virus is less severe than its predecessor. .



(a) Daily cases. (b) Daily deaths.

Fig. 1

THE REGIONAL DISTRIBUTION OF COVID-19

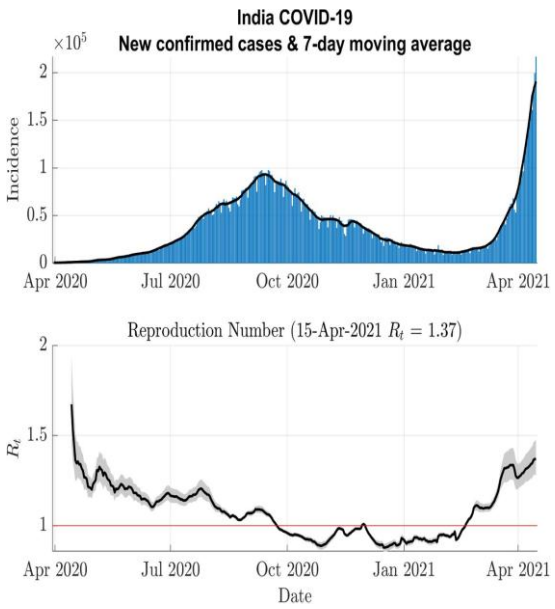


(a) Daily cases. (b) Daily cases (log-scale).

Fig. 2

We also look at the regional distribution of COVID-19 spread to further characterize the second wave. Figure 2(a and b) shows the daily numbers of cases in 16 key states in India in linear and log scales respectively. In figure 2(a), we note that all the states are showing a surge in the number of cases since 13 February, 2021. Further, the slopes of the growth curve are very high in the second wave compared to the first. The daily number of cases in Maharashtra, which also leads in the daily as well as cumulative infections, went from daily cases of 652 on Feb 11, 2021 to about 63,000 in two months (as on April 11, 2021). This exponential growth is also observed in other states (see figure 2(b)), albeit the number of daily cases is fewer than that in Maharashtra. The growth curve in the second wave can be further divided into relatively slow and fast growth phases as shown by green and red shadows of figure 2(a and b). In the first region, until the first week of March, all states except Maharashtra exhibited a slow increase in the number of cases. However, in the second region, most states show a sudden spurt in the number of infections propelling India's total daily count to about 0.2 million.

R_t–EVALUATION



In order to identify the first and second waves, we study the effective Reproduction number (R_t) as a marker for the decrease or surge in infections. R_t provides real-time feedback on the spread of pandemic as the $R_t > 1$ indicates a growth in infection, thus the goal is to implement social interventions to bring down R_t below 1 and close to 0 as much as possible. Figure 3 exhibits the daily confirmed cases of COVID-19 and Rt in India. The effective reproduction number trend is commensurate with the infection rate as shown in the panel below. The Rt value decreased from about 1.37 (95% CI 1.25-1.52) on 17 April 2020 to 1.09 (95% CI 1.07-1.11) on 10 September 2020. R_t went below the self-sustaining threshold of 1 for the first time on 23 Sep 2020 and remained there for the next 5 months, except for a minor flare up on 29 Nov for a couple of days. After this relatively long quiet interval, R_t started rising on 19 February 2021, which is taken as the arrival date for the second wave in India. The Rt has been increasing since then; as on April 15, 2021, R_t has reached approximately 1.37 (95% CI 1.28-1.47).

Region	TPR (%)	CFR (%)	R_t	Vac/100	Remarks
Andhra Pradesh	6.0	0.8	1.52	8.77	
Arunachal Pradesh	4.0	0.3	1.98	10.67	
Assam	2.9	0.5	1.87	4.59	
Bihar	1.2	0.6	2.05	4.36	High R_t, low vaccination rate
Chhattisgarh	7.6	1.1	1.15	15.97	High TPR
Goa	3.4	1.0	1.40	13.64	
Gujarat	2.4	1.4	1.43	14.51	
Haryana	4.9	1.0	1.49	9.69	
Himachal Pradesh	3.4	1.0	1.34	16.30	
Jharkhand	2.4	0.9	1.67	7.03	
Karnataka	4.8	1.2	1.43	9.92	
Kerala	8.5	0.4	1.46	15.11	Low CFR, high vaccination rate
Madhya Pradesh	5.3	1.2	1.53	8.40	
Maharashtra	15.7	1.6	1.16	9.01	Very high TPR
Manipur	5.0	1.3	1.55	4.84	
Meghalaya	3.4	1.0	2.14	4.97	
Mizoram	1.8	0.3	1.87	11.65	
Nagaland	8.9	0.7	0.85	6.05	Only state with $R_t < 1$
Odisha	3.8	0.6	1.86	10.66	
Punjab	4.4	2.7	1.07	6.93	
Rajasthan	5.1	0.8	1.66	12.99	
Sikkim	-	2.1	1.69	22.73	Reliable tests data not available
Tamilnadu	4.6	1.4	1.40	5.41	
Telangana	3.0	0.5	1.59	6.62	
Tripura	5.1	1.2	1.49	21.30	
Uttarakhand	3.6	1.6	1.73	13.36	
Uttar Pradesh	2.0	1.3	1.97	4.44	High R_t, low vaccination rate
West Bengal	6.5	1.7	1.67	8.70	
Delhi	4.8	1.5	1.81	11.9	
Jammu & Kashmir	2.2	1.4	1.41	11.85	

All the states (except Nagaland) in India have R_t > 1 indicating the arrival of the second wave. It appears that mutant viruses are playing some role in the second wave. A more concerning fact is that some of the most-populated states such as Uttar Pradesh and Bihar, which were some of the least impacted states during the first wave, now show very high reproduction numbers. Note that there is a large rural population in these states where the healthcare system is inadequate for such a scale of pandemic. With the spread of the virus in these remote and rural areas, an effective administrative intervention is required to minimize the impact of the pandemic.

FATALITY RATE

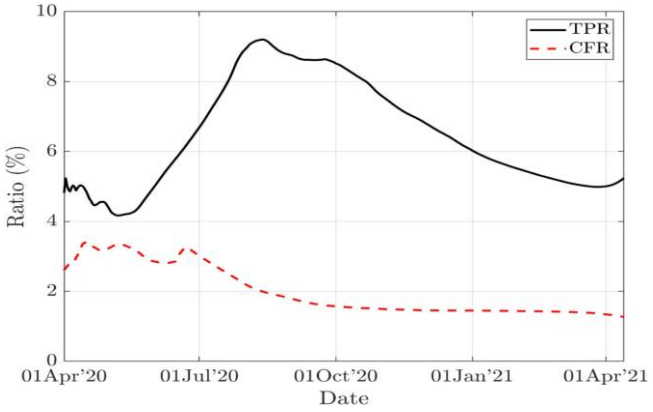
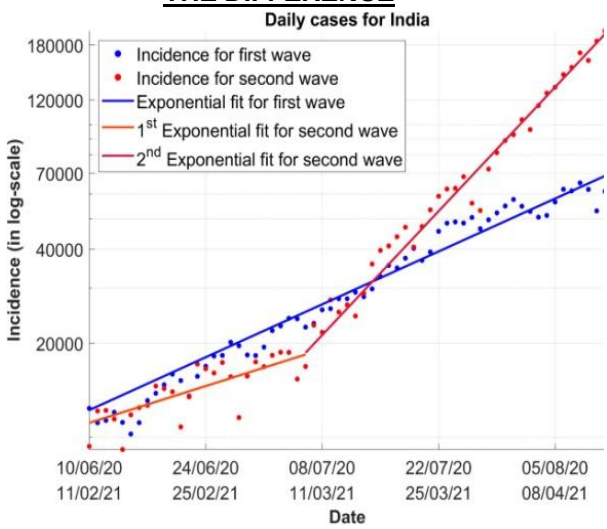


FIG 5: Temporal variations of characterizing parameters- Test positivity rate and Case fatality rate.

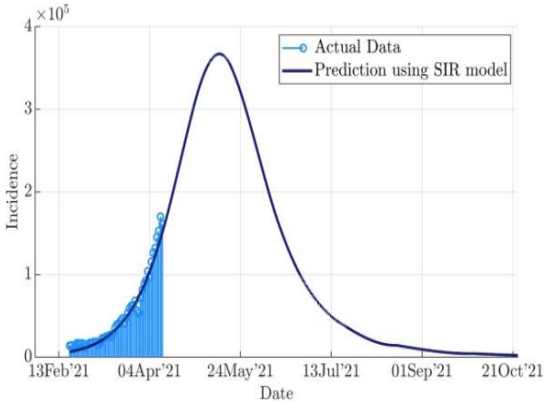
Next, we report the case fatality rate for India in figure 5. The CFR curve shows a downward trend – from 3.5% in mid-April 2020 to 1.2% in mid-April 2021 with minor fluctuations. Interestingly, although the second wave shows the virus to be more infectious, the decline in the CFR curve suggests a silver lining of a relatively less fatal mutant. However, considering an exponential increase of cases at a very high rate, it is expected that soon the healthcare facilities will be fully throttled resulting in the unavailability of hospital

beds and ventilators to those in critical needs. This may result in an increase in CFR. Even otherwise, in terms of absolute numbers, the daily deaths are already at the level of peak values in the first wave (see figure 1(b)). The previous table lists state wise data of CFR, with Punjab having the highest value and Kerala the least among severely-affected states. Finally we describe the vaccination data in states as listed in. Among the most-impacted states with sizeable population, Kerala and Chhattisgarh have highest vaccination per 100 people. Uttar Pradesh and Bihar, which have very high R_t, have the lowest level of vaccination per capita. This further suggests the need for strong lockdown measures in the North Indian states while vaccination capacity is increased simultaneously. However, the exponent of the second fit on more recent data in the second wave is more than twice of the first wave that explains the rapid growth of the pandemic. Fits for both the first wave and rapid second wave are statistically significant with adjusted R_t greater than 0.95.

THE DIFFERENCE



The second COVID-19 wave in India, which began on February 11, 2021, presents a grim situation as the number of cases crossed 0.2 million a day on April 14, 2021. The data suggests that at present the virus is much more infectious than the first wave, but the number of daily deaths per infection is lower. However, with an inordinate increase in the number of cases and over-stretched healthcare system, the daily death count may increase substantially. The effective reproduction number (R_t) is estimated for India, as well as for the Indian states. At present, almost every state show $R_t > 1$ suggesting that the second wave has spread everywhere including the rural areas which were largely untouched during the first wave. This includes populous states like Uttar Pradesh, Bihar, and West Bengal: each has R_t value greater than 1.68. With rural areas impacted, it may be necessary to take aggressive lockdown measures to arrest the further spread while sufficient amount of vaccine becomes available. The SIR model suggests the peak of the epidemic to occur in the middle of May 2021 with approximate daily infections exceeding 0.35 million.



CONCLUSION

In summary, using the available infection data, we analyze the second COVID-19 wave in India. We observe that the epidemic is creating unprecedented havoc in the population which would be soon resolved.

DIFFERENTIAL CHARACTERISTICS BETWEEN COVID-19 1ST AND 2ND WAVE IN INDIA

-by SHATADRU CHAKRABORTY & SAMADRITO CHATTERJEE

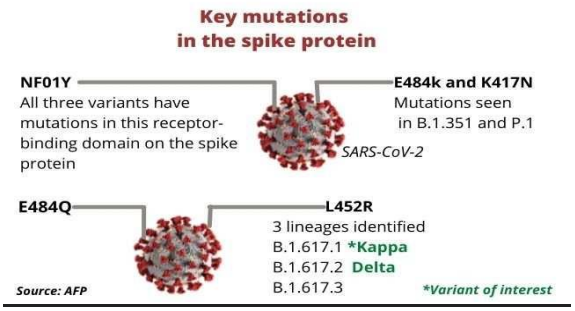
An overview of COVID-19 pandemic in India

The first case of COVID-19 in India was reported on 30 January 2020 in Kerala. The first cases of COVID-19 in were reported in the town of Thrissur, Alappuzha, and Kasargod, all in the three states of Kerala, among three medical students who had returned from Wuhan. The disease transmitted so rapidly that lockdowns were implemented in Kerala on 23 March 2020 and in rest of the country on 25 March 2020. By mid May 2020, Mumbai, Delhi, Ahmedabad, Chennai, and Thane were the cities with half of all the reported cases in country. The active cases were generally increasing, but on 10 June 2020 India's recoveries exceeded active cases for the first time. Infection rates started to drop in September along with new and active cases. Daily cases of COVID-19 in India peaked mid September with over *90,000* cases reported per day, dropping to below *15,000* in January 2021. But unfortunately a second wave of COVID-19 hit India in the beginning of March 2021, which was much larger than the first with high rates of infectivity and mortality. During the devastating second wave, major parts of the country faced shortages of vaccines, hospital beds, oxygen cylinders, and other medicines which multiplied the mortality rate to a great extent as compared to the first wave. Many experts are believing that the current surge of COVID-19 second wave is pushed by homegrown mutant variant of SARS-CoV-2, mainly *B.1.617.2* sub lineage (*delta* variant) and *B.1.617.1* sub lineage (*kappa* variant), identified as Indian variants. By late April India led the world in new and active cases, and on 30 April 2021 India became the first country to report over *40,000* new cases over a 24-hrs period. As of 12 June 2021, India had the 2nd highest number of confirmed cases in the world (after the United States) with *3 crores* reported cases of COVID-19 disease and the third highest of COVID-19 deaths (after United States and Brazil) with *3.91 lakhs* deaths.

How is India's second wave different from the first?

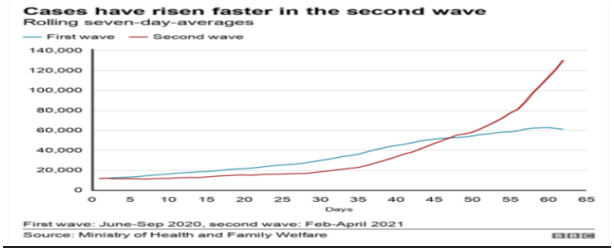
Now let us focus on some of the minute yet differentiating aspects following which we can do a comparative study between the 1st and 2nd wave of COVID-19 surge in India.

"Homegrown" mutant variants: 1st wave vs. 2nd wave



During the first wave of the COVID-19 pandemic in India, local mutations did not play a major contributing role. But many experts believe that the current surge in Covid-19 cases is being pushed by homegrown mutant variants of SARS-CoV-2. Genome sequencing in Maharashtra attributed over 60 per cent of fresh cases to India-grown mutant variants of coronavirus. It is deduced that the *B.1.617* lineage, identified as the "Indian variant" has played a major role in the second wave of COVID-19 infections in India and has spread to many other countries including UK. There is growing evidence that this variant spreads faster than the *B.1.1.7* lineage ***(****kent* variant***)*** from the UK. This *B.1.617* lineage has *B.1.617.1, B.1.617.2,* and *B.1.617.3* sub lineages according to the PANGO nomenclature. The *B.1.617.2* sub lineage, known as *delta* variant, has become the most common variant reported in India, with four main mutations that cause alteration in the amino acid sequence of the viral spike proteins which are *D614G, T478K, L452R,* and *P681R*. Including these mutations 15 mutations are present in the viral genome. The *E484Q* mutation is not present in the viral genome. The *B.1.617.1* sub lineage, known as the *kappa* variant, with three notable mutations in its spike protein code which are *L452R, E484Q,* and *P681R* is also responsible for the COVID-19 infection surge during the second wave in India. Preliminary evidence suggests that the *B.1.617* lineage is more contagious than the previous strains of the virus, and a study found that the *L452R* mutation may enhance the probability of the viruses to affect human cells. Several studies have also suggested that these mutations in the genome of *B.1.617* variants have increased the ability of the virus to evade the immune system. Apart from these "Indian variants", other variants including *B.1.1.7* (from the UK), the *P.1* variant (first detected in Brazil), *B.1.351* variant (evolved in South Africa) have also played a part in the second wave of India.

Rate of transmission of infection: 1st wave vs. 2nd wave



Across India, experts and doctors believe one of the features of second wave that make it different from the first wave is greater infectious ability of the virus. Dr. S.P. Kalantri, professor of Medicine at the Mahatma Gandhi Institute of Medical Sciences, Mumbai said, "*The virus seems to have acquired a greater transferability now*." He added, "*The entire spectrum of age groups- from the pediatric to the geriatric population- everyone is getting affected now*." Dr. Yogesh Jain said, "*The allegation that people are careless is completely nonsense, it is predominantly because the virus has changed its form and it is coming with the advantage of being far more infectious. Every other person now has COVID. This was not the case last year*." Dr. Randeep Guleria, director of the All India Institute of Medical Sciences said, "*During the first wave, a patient could spread the infection to 30% to 40% of their contacts. This time it has been observed that 80% to 90% of people who come in contact with a patient turn positive.*" In Punjab, a new variant of the SARS-CoV-2, which was first detected in the UK, has been found in 81% of the 401 samples put through genome sequencing, indicates the greater infectiousness of the virus. Similarly it is seen that, the *L452R* mutation in the *B.1.617* variant, first detected in Maharashtra, is associated with higher transmission rate. Epidemiologists are saying that, that the reproduction rate that indicates how fast the infection is spreading is higher in the second wave than the first. Bhramar Mukherjee, professor at the University of Michigan, pointed out in an interview with the Deccan Herald that, "*In May 2020' the rate of spread of infection was 1.65, with India reporting 3000 cases daily. But now as several states are reporting the double the no. of cases, the rate has increased to 2*." These studies infer that the rate of transmission of infection is much more in the second wave than the first wave.

Viral load: 1st wave vs. 2nd wave

Viral load refers to the amount of virus in an infected person's blood, expressed as the no. of viral particles in each mL of blood. In case of COVID-19, a higher viral load could impact the transmission rate of the contagion. Reports suggests it has been witnessed that, in the second wave, people testing positive for the SARS-CoV-2 are also showcasing a higher viral load in comparison to the first wave. This further implies that the rate of infection, and perhaps re-infection could be higher too (*as an infected person with a high viral load is more likely to shed more virus particles, in the process known as "viral shedding*") in the second wave than the 1st wave.

Symptoms: 1st wave vs. 2nd wave

During the first wave of COVID-19 spread, symptoms like fever (with or without chills), shortness of breath, cough, headache, body aches, sore throat, a loss of sense of taste or smell, nasal congestion, fatigue, and muscle soreness were observed. In the second wave, most of these symptoms remain the same, but more serious shortness of breath or breathing difficulties (dyspnae) is observed in the affected patients, which is resulting in more severe lung failure than the first wave. Gastrointestinal tract infections (resulting in loss of hunger, vomiting, abdominal pain) and diarrhoea (loose watery stools) are very common in the second wave as mutant virus strongly attaches itself to high loads of *ACE2 (Angiotensin-converting enzyme 2) entry receptors*, present in the digestive system. Other symptoms like hearing loss, extreme lethargy and weakness, unexplained fatigue, dry mouth (not enough saliva), pink eye (conjunctivitis), severe headache, and skin rashes, which were not very common among Covid-19 patients in India in the first wave, are being reported with greater frequencies during the early days of COVID-19 infection in the second wave.

Severity of infection and oxygen requirement: 1st wave vs. 2nd wave

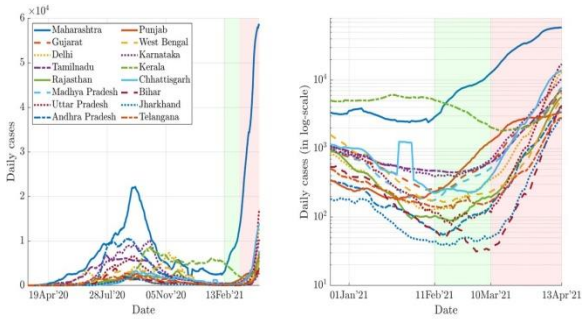
MORE NEED OXYGEN

Infected	1st wave	2nd wave
<30 years	31%	32%
30-40	21%	21%
Seriousness Of Infection		
Shortness of breath	41.7%	47.5%
Needing oxygen	41.1%	54.5%

Reports suggest that in the first wave, most COVID-19 cases were mild, or asymptomatic. But in the second wave, it is reported that the severity of infection has increased considerably, with a large number of symptomatic patients. A lot of experts are suggesting that the mutant strain (*B.1.617*), tracked in Maharashtra, possess high infectious ability, rapidly spreading to the lungs and respiratory pathways, causing severe pneumonia, which is a lethal COVID complication. It is also observed that in the second wave, the infection by the mutant strain is causing a rapid decrease in oxygen saturation (SpO2 levels), which is resulting in fatal lung damage and in some cases, even multiple organ failure. This type of severe pneumonia and decrease in SpO2 levels, which is proving to be lethal for many, was not reported in the first wave. Dr. Sumit Ray of holy Family Hospital, Delhi said, "The inflammatory response is earlier, lung disease is occurring earlier among patients, instead of the second week of the illness as seen during the first wave, it is manifesting in four to five days." He added, "Fever is higher and that's a sign of the inflammatory response, and this seems to be in more no. of people. The oxygen requirement in the second wave is much more than the first, as the infection by the mutant variant is causing rapid decrease in the SpO2 levels of the patients. Dr. Balram Bhargava, ICMR Director General said, "About 41.5% patients required oxygen in the first wave and 54.5% require oxygen in the second wave." This high level increase in the requirement of medical oxygen perhaps can explain why oxygen shortages are being reported in many places. Another proof of the increased severity of infection in the second wave is that many Indian cities are reporting a chronic shortage of hospital beds, as the no. of severe cases of infection

are considerably much higher than the first wave. Disturbing reports of people dying without getting timely treatment are coming from all over the country, which was not the scenario last year. Reports mentioned that during the second wave, 37.3% patients required mechanical ventilation, while in the first wave the no. was 27. 8%. The shortages of medical oxygen and hospital beds can be a result of the high no. of COVID-19 cases in the second wave than the first.

State wise spread of infection: 1st wave vs. 2nd wave



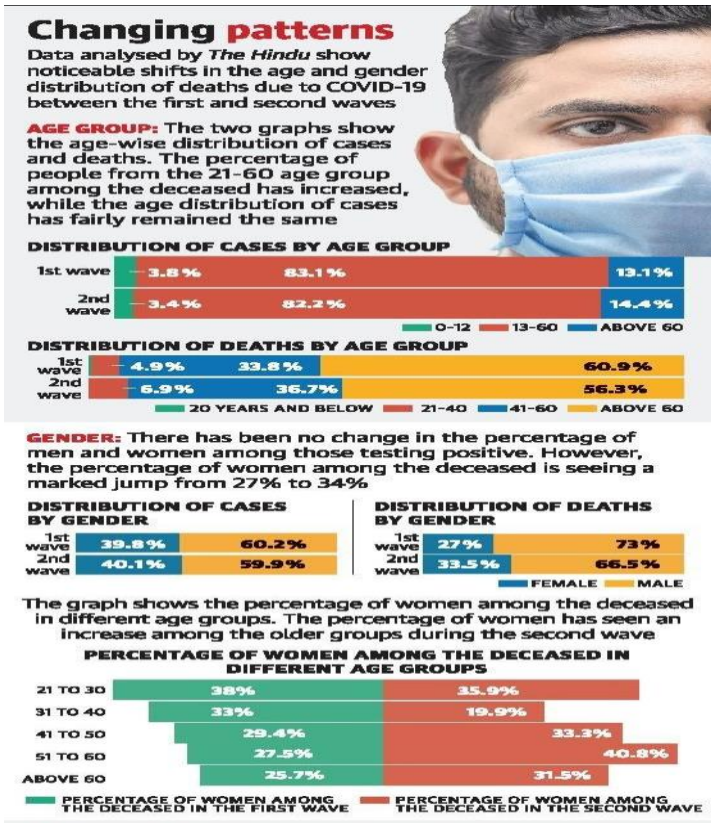
(a) Daily cases. (b) Daily cases (log-scale).

Comparing the reports regarding the geographic spread of COVID-19 infection all over the country, it is seen that the first wave of Covid-19 was more widespread in geographical reach with hotspots spread all over the country than the second wave. Reports say that the second wave is much more infectious and severe but has been limited to fewer hotspots. The analysis of report of **Lancet Covid-19 Commission by India Task Force members (India Today)** points out that the second wave has been more geographically clustered so far than the first wave. It is seen from the reports that the number of districts comprising the top 50% has dropped from over 40 at the time of the first peak to less than 20 currently. Reports say that at the time of surge of first wave of COVID-19 cases in August-September 2020, 60-100 districts reported 75 August-September 2020, Covid-19 pandemic saw 60-100 districts reporting 75 per cent of the cases in India August-September 2020, Covid-19 pandemic saw 60-100 districts reporting 75 per cent of the cases in India% of the active cases in India. It is seen that only 20-40 districts are reporting 75 per cent of all cases in the second wave. According to the data shared by the Union ministry of health and family welfare of India, Maharashtra, Karnataka, Kerala, Tamil Nadu, Uttar Pradesh, Andhra Pradesh, Delhi, West Bengal, Chhattisgarh, and Rajasthan are the top 10 worst affected states, with more than 70% active cases and deaths all over India, in the second wave of COVID-19 infections in the country.

Age and gender wise breakup of cases and deaths: 1st wave vs. 2nd wave

Age group: The higher age profile of people getting infected with COVID-19 in the second wave remains almost unchanged with slight fluctuations, as compared to the first wave. But data by health officials indicates that much more young people and children are getting infected in the second wave as compared to the first. Among all the age profiles of hospitalized patients, a higher requirement of oxygen is observed in the second wave than the first wave. Data from the Centre's Integrated Disease Surveillance Programme (IDSP) showed that in the second wave, around 32% patients (both hospitalized and outside hospitals) were aged less than 30, which was 31% in the first wave. Reports showed that in the second wave, around 5.8% patients hospitalized aged 0-19 years, while in the first wave the percentage was 4.2%. Hospitalized cases within the age profile 20-40 increased to 25% in the second wave, from 23.7% in the first wave. But in both the waves around 70% of the hospitalized patients are aged 40 and above, indicating that older people continue to be more vulnerable to the infection. Reports also shows higher proportions of asymptomatic patients from all age profiles got hospitalized in the second wave with more complaint of breathlessness, as compared to the first wave. In context to the fact that children are getting infected more in the second wave, Dr. Tanu Singhal, pediatrician and infectious disease specialist from Mumbai said, "*Children are definitely more symptomatic now than what we saw in the first wave. The severity of their illness has gone up.*" Reports have shown that in the second wave, among 21-60 age profile, the percentage of deceased has increased from the first wave.

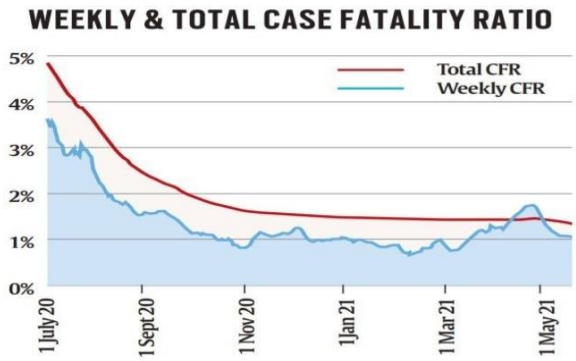
Gender: Though no change is observed between percentage of men and women getting infected, reports indicates that in the second wave the percentage of women among the deceased has increased to 34% from 27% in the first wave.



Case fatality rate (CFR): 1st wave vs. 2nd wave

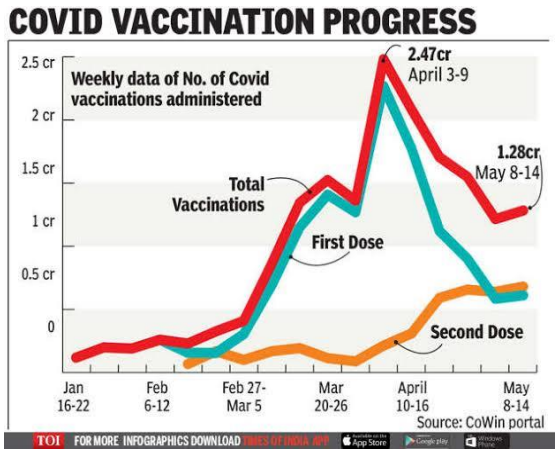
India has the world's third largest death count with 3.91 lakhs death, accounting for 9% of global deaths. The second wave till April 2021 experienced lesser deaths than the first wave of COVID-19 pandemic in India. But the no. of deaths in the second wave doubled in May 2021, when the no. of the deceased went close to 92,000, resulting to be the deadliest month of the second

wave so far. But if we compare the case fatality ratio (CFR) of both the waves, we see that the CFR of the second wave is less than that of the first wave so far. CFR is calculated by measuring the total no. of deaths against the total no. of cases. Though the no. of deaths increased in the month of May, there has been a steady decline in the current CFR (total and weekly both) because the no. of deaths are no longer increasing as quickly as they were in the first wave of the pandemic. Though, the virus is more infectious in the second wave, it is seen that there is a steady decline in the CFR curve as we compare the second wave with the first wave. The CFR decreased to 1% in mid-April 2021 (second wave) from 3.5% in mid-April 2020 (second wave). But in May 2021, the CFR increased to 1.2% from 1% due the increase in no. of deaths. Hence, analyzing various reports it is seen that the absolute number of deaths is higher in the second wave than the first as the total infected has been much higher, but the case fatality ratio (CFR) in the second wave is lower than the first. However, considering an exponential increase in cases at a high rate may result in an increase in CFR.



Vaccination: 2nd wave

India is witnessing a second wave of Covid-19 pandemic when the country is concurrently running a vaccination drive. Till now, vaccines are available only for the 45-plus population. Demands are rising for opening up vaccination for all those who need it. To ramp up the vaccination drive, the government recently modified its vaccine policy to allow foreign developers and manufacturers entry in the Indian market. Earlier, every vaccine got approval only after a trial in India. This provision has been done away with to fast-track vaccine availability to Indians.



Conclusion

Future prospects are difficult to predict. We think that COVID-19 will not disappear in the short or medium term. New variants of the virus may appear, the vaccination process can predictably last all year 2021 or more, until a sufficiently high percentage of the population is protected, and the maintenance of strict lockdowns for very long periods is difficult to bear from the economic, social and psychological points of view. Currently, the whole world is in the middle of the second or perhaps the third wave,. We believe that the most important conclusion of our work is that we must remain vigilant in the constant study of the characteristics of the disease, be able to modify treatments quickly, if necessary, and disseminate our results to the scientific community and society as soon as possible for coordinate and global action.