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Analyzing the Impact of Lockdown in Controlling COVID-19 Spread and Future Prediction

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COVID-19 outbreaks are the critical challenge to the administrative units of all worldwide nations. India is also more concerned about monitoring the virus's spread to control its growth rate by stringent behaviour. The present COVID-19 situation has huge impact in India, and the results of various preventive measures are discussed in this paper. This research presents different trends and patterns of data sources of States that suffered from the second wave of COVID-19 in India until 3rd July 2021. The data sources were collected from the Indian Ministry of Health and Family Welfare. This work reacts particularly to many research activities to discover the lockdown effects to control the virus through traditional methods to recover and safeguard the pandemic. The second wave caused more losses in the economy than the first wave and increased the death rate. To avoid this, various methods were developed to find infected cases during the regulated national lockdown, but the infected cases still harmed unregulated incidents. The COVID-19 forecasts were made on 3rd July 2021, using exponential simulation. This paper deals with the methods to control the second wave giving various analyses reports showing the impact of lockdown effects. This highly helps to safeguard from the spread of the future pandemic.

Keywords: COVID; coronavirus; India; prediction; lockdown impact.

1. Introduction

Since the identification of the novel coronavirus in Wuhan, China, in December 2019, there has been unprecedented spread of the virus resulting in severe crisis in world countries.[1] Coronavirus is described as a viral family by the World Health Organization (WHO), ranging from general cold to coronavirus of the Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS).[2] This virus can spread from animals to humans and among individual wild animals. In combination with other common cold and fever symptoms, these viruses can lead to respiratory signs in people. Till date, no particular therapies have been identified to cure this virus. However, we can protect ourselves from infected people by simply maintaining personal hygiene and social distancing.

On 11th March 2020, the WHO declared Coronavirus Disease 2019 (COVID-19) a pandemic.[3] COVID-19 spread across 210 countries and regions worldwide, with over 2 million confirmed cases in total.[4] In India, the disease was 1st identified in a student who returned from Wuhan on 30th January 2020 to Kerala.[5] The total number of (cumulative) confirmed cases throughout India were 226,770 (up to 5th June 2020). The chart in Fig. 1 shows how COVID-19 cases rise daily in India. There were no further confirmed cases for nearly a month since the first 3 cases were identified between 30th January 2020 and 3rd February 2020. Approximately by 2nd March 2020, the coronavirus cases emerged again. Those infected people were either displaced or from corona affected countries.[6] The average number of COVID-19 cases across Indian states increased exponentially as of 20th March 2020. In India, 3.06 Cr. confirmed cases of COVID-19, with 4.03 Lakhs deaths, and 2.98 Cr. recovered cases occurred till 3rd July 2021.[7]

The spread of COVID-19 in a country can be broadly categorized as follows[8]:

Stage 1: During this time, the country/region has imported immigrants from COVID-19-affected countries.

Stage 2: People belonging to a country/region would not have any travel history; however, they get infected with this disease due to their contact with people in Stage 1.

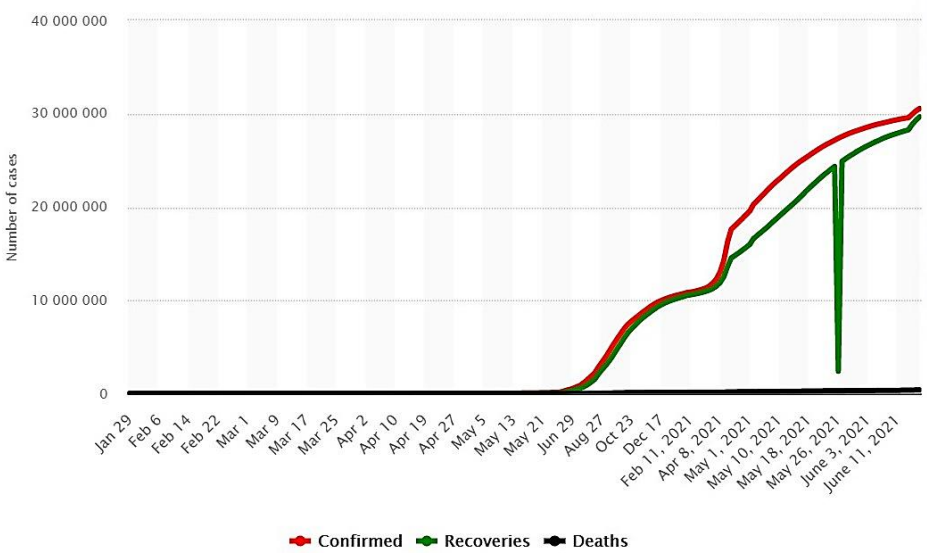


Fig. 1. Analysis of cumulative number of positive, recovered, and death cases toll across India from 29th January 2020 to 3rd July 2021. The linear curese is represented as daily (red), death (black) and recovery cases (green).

Stage 3: In this period, the infection becomes a community spread. A person having no contact with the infected person or someone with a travel history is affected by the virus for the first time.

Stage 4: The virus's spread is virtually unpredictable, and the country may have many major infection groupings.

Many news agencies repeatedly interrogate if India[9] is currently in Stage 3. At the time of this infectious spread, several Indian cities are or will be at different stages. It's problematic to mark a COVID-19 stage at the PAN India level and confuses ordinary people. Some of the state, which is in Stage 3, requires quicker attention than others. On the other side, main cities in Stages 1 and 2 intend to evade community spreading.

Various countries now see India as a world leader, and even the WHO has recognized that India's strategies are being pursued to contain this outbreak.[10] India is the world's 2nd most populated country, accounting for almost $^{1}/_{5}$ of the global population. India contributes to GDP worldwide and has relatively stable economic growth percentages, making it the most developing country globally.[11] India's congenial behaviour makes it an ideal ally with other countries. Therefore, comprehensive analytical studies are needed based on the various strategies adopted by Indian administrators. The analysis of COVID-19 outbursts was carefully monitored in India and also worldwide.

Since 22nd March 2020, all over India was locked for a single day, and a 21 days lockdown was declared after a couple of days. The only thing is to control the spread of disease by maintaining social distancing all over the world. Various administrative bodies have undertaken every single operation in India with permission, and nearly all domestic

and global travel have either been carefully prohibited or supervised. India is currently in the third stage of COVID-19, i.e. the spread of the infection in various countries. The mass migration of people from one city to another (especially from Delhi to nearby states) and the recent holding of a religious event in Delhi led to a substantial increase of cases in various cities of Indian states.[12]

Various traditional methods are available to improve humans' immunity power, such as the consumption of green vegetables, dry and citrus fruits, etc. The primary cause of the disease is cleanliness. People do not maintain hygiene and social distancing nowadays as they did earlier, for example, washing their legs, hands and face, which continuously battled all viruses. The prime minister of India interacted with the people and used unique strategies to engage the nation in various activities. India's present situation due to the impact of the virus need to be studied using data analysis, and various plans have to be devised by Indian administrators and medical experts.

On 22nd March 2020, Indian prime minister Narendra Modi observed a 14 hours voluntary public curfew. Mandatory lockdowns were implemented at corona hotspots, and all significant cities followed it. The prime minister also ordered a 21 days national lockdown on 24th March 2020, causing an impact on India's whole 1.3 billion population. The prime minister extended the nationwide lockdown from 14th April 2020 to 3rd May 2020, followed by a 2 weeks extension with significant relaxation beginning on 3rd May 2020 to 17th May 2020. The government started unlocking the country (barring containment zones) in three unlocking phases at the beginning of April 2020.[13]

Current studies investigate several aspects of COVID-19 lockdown in India and the severely affected areas. The Research Questions (RQ) in this study are as follows[14]:

- **RQ 1:** What is the influence of Covid Lockdown after it is relaxed?
- **SRQ 1:** Does lockdown help minimize the number of deaths and deflate the curve to indicate the number of cases requiring hospitalization to remain below the healthcare system's capacity?
- **SRQ 2:** Does lockdown minimize the number of new cases and turn around the active case line?
- **SRQ 3:** Does lockdown help to control the disease and prevent spread to newer and rural areas?
- **SRQ 4:** Will lockdown help to improve the healthcare system's medical facilities?
- **RQ 2:** Which states are most affected, and how do the lockdown control the virus's spread?
- **RQ 3:** What short-term forecasts are made in a profoundly affected city in the states for the next 3 to 4 weeks regarding the number of infected cases based on the current situation?

1.1. *Effects of second-wave in India*

India was severely hit by the 2nd wave of the COVID-19 pandemic. More than 2 lakh positive cases for 5 successive days have been recorded. The country is grappling due to shortage of medical oxygen, antiviral remdesivir, bed availability in hospitals and

vaccines. The Indian Council of Medical Research (ICMR), one of India's top medical research bodies, has provided data about the corona infected patients hospitalised during the 1st and 2nd wave of the pandemic. It is explicit from the data that the youth population has no severe risk in the present phase and the endless number of death count of patients who died in hospital in the 1st and 2nd waves.[15]

The ICMR has conducted an interim analysis of the huge number of asymptomatic people admitted to hospitals in the 2nd wave, and extensive studies are still in process. According to ICMR, in the second wave of COVID-19, many cases were reported to have suffered from breathlessness, whereas common symptoms like dry cough, headaches, and joint pain were witnessed in the 1st wave. Compared to the 1st wave, the 2nd wave symptoms such as sore throat, loss of smell, fatigue, joint ache, and muscle ache were minor. But more patients were suffering from shortness of breath, causing acute shortage of supplemental oxygen in the country.[16]

- *First Wave*: Of cases were reported with headaches, dry cough and joint pain.
- *Hospitalised Patients*: Patients with shortness of breath were reported to be 41.7%.
- *Second Wave*: This wave caused more cases of breathlessness, leading to greater oxygen requirements.
- *Hospitalised Patients*: Patients with shortness of breath were reported to be 47.5%.

1.2. *Infection in young individuals*

The number of positive cases[17] of people in the age group of 30–45 years is the same as the last year count of 21%.

First Wave: 31% positive cases were reported to be under 30 years

Second Wave: 32% of positive cases were reported to be under 30 years

Average Age: The young age patients infected by COVID-19 are only marginally in high proportion compared to the average age of corona infected patients. People in the age group above or equal to 40 were 70%

First Wave: 50 years was the average age of patients

Second Wave: 49 years was the average age of patients

1.3. *Rate of death*

Comparatively, the 2nd wave of COVID-19 caused less severity in India than the 1st wave, and the death rate is constant.[18]

(a) *The Virus Itself*: *SARS-CoV*-2: The virus has mutated several times in the past years. Many mutations are unidentified, but some are taken seriously.
(b) *First Wave*: The actual form of SARS-CoV-2.
(c) *Second Wave*: In addition to the UK, Brazilian, South African variants, there is a highly transmissible double mutant.[19]

The present study consists of 5 sections. The study context was set out in Sec. 1. Section 2 discusses many literary reviews and analytical methods followed by researchers worldwide. The methodology and research variables are presented in Sec. 3. In Sec. 4, the study results are presented, and the various research questions that have been raised in this chapter are discussed. Section 5 concludes the study and presents its limitations and guidelines.

2. Literature Review

Several studies concentrate on Indian region pattern analysis and forecasting based on the various literature documents. The Indian region studies[20] show short and long-term trends, respectively. The time series from the University of John Hopkins is the data source for these studies and further prediction of Auto-Regressive Integrated Moving Average (ARIMA) model, Exponential Smoothing methods, Susceptible-Exposed-Infectious-Removed (SEIR), and Regression models. Nevertheless, in these studies, network modelling and pattern mining are not attempted. Moreover, too much focus was given on the past Indian studies regarding the analysis of time series based on the cumulative data of the Indian terrain than elsewhere, apart from just taking account of the number of patients infected. Thus, the authorities must analyze the patient's history and information to understand the situation better.

Similarly, in India, mathematical models for the study of COVID-19 outbreaks are developed. A model has been presented in Ref. 21 to study the impact of social distance on patients' age and gender. India, Italy, and China's populations were compared and stated that all nations were among the most susceptible age and gender groups. The study also anticipates the increase in the cases of infections in India with different lockdown times. Besides, it used a network structure approach to determine if individual node clusters were formed. However, the authors only considered travel data nodes to determine that important cities were affected by Indian travellers' returning to their native country. In the study, the Susceptible-Infected-Recovered (SIR) model for identifying transmission of COVID-19 among Indian patients was also presented. Authors of previous times also presented an analysis of the testing laboratories and infrastructure.

Medical doctors and health workers have also presented some studies at the frontline. In India, health workers have less stress than other countries such as Italy, Spain, and the US, since they are in phase two transmission or local transmission. However, Indian health infrastructure was also claimed not to be very strong according to the WHO guidelines, and the distribution of these facilities in the event of a community expansion can be difficult for the Indian Government. Several studies[22] also discuss in detail the nature of the COVID-19.

Besides the Indian model, many other countries' models are also available due to many infected people, especially in China, Italy, and USA. Studies have been carried out in Ref. 23 on different mathematical models in the determination of disease spread, the prediction of the number of patients infected, and analysis of the arrangement done in

each country to encounter the virus spread. Many research studies in the world are yet in the preprint phase and must be examined by pairs.

The studies still need to examine various policies and conduct research activities to address COVID-19 containment in the Indian area. There is less evidence even in preprint databases, which work with more granularities in the Indian region and develop strategies for aiding many agencies in India in decision-making to prevent lockdown and go ahead with future strategies. Thus, this study is carried out to analyze COVID-19 spread in India and its effects on the cities in every state and central levels of the various governmental strategies.[24]

3. Methodology

Specific approaches covering many data sources, data sets, model-making techniques, and result variables have been used to answer different research questions. The time-series data from 30th January 2021 to 3rd July 2021 are covered in the Indian COVID-19 database for the first question of the investigation.[25] The trend analysis at the national level and the average number of infections in the top 4 cities in the States were compared. The second research question was answered using Predictive modelling to estimate the next three weeks of short-term trends on the same data set.

3.1. *Predictive modeling — SEIR model*

Here, we have briefly addressed the properties of the SEIR specific framework used in explaining the recent COVID-19 outbreak in China.[26] For the simulation of infectious disease spread, we considered a simple SEIR epidemic. People are allocated with one of the following conditions; Susceptible (S), Exposed (E), Infected (I), and Recovered (R) for parts that have not yet been affected and free of diseases, persons with incubation times, and confirmations (isolated). Figure 2 of the SEIR explains how people pass into each model compartment.

SEIR model produces prediction accuracy about the infection, how it is increases more in the suspicious person, and the parameters used to calculate the time taken to get infected when exposed to the susceptible person. This model shows how it communicates and produces an impact in the social community. The parameters required to identify the infectious cases are Y, D, μ etc.

Fig. 2. SEIR predictive model with components.

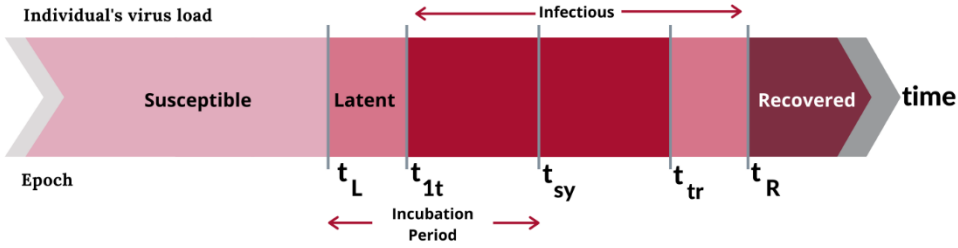


Fig. 3. Progress of virus inside an individual.

a) In this Model, the Parameters are:

1. β controls the spread rate, reflecting a probability of disease transmission between an infected individual and a healthy one. This article has a reproductive number of 2.
2. Incubation is the extent of contamination in latent individuals. It was owing to the known average incubation tim $Y, \mu = \frac{dy}{dx}$. The maximum incubation time is 5.2 days.
3. Recovery rate $\mu = \frac{1}{D}$, calculated by an infection's estimated recovery time *D*.

They enter the deleted process after this time. Infection's average duration is calculated as the average serial time minus the average incubation time. This paper uses the standard serial period of 7.5 days. Here, it is used for 2.3 days with a standard period of infection. Figure 3 shows a diagram of the progressive virus in a human where infectious diseases exist t_L, infected individuals are not infectious during the latent phase, and there are signs and complications. The first transfer to the left is to healthy persons. Following t_R, the removed people (recovered) are no longer considered infectious.

$$\frac{d_S}{d_t} = -\frac{\beta SI}{N} \tag{1}$$

Equation (1) gives the distributional assumptions regarding infectious nodes across the State and the time taken to recover from the disease. Equation (2) gives the approximate rate of derivative counts and time given to identify the recurrence relationship's spreading counts. The number of confirmed cases with the probability of distribution mass function is at Eq. (3).

$$\frac{d_E}{d_t} = \frac{\beta SI}{N} - \sigma E \tag{2}$$

$$\frac{d_I}{d_t} = \sigma E - \gamma I \tag{3}$$

The newly reported cases are identified by differentiating existing and newly infected cases at Eq. (4).

$$\frac{d_R}{d_t} = \gamma I \tag{4}$$

4. Findings and Discussion

The following section will determine the different kinds of data analytics carried out on different data sets.

4.1. *Lockdown*: *Objectives vs improvements*

4.1.1. *Objective* 1: *To minimize the number of deaths occurring, deflate the curve to indicate the numerous cases requiring hospitalization to remain under the health care system's capabilities*[27]

The flattening curve is a public health method to block the spread during the COVID-19 epidemic of the SARS-CoV-2 virus. The pandemic curve, which graphically represents infected patients' information in clinical care processes, has got flattened. The need for national health services increases during the pandemic if the number of infected citizens is more. Flattening the curve means stopping the spreading of the epidemic, thus decreasing the maximum number of people who need care at a time and not exceeding their potential. The flattening of the curve relies on measures such as social distance.

India had a low doubling cycle due to the impending implementation of the lockdown to minimize the doubling rate of virus spread from the original every 5 days to every ~13 days.[26] In comparison, ~50 days after the 500th occurrence, the United States had 10 times as many cases as India.

India has also continued to retain its healthcare system's capacity in almost all major cities in states despite the number of cases. Out of the hospital beds allocated for 130,000 positive cases to the COVID-19 stations, less than 1.5% was used.[44] According to news reports, in Mumbai, exceptionally, all the hospital beds were used by the infected.[43] The number of people who have been infected has been projected to be 100 to 18200% higher, with cases regularly doubling every 3 to 7 days, with a whopping of 169,000 to 190,000.

The lockdown succeeded, and the curve has emerged to a degree where the rate of increase is the measure of the number of cases. Due to the efforts are taken by health care systems, thousands of possible deaths were avoided in exchange.

4.1.2. *Objective* 2: *Reduce the number of new cases and change the active cases*

The absolute number of newly reported cases should be lowered until the lockdown is lifted and the rate of growth in infections reduced, especially when there are high numbers of absolute cases. This measure helps policymakers assess whether the plateau is reached and find the decline in the count of new cases (indicating a negative growth rate).

To date, the number of maximum cases was not yet indicated (Fig. 1). Some smaller cities in states, such as Himachal Pradesh and Uttarakhand, and some major cities in states such as Kerala and Punjab, have reached the following "inverted" U.[28] Similarly, many districts have made tremendous progress here or temporarily recover in Coimbatore, Palghar, and Saharanpur. By 3rd July 2021, the number of regular new cases appeared to have been reduced throughout Andhra Pradesh, Haryana, and Uttar Pradesh.

But most major cities in states are still at their peak when it comes to the number of new cases. All new Maharashtra, Tamil Nadu and West Bengal cases were brought to light daily, despite a national lockdown. The trend is that there have been positive cases emerging and increasing in several States of cities after 3rd July 2021. The rapid rise in the past two weeks in Bihar, Tamil Nadu, Orissa and West Bengal shows that the problem has only begun in these states.

New cases' growth is significant for many districts in the cities like Mumbai, Ahmadabad, Chennai and Pune. Some other areas have reported many new cases, especially in Bihar and Uttar Pradesh, but the absolute numbers are relatively limited. At least 6 of the 36 Districts in Maharashtra was severely affected, while six other districts seem to have been stable.

4.1.3. *Objective* 3: *Disease control, prevent expansion to new and rural areas*

The lockdown has mixed results when the predictor is the number of new regular cases. During its service in some cities and states, most large cities and states did not freeze for 50 days to turn the line around. The absolute number of cases in this time, even with the low growth rate, had increased considerably.[29] The decline rate had prolonged.

There were no cases in 417 districts on 6th April 2021. There were 324 districts with no reported cases on 1st April 2021. That number was reduced to 166 by 1st May 2021. 158 new districts reported cases between 1st April 2021 and 31st May 2021. This includes 29 Uttar Pradesh, 26 Bihar, 20 Madhya Pradesh and 12 Orissa.

Two factors may lead to the late onset of COVID-19 spread. The 1st test might be late, particularly in Uttar Pradesh and Bihar, where only approximately 200 per million people were tested. The 2nd explanation was that migrants moved from the hot spots to rural homes, primarily to Bihar, Madhya Pradesh, Orissa, Uttar Pradesh, and Jharkhand. It means that the hotspots had widespread than previously expected.

The numbers are reasonably high within the new districts, but more migrants will have to be held up with this pattern in the coming weeks. The lack of checks and failure of Central and State administrations to ensure that migrant people can provide good services and transport to their hometowns seems to have contributed to the disease being transmitted to the countryside and declining several green areas. This undermines one of the country's main objectives.

4.1.4. *Objective* 4: *Utilize lockdown to progress the healthcare system's capability*

The health system's attempts to improve its facilities during the lockdown because of controlled spread. If that happens, the medical system could ensure that people do not die because of their inability to access health services when the lockdown is in progress.[6] The lockdown period helps to stop the burden of the medical team and the government to use the time for enhancing the facilities, which would resultantly help release the lockdown. That is similar to Sweden's policy, where the nation remains open, as the number of critical care patients is less than the healthcare system's capacity, and pedagogical treatment is inadequate.[30]

In India, the capacity of existing hospitals has increased. There are currently 970 COVID-19 hospitals throughout Germany, 2,300 clinically mild patient health centres, and 6,45,000 (0.65 million) patients and suspected isolation beds, some of which are converted into hospital beds by the Government.[31] Thirty thousand hospital beds with ICU and oxygen services are available throughout the country for accessibility. Government officials have announced that more than 6,000 respiration devices in COVID-19 hospitals are already available, and 60,000 more respiratory devices have been ordered. Cities such as Mumbai have already constructed additional facilities to meet the anticipated rise in hospitalization.

Figures 4–6 suggest that the magnitude of the infection throughout India is small, with just 1.01% of patients requiring a ventilator, medical oxygen for 3.3%, and 4.08% in

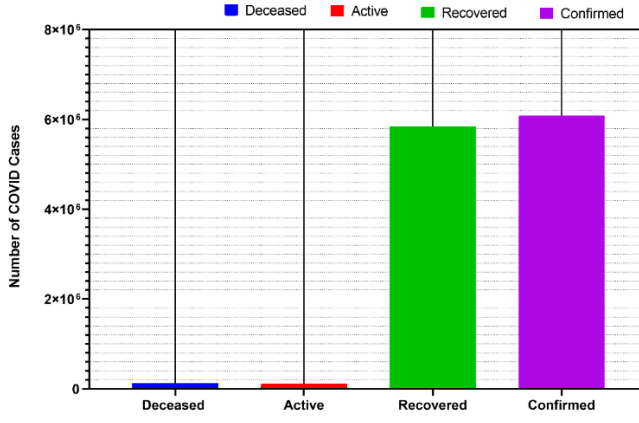


Fig. 4. Number of new cases of COVID-19 according to states in India until 3rd July 2021.[34]

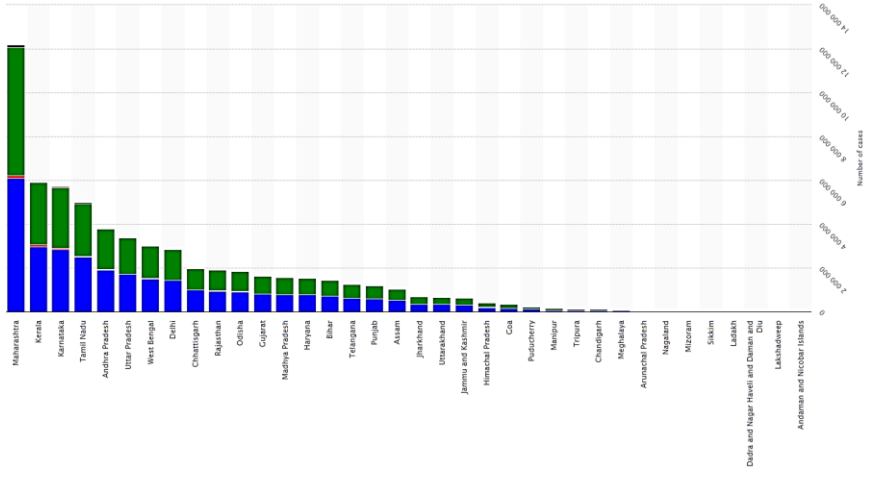
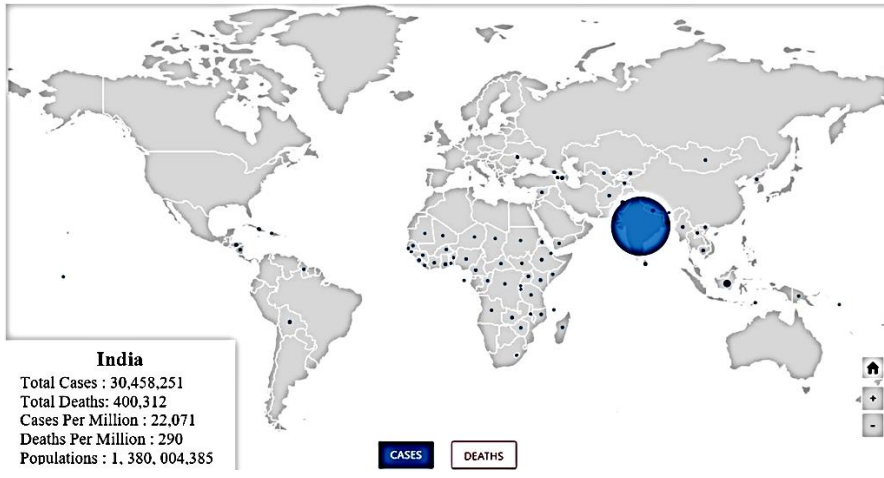


Fig. 5. Daily growth rate for confirmed (blue), active (red), recovered (green) and deceased cases (black).[35]



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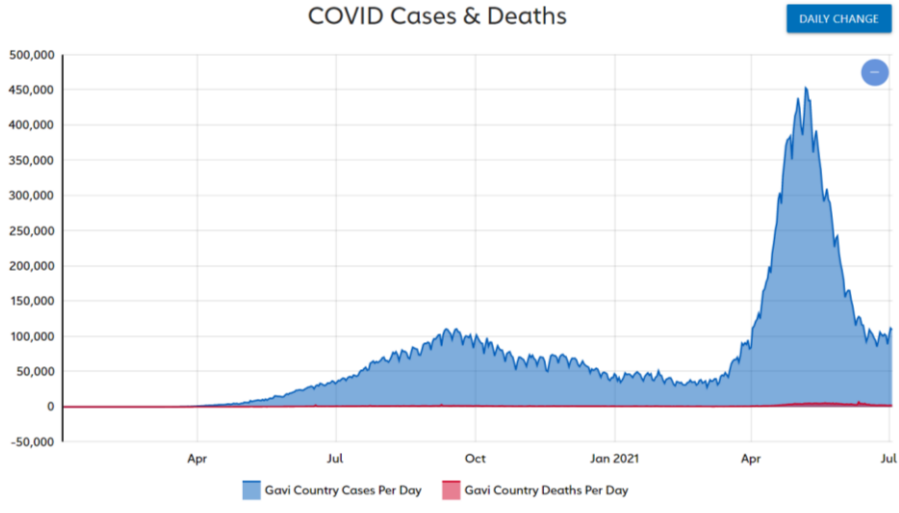
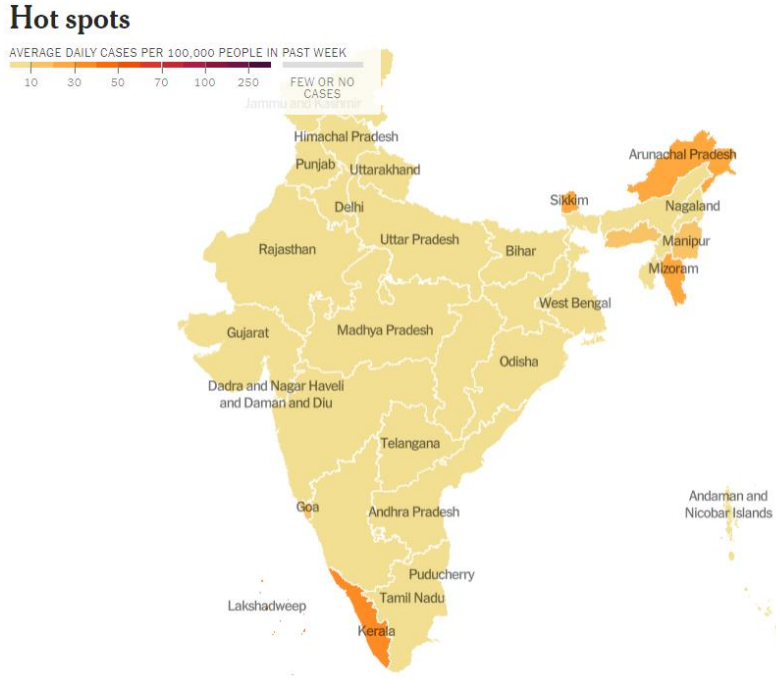


(b)

Fig. 6. (a) and (b) Linear graph of COVID-19 cases and deaths globally till 3rd July 2021.

need of Emergency beds. Raw projections illustrate that India can handle up to 545,500 instances, not including preventable deaths, with a potential of 6,078 ventilators. The nation will accommodate up to 1.5 million cases with a capacity of 130,000 beds (if sufficient oxygen and an ICU are available to patients). Figures 7 and 8 apply because the allocation of cases matches the healthcare system's capacity.[32]

The lockdown was partially used to enhance the capacity, which would be needed when the lockdown was fully lifted. It is also necessary to question how the Government can trust its people when lockdown is lifted and decrease the number of cases.[33]



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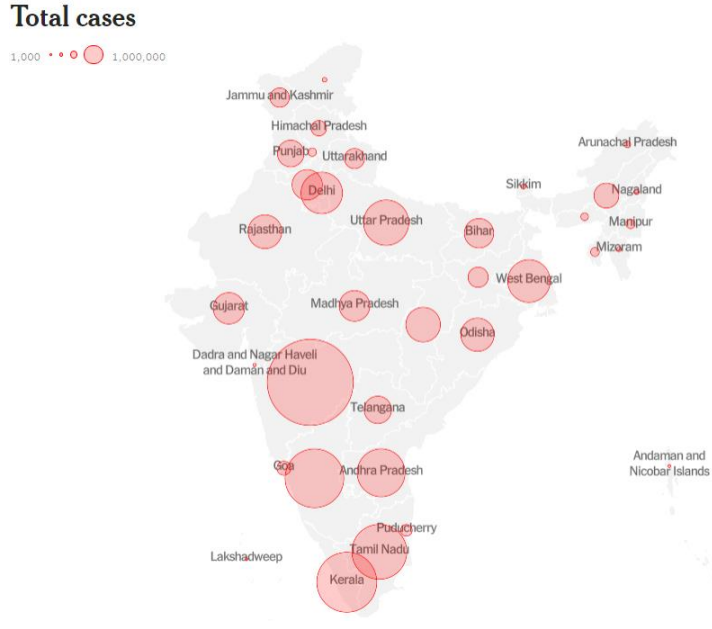
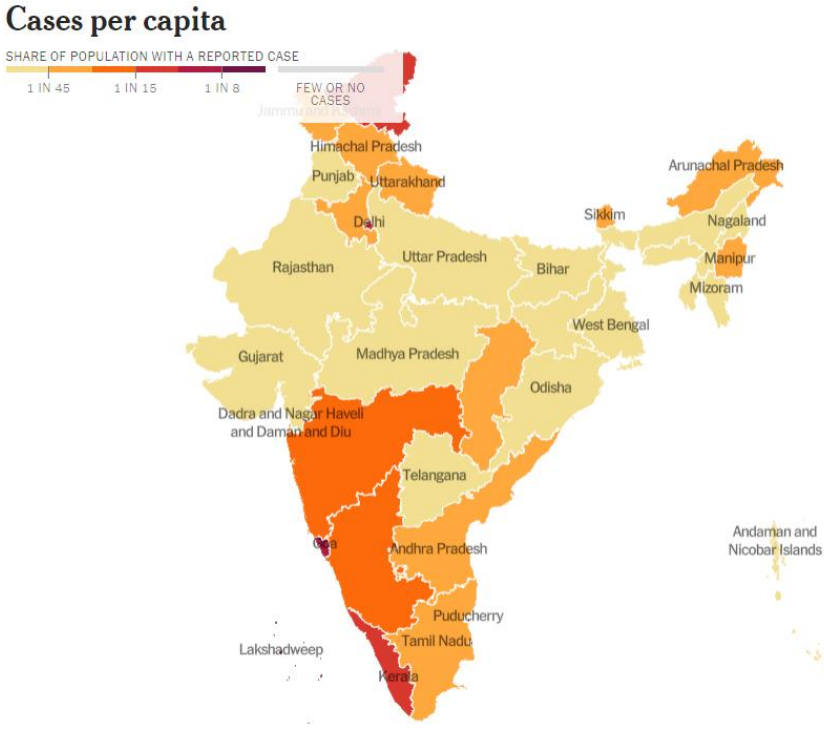


(b)

Fig. 7. Tracking of COVID-19 in India: Latest map and case count, till 3rd July 2021.[36]



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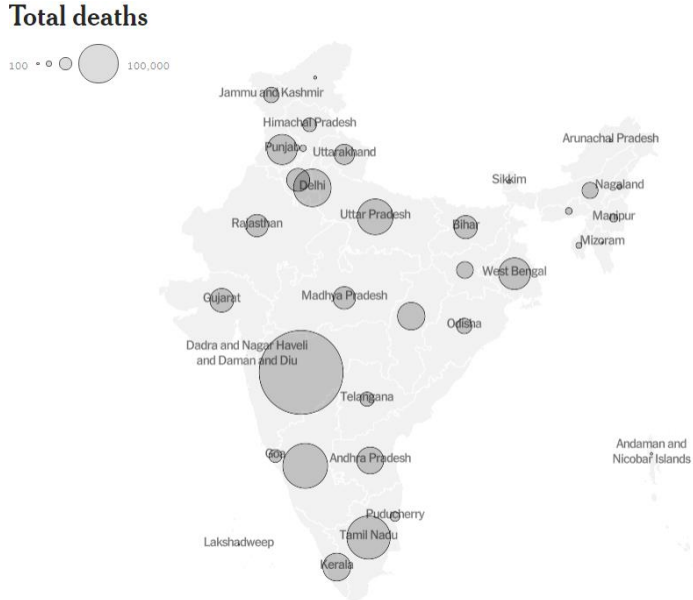

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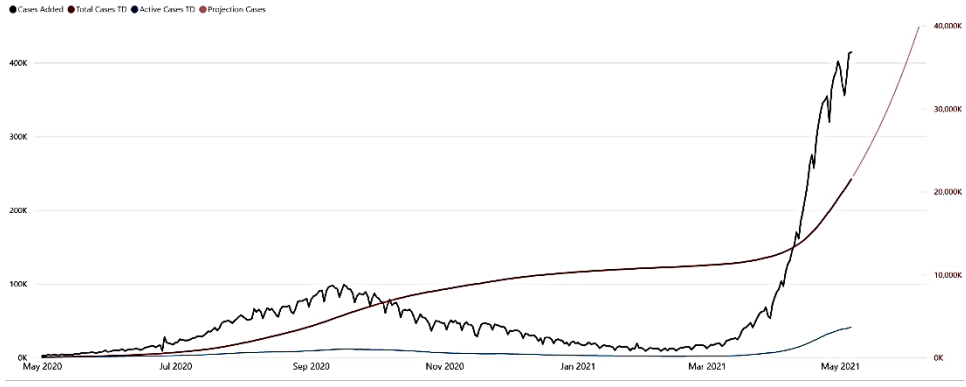
Fig. 7. (*Continued*)



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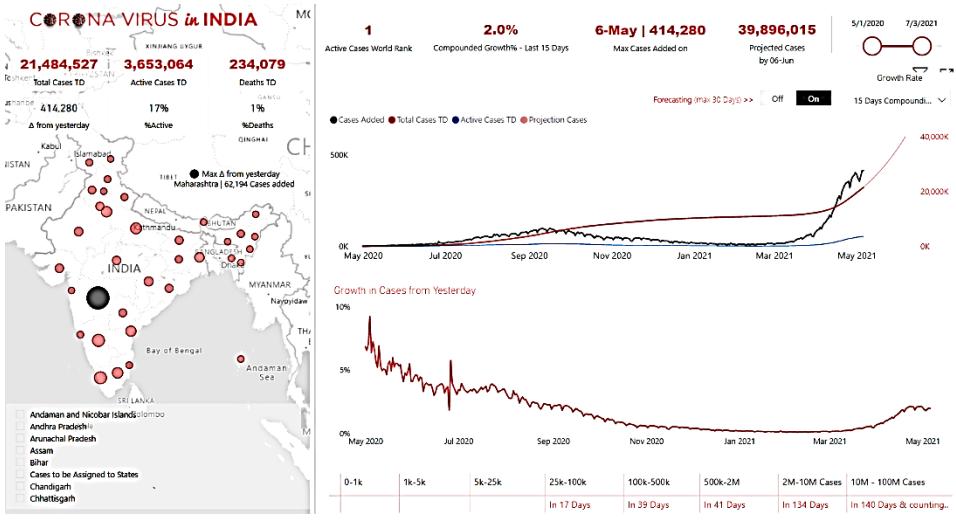


(b)

Fig. 8. Interactive map showing COVID-19 in India with graphs of state-wise tally.[37]

4.2. *State A*: *Maharashtra*

State A has already reported 42,829 confirmed COVID-19 Cases as of 3rd July 2021 as a densely populated state. In the next 30 days, the number of cumulative infected cases could reach approximately 2661 based on the predictive model. In recent days, the Daily Infection-Rate (DIR) has not decreased. The infection rate observed currently ranges from 0.23 to 0 — the preventive measures are already in place, considering 36 as relatively high. The high infection rate could suggest that many community people could be infected with COVID-19 without knowing they already have it. The city could lead to the spreading of COVID-19 in the community (Table 1).[38]

Table 1. Report of major states affected by COVID till 3rd July 2021.[42]

State	Total cases	Total active cases	Total revovered cases	Total deaths cases
Maharashtra	6,051,633	120,282	5,809,548	121,803
Kerala	2,910,508	99,640	2,797,774	13,094
Karnataka	2,840,428	86,012	2,719,480	34,936
Tamil Nadu	2,475,190	39,335	1,403,349	32,506
Overall cases in India	30,361,305	542,956	29,429,857	398,492

On 3rd July 2021, total cases were 6,051,633, active cases were 120,282, recovered cases were 5,809,528, and death cases were 121,803, in State A, with a total of 1.154 positive cases and 8.22% of positive cases. The state's population is 201.78,879 (+20 million), and it falls into the category of 11–37 million states with population, and 696 tests per million were performed on 3rd July 2021. The 2nd highest in this category is Kerala that has announced a free COVID-19 test for media persons in that state. As of 3rd July 2021, a test was conducted in State A for 6,051,633, with 120,282 active cases (Fig. 9).

4.3. *State B: Kerala*

According to the government health department, with 480% COVID-19 cases on 3rd July 2021, State B's count exceeded 20,000 marks to reach 20,097. Besides, there

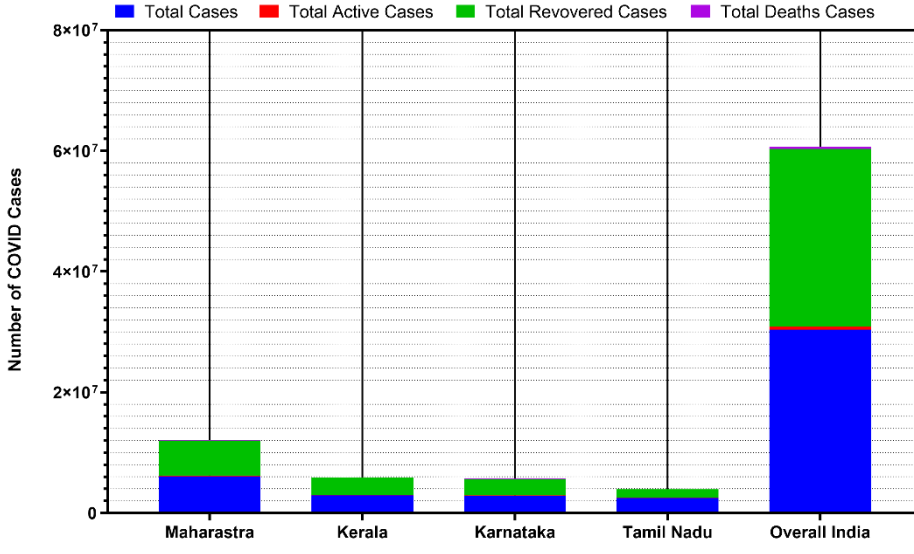


Fig. 9. COVID-19 pandemic in the major states in India (A: Maharashtra; B: Kerala; C: Karnataka ; D: Tamil Nadu).[41]

was an increase of 1,249 deaths in the city of the state, while it was reported that another 30 patients died of the highly infectious disease. A health official said that 21 deaths were recorded in Ahmedabad alone, pushing the death toll to over 1,000 people in the smart city. The term smart city is added because it consists of various electronic and electrical equipment for various processes like washing, cooking (microwave oven), automobiles, etc. So that people are running towards a smart city, and also a smart city contains more population. This overpopulation doesn't support social distancing. Kerala has currently reported 13,094 COVID-19 deaths, and 2,910,508 patients were tested positive. At the same time, 2,797,774 COVID-19 infected patients got recovered from hospitals until 3rd July 2021. There are currently 99,640 active cases with 69 patients in ventilator support (Fig. 9).[39]

4.4. *State C*: *Karnataka*

The 1st COVID-19 case was testified on 7th March 2020 in State C. By 18th June 2020, 50,193 cases, including 576 deaths and 27,674 recoveries, were confirmed by Family Welfare.[40] In India, after State D, State C has the 2nd maximum confirmed cases. The pandemic affected all 37 districts, with the highest cases in the capital city. Over half of the confirmed cases are from the state district of Karnataka. The rate of death in the state is one of the lowest in the country. According to the department of health, 91.29% of patients have been asymptomatic, while 84% had co-morbidity. In June 2021, the state witnessed an increase in deaths, with the number of deaths occurring between 11th June 2020 and 3rd July 2021 (34.18% of the state deaths recorded).

The state government responded to the outbreak with a contact tracing, testing, and surveillance pattern. ICMR has approved 79 laboratories capable of carrying out testing. The state carried out 621,171 tests on 3rd July 2021 (Fig. 9). Since 25th March 2020, the state was locked down and was relaxed from 4th May 2021. The lockdown was extended with further relaxation until 1st June 2021. In 4 districts, including the state capital, the state-enforced stricter lockdowns between 1st June 2021 and 30th June 2021 and denied any previously granted relaxation.

4.5. *State D*: *Tamil Nadu*

On 9th March 2020, the 1st case of the COVID-19 pandemic in State D was confirmed. State D represents almost $^1/_3$ of India's total cases and about 40% of all deaths. As of 3rd July 2021, the state's fatality rate was 3.6%, lower than the world average but significantly higher than many other Indian states. With more than 2,475,190 cases, Mumbai is the worst affected city in India (Fig. 9).

4.6. *Short term predictions for infected cases*

We have used evidence for our research in our latest study until 31st May 2020. We evaluated the time series training data before implementing the prediction model to

ensure it matched the results. The effect of reported cases in the $\log_{10}$ base relative to the final 15 days of training data is seen in Fig. 6. This is attributed to the substantial rise in reported cases, as shown in Fig. 4 in the usage of the last 15 days of training results.[43]

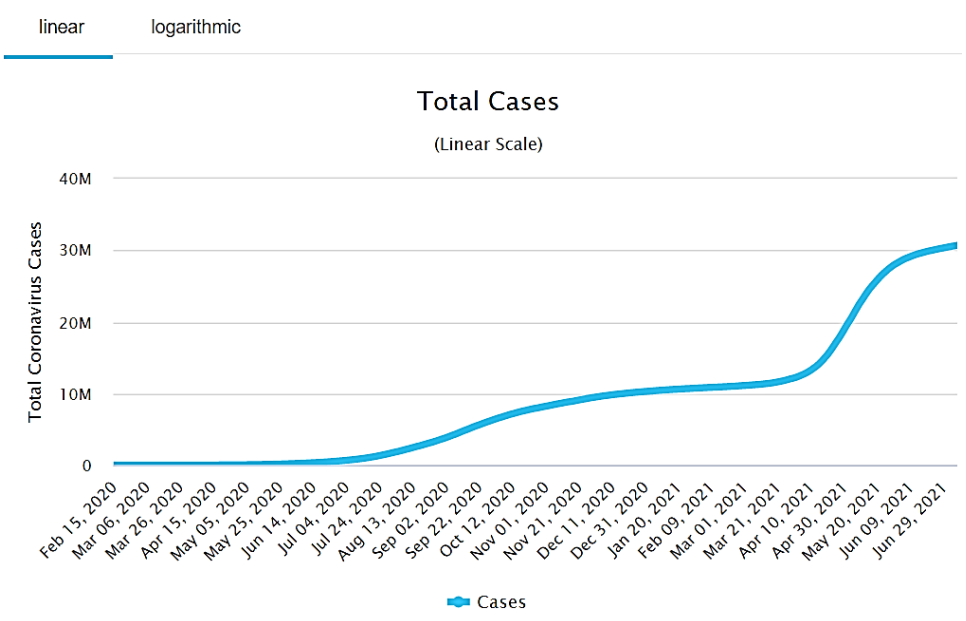
Then, we conditioned the SEIR model, and Fig. 7 demonstrates the product of the deployment line. During the SEIR protocol, we took charge of several interventions, such as quarantine and lockdown, which were declared during India's time. For our model, which is a half decay, we used hill decay, and its formula is provided for Eq. (5), where L defines the decline rate, T is time, and k is a (no dimensions) parameter. Half of the decay function never reaches '0', and at the moment, L has half of its initial usage.

$$h(x) = \frac{1}{\left(1 + \left\lfloor \frac{T}{L} \right\rfloor^{k}\right)} \tag{5}$$

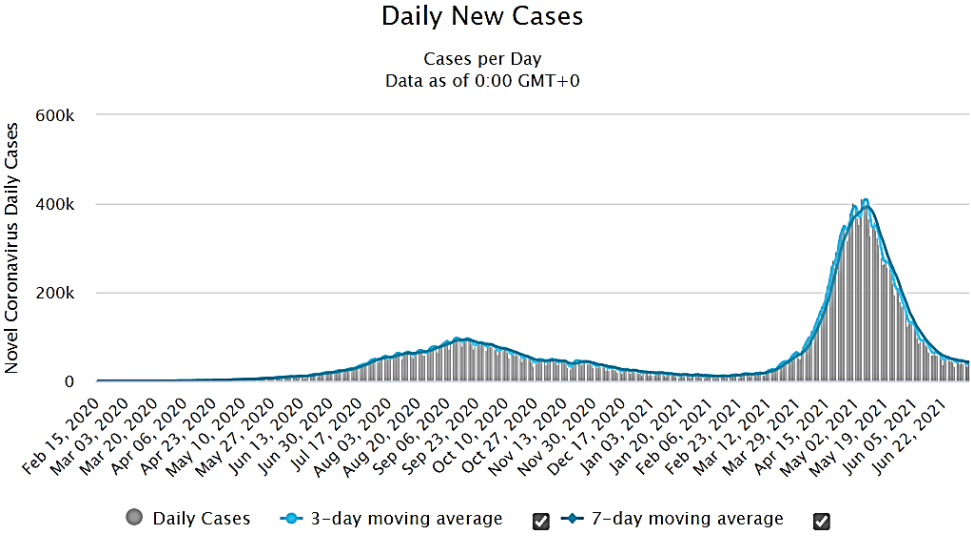
For India, beta values equal to 0.6206 and gamma values equivalent to 0.5106 were determined from training results. We have measured the disease propagation magnitude of R_0 equal to 2.02. As we know that COVID-19 is infectious, the transmission rate is 2.02, and we must estimate the degree to which the disease will spread. The prediction findings are indicated in Table 1 for the two models. We used 25 days of training data in both models because no major trend occurred in India until March 2020. The Root Mean Squared Logarithmic Error (RMSLE) and RMSLE values were used in the regression model of 1,52 and 1,75 to validate the models' efficiency in this analysis. The RMSLE error rate was estimated at 2.01 between the SEIR and the regression models.[44]

The next three weeks for infected cases in India were projected using an infinite method. Considering the historical evidence showing the doubling rate, Fig. 13 shows the count of prediction cases in India. Different degree values were identified in the polynomial regression line based on exponential modelling growth based on India's number of positive cases (Figs. 10(a)–10(h)). A total of five degrees between 2 to 6 were checked, and all cases were monitored for Root Mean Error (RME). The lowest RME for the Grade 4 model was reported as 237.58. It was then established and used for the predictive model of degree 4 polynomial regression. Data from 1st April 2021 to 3rd July 2021 were considered for the training set for 61 days. Fewer cases in India were reported before 3rd July 2021, which affected the prediction models. Additional training and tests were also taken into account with similar predictions. With those predicted values, India's values for infected cases can rise around 30,663,665, which might not be a unique situation in India.[45]

Although there is a 17–21-day slowdown between infection and deaths, daily deaths is the primary determinant of pandemic progression.

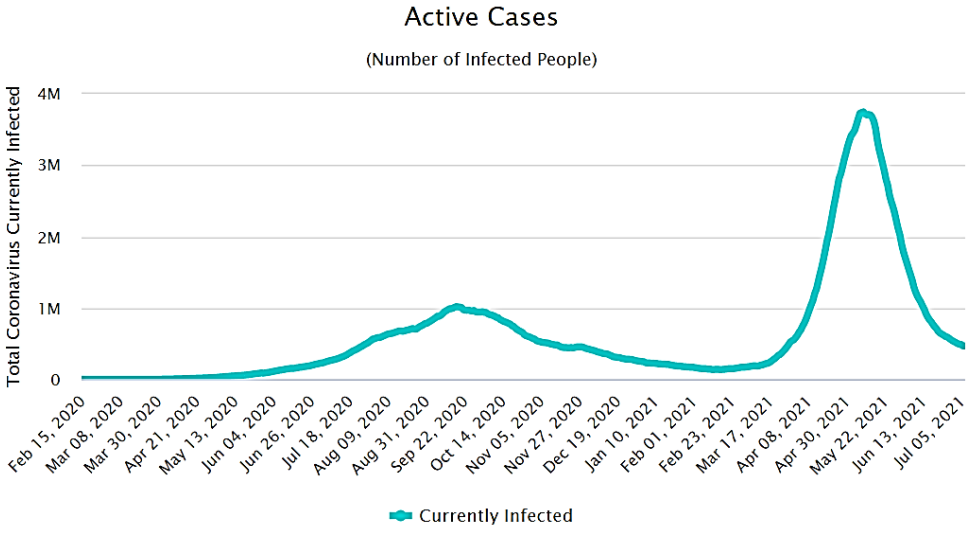


(a) Total COVID-19 cases in India.

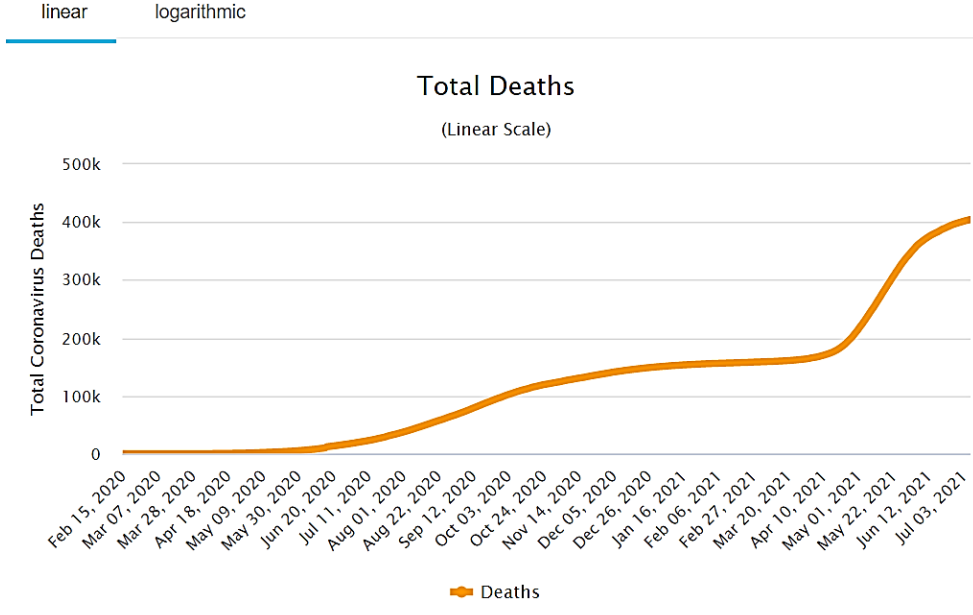


(b) Daily new cases in India.

Fig. 10. (a)–(h) India recorded 30,663,665 COVID-19 cases since the epidemic began, according to the WHO. In addition, India reported 404,240 COVID-19 deaths and 29,799,534 recovered cases.[46]

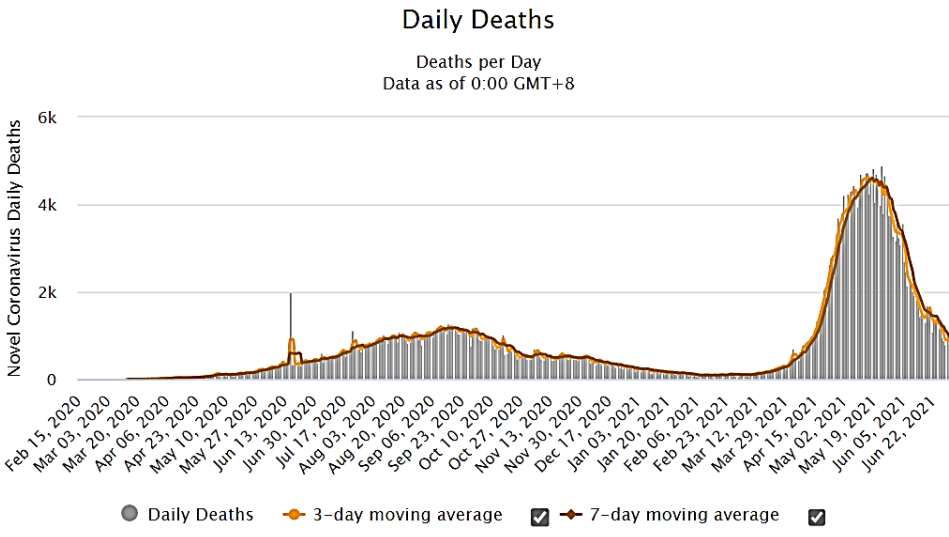


(c) Active cases in India.

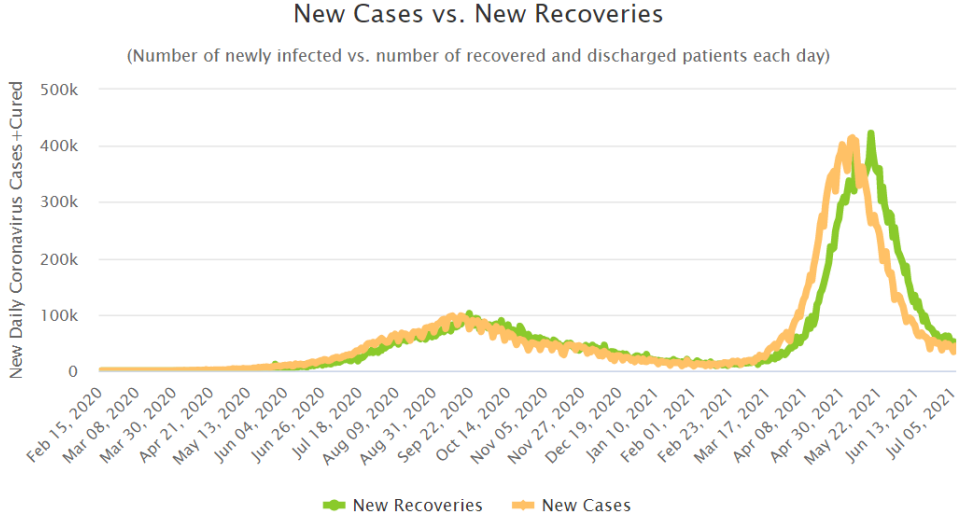


(d) Death cases in India.

Fig. 10. (*Continued*)

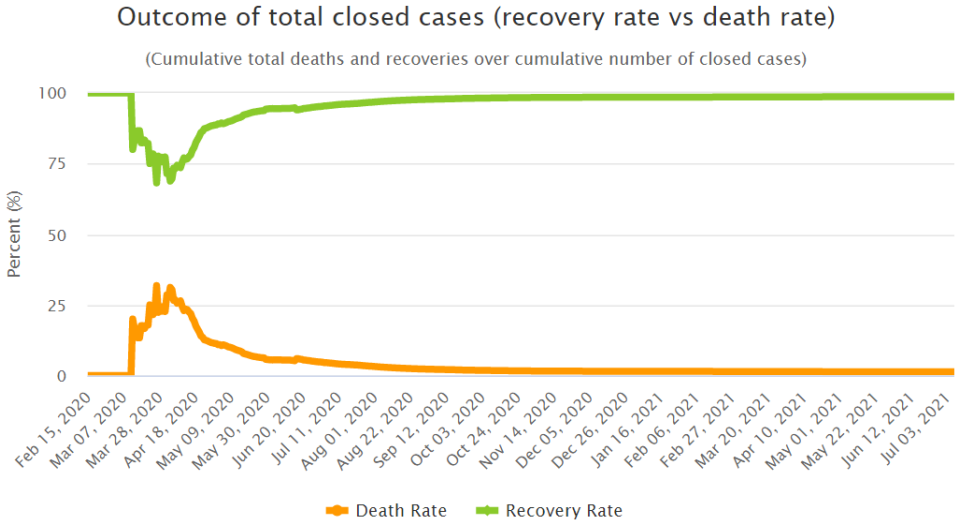


(e) Daily new deaths in India.

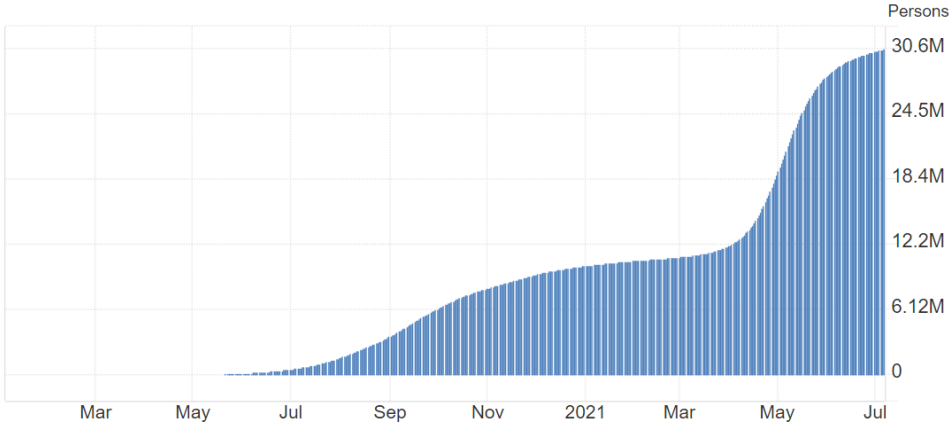


(f) Newly infected vs recovered in India.

Fig. 10. (*Continued*)



(g) Outcome of cases (recovery or death) in India.

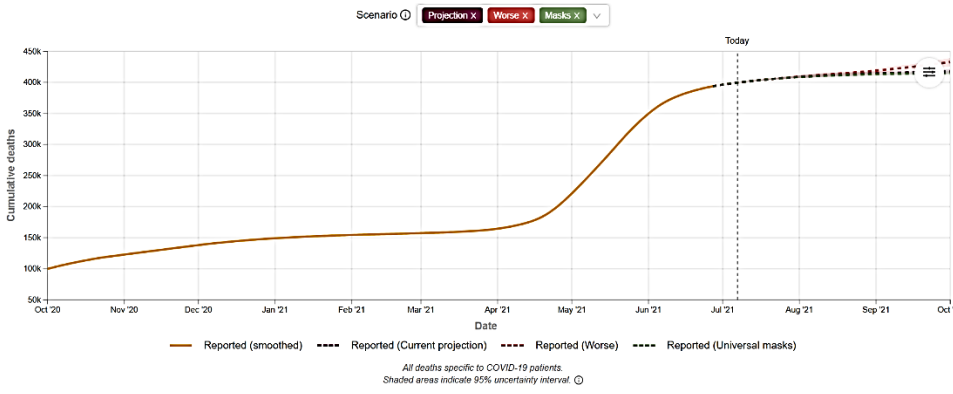


(h) Statewide COVID-19 till July 2021.

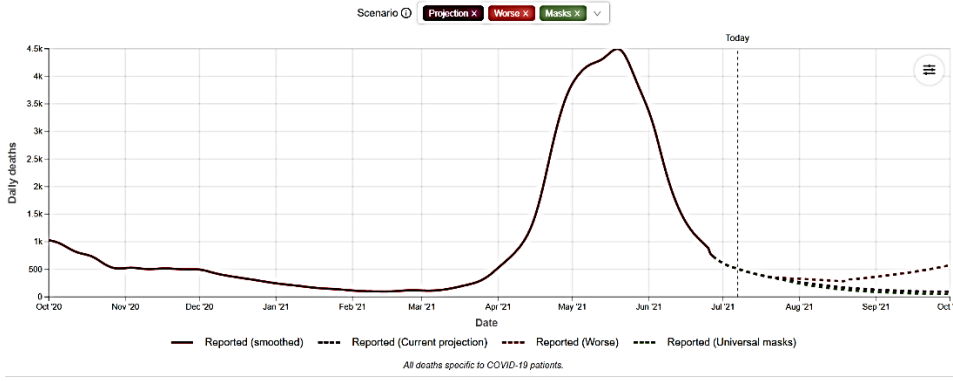
Fig. 10. (*Continued*)

Hospital resource use confirms how well a clinic is equipped to treat COVID-19 patients in the current prediction case. For summaries of each measurement, select all/ ICU beds.

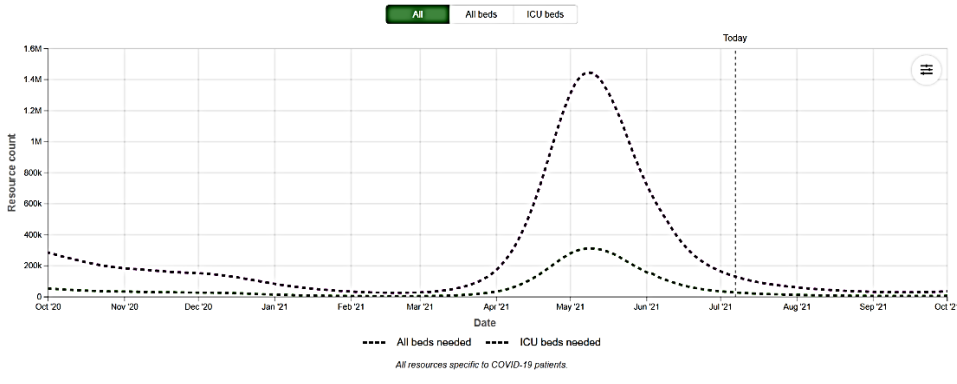
Approximately infectious diseases are the percentage of people we believe have been exposed to the virus with COVID-19 regularly, including those who have not been tested.



(a) Cumulative deaths.

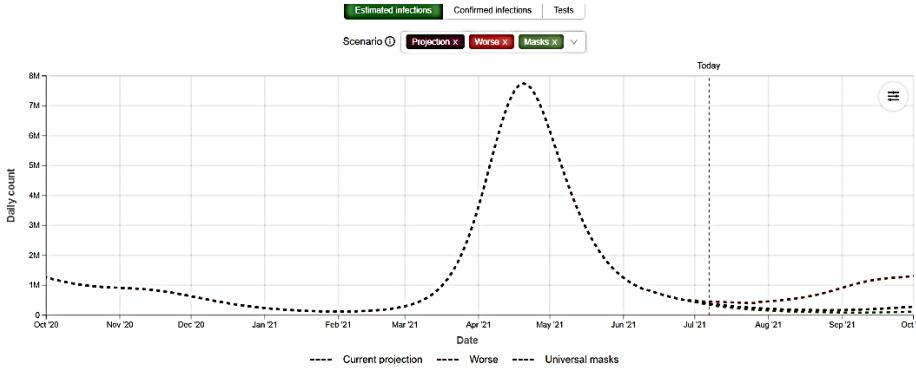


(b) Daily deaths.

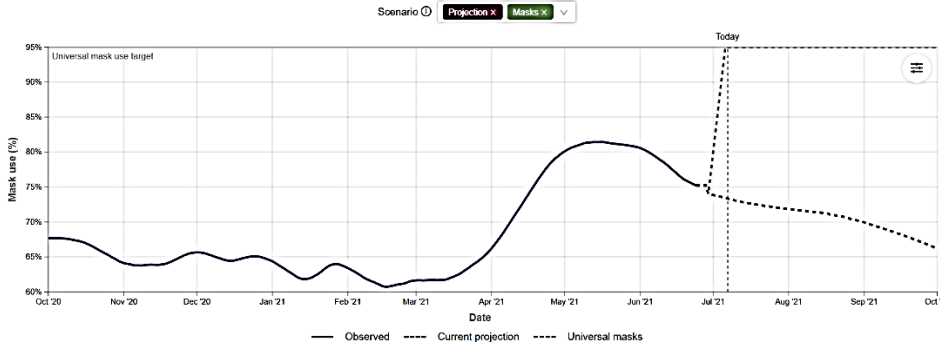


(c) Hospital resource use.

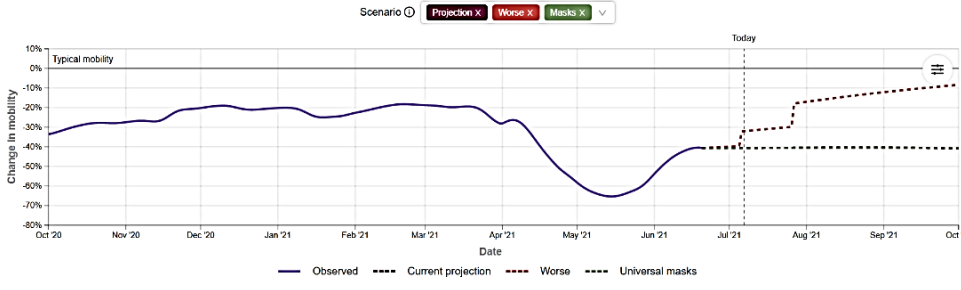
Fig. 11. (a–f) The number of positive cases in India by exponential modelling predicted for the next 90 days (from 1st July 2021).[44]



(d) Daily infections and testing.



(e) Mask use.



(f) Social distancing.

Fig. 11. (*Continued*)

Mask use is the number of people who say they always wear a mask in public. The use of a mask can significantly decrease transmission by 30% or more.

Decreasing social contact (as tested by mobile phone mobility data) can reduce infectious diseases and allow mask use, testing, separation, and contact tracing to work together to contain the virus.

5. Conclusion and Future Work

This research provided a detailed examination of COVID-19 situations in Indian cities. These cases develop very rapidly, and the Indian administrative unit requires effective management measures. This study covers different aspects and provides a detailed answer to the efficiency of lockdown in the 2nd wave. There have been numerous methodological approaches and tests associated with minimal literature studies. The work is valuable for the Indian government and other Asian governments, the Asian management units, the Indian health department, scientists, and research scholars. In most Indian districts, the nationwide 50 days lockdown controlled the development of the virus. It could not stop or reverse the trend, however. But the old metropolitan trend stretches now to a larger area. India also has a lockdown impact that does not rely on the fact of the world. The lack of health care infrastructure, unhealthy and congested conditions of poor people's lives in city areas and lack of city migrant workers' facilities made it more difficult for the epidemic to be monitored, managed, and tracked. The influence of inadequate preparation and execution is evident, and in the coming weeks, it will be more.

Training results before 3rd July 2021 have been taken from the news India report. Moreover, because of the pattern, the number of cases will undoubtedly increase. The safety of physicians, health professionals, and others involved in delivering vital services must be following the specified professional standards. The number of cases will exponentially be increasing in the future because individuals and organizations are negligent. The high point still exists, and so the government must be particularly cautious and impose stringent measures.

Moreover, healthcare services in the country must be vigorously improved. This study also promotes considering different facets of COVID-19 management in their respective regions by administrative units of other countries. In the future, we plan to design a model to predict the spread of the disease using various models of machine learning throughout India. This will help take precautionary measures to control the virus spread and spot the location where it spreads more.

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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