PREDICTION OF NUMBER OF CASES AND DEATHS DUE TO THE SECOND WAVE OF COVID-19 USING ARIMA MODEL FOR MAY 11-JUNE 30, 2021: A STUDY ON INDIA AND ITS MAJOR STATES

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ABSTRACT

Background: *The devastating spread of the novel coronavirus, named COVID-19, starting its journey from Wuhan Province of China on January 21st, 2020, has now further threatened lives of almost all the countries of the world in different magnitudes with its second, and somewhere third waves. Mostly the developed countries have been hit hard, besides the emerging countries like China, India and Brazil. The Indian major states are now highly affected by its second wave starting from Maharashtra and Kerala in early February 2021. The government of India as well as the state governments are struggling to arrest the situation.* ***Objectives:*** *The study aims to predict the number of cases in India and its severely impacted states like Maharashtra, Kerala, Karnataka, Tamil Nadu, Gujarat, Andhra Pradesh, Uttar Pradesh, West Bengal, Rajasthan and Delhi for the period May 11-June 30, 2021 and compares the predicted values with the actual values to judge its depth of severity and growth. Method: The study uses Box-Jenkins method of forecasting in an Autoregressive Integrated Moving Average (ARIMA) structure on the basis of the daily data published by the Government of India from February 1st to May 10th, 2021. Results: It is derived that India and its ten highly affected states will be facing the gloomy scenario in the number of cases and deaths in the coming 51 days. Tamil Nadu is an exception with regard to the number of deaths as its predicted deaths will be declining. India will reach around 3.87 crore of number of cases and 4.9 lacs of death on June 30. Maharashtra will be the leader in the*

group keeping all the remaining states well behind in both the number of cases and
deaths. Mass scale vaccination is recommended to save the people of country from
the ill effects of the virus.

INTRODUCTION

COVID 19 in its second- round outbreak has affected a list of countries from both the developed and developing countries with a greater severity due to, as the scientists claimed, its several times mutations. The countries such as England, United States, Brazil, Spain, France, South Africa etc. were badly hit in the early phase of the second round. Mostly the mutated forms such as Britain strain and African strain were responsible for this severity in its attack. But, since the last couple of months, India has been the worst hit country in the world. According to Rao (2020, September), in the National Herald, has mentioned that India has been the new epicenter of global pandemic. The effects of Britain strain and a deadly variant, Indian strain, have been identified as the central cause of the new spread in the sub-continent. The Lancet (2021, May) very recently opined in its editorial that there will be about one million death by 1st August, 2021. Several causes have been identified by the report for this massive death rates, out of which policy failure on the part of the government regarding vaccination and capacity buildings have been in the priority list. But it is not observable from the report the method through which the estimation is made. Further, having an average span of three to five months of the impact in the second round, the estimated figure for August may be too late. In addition to that, the report could not throw lights upon the consequent impacts across the major/highly affected states in India in terms of both the number of cases and number of deaths.

The present study under this backdrop aims to proceed for twin objectives. Objective 1 aims to predict the total number of incidences/cases and number of deaths for the period May 11, 2021 to June 30, 2021 for India as a whole and its ten highly affected states, Maharashtra, Karnataka, Kerala, Andhra Pradesh, Tamil Nadu, Gujarat, Uttar Pradesh, Rajasthan, West Bengal and Delhi. And Objective 2 tries to test whether the predicted average values are greater than the actual values for the number of cases and deaths for the same set of units to justify whether the country and its states are recovering from the pandemic.

Existing Literature

There have been a lot of studies in the existing literature that deal with the effect of different viruses and bacteria upon the people of Asia and Africa which show that the people of these regions are with high immunity base due to high magnitudes of hunger and poverty levels and hence they are least affected by bacteria and virus

like COVID 19 (Raja, 2008; Hoch, 2010; Barreiro, 2016; Curtis et al, 2020). But it is now proved wrong in case of COVID 19 and its different strains.

There have been some studies done in the recent past that made predictions of COVID spread and death rates for different countries and regions of the world. Das (2020) had made forecasting of incidences for the countries such as USA, UK, Italy, Spain, France, China and India for the period July 12-Septembert 11, 2020 and estimated that USA and India would face respectively 80 lakhs and 41 lakhs number of cases. The actual results were near the estimated results. Hernandez-Matamoros et al (2020) did the forecasting of COVID 19 for specific geographical areas, specific countries, or create a global model and showed that there was a relation between the virus spread and the different variables present in the countries, which belong to the same geographic region. Bayyurt and Bayyurt (2020) aimed to compose of forecasting model to predict the spread of COVID-19 in Italy, Spain and Turkey in an ARIMA structure and the results showed, while number of cases in Italy and Spain was expected to decrease as of July, in Turkey was expected to decline as of September. Further, the number of deaths in Italy and Spain was expected to be the lowest in July and highest for Turkey in July. In a recent study, Malki et al (2021) developed a predictive model to estimate the expected period that the virus could be stopped and the risk of the second rebound of COVID-19 pandemic using a SARIMA model on several selected countries and showed the expected COVID-19 infections for the top countries of the highest number of confirmed cases would be manifested between December-2020 and April-2021. Further, the study forecast that there might be a second rebound of the pandemic in a year time if the currently taken precautions were eased. There are a few more studies in the list that could be added. But no study except the report of The Lancet (2021) has focused upon the new epicentre, India, and its states, to predict the number of cases and deaths in the coming two months around. The present study aims to accept the venture and makes predictions of number of cases and deaths for India and its ten major states in terms of spread for the period May 11-June 30, 2021 and to compare the mean values of the predicted with that of the actual to judge whether the situation is improving.

Data

The data on number of cases and deaths for India are obtained from the WHO database and for the states they are from India Government Database (www.mygov.in) for the date 01.02.2021 to 10.05.2021. There are ten highly affected states considered for the study which are Maharashtra, Karnataka, Kerala, Andhra Pradesh, Tamil Nadu, Gujarat, Uttar Pradesh, Rajasthan, West Bengal and Delhi. These states constitute around 75% of the total number of COVID cases in all India level for the selected period of the study.

Methodology for Objective 1

There are several methods of forecasting of a variable available in the literature of natural as well as social sciences. The present study uses the Box-Jenkins (1976) method of forecasting in an Autoregressive Moving Average (ARMA) framework which is a widely used method in forecasting variables in economic science. The period of prediction is taken to be 11.05.2021-30.06.2021, a 51-foreword time point.

Box-Jenkins's (B-J) method is a linear structure model which traces all the past values of the variables and their stochastic components to predict the values for all the future periods. Before to proceed for forecasting we need to have the idea on'how a time series data of a particular variable is generated'. There are three such processes behind the unit of a time series data-

1. **AR (autoregressive) Process:** Here, the past values of the variable and error term lead to the generation of the data.

2. **MA (moving average) Process:** Here, only the errors or the disturbance term generate the data, no values of the variable under concern is taken into consideration.

3. **ARMA (autoregressive and moving average) Process:** Here the data is generated by the combination of AR and MA processes which is both the past values of the variable and the error term.

Any time series of a variable has its own order of integration, that is, how many differences are to be taken to convert the series into the stationary series. For example, if the series is differenced once then it is called integrated of order one or I(1). Hence, the ARMA model is modified to ARIMA model where 'I' stands for the order of Integration of the series or how many differencing is done for making the time series of the variable to be stationary.

An AR (p) process is one where the current or present period's value of a variable 'x' depends on only the past values plus an error term. If there are 'p' order in the process i.e. current value of 'x' depends on the 'p' order of past (e.g. t-1, t-2, etc.) values and an error term of the current period then the AR(p) can be written as-

$$x_t = \mu + \varphi_1 x_{t-1} + \varphi_2 x_{t-2} + \varphi_3 x_{t-3} + \varphi_4 x_{t-4} + \ldots\ldots.. + \varphi_p x_{t-p} + u_t = \mu + \Sigma\, \varphi_i x_{t-i} + u_t \quad \ldots (1)$$

where u_t is the white noise (WN) error term having zero mean, constant variance and zero auto-covariance features.

On the other hand, an MA(q) process, is the linear combination of all the q terms of the past values of the white noise terms depending on time. It is a white noise process in which the current value of 'x_t' depends on the current value of the WN error term and all past values of the error terms. Because all the errors are WN, the

combination of all plus and minus values of the errors hover around the value zero, so, an MA process is necessarily a stationary process.

Therefore, an MA (q) process can be written as-

$$x_t = u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \theta_3 u_{t-3} + \theta_4 u_{t-4} + \ldots\ldots + \theta_q u_{t-q} = u_t + \Sigma\ \theta_i u_{t-i} \ \ldots\ldots (2)$$

An AR process becomes stationary if the characteristic root lies outside the unit circle or having the values greater than unity. If it is so then then φ becomes less than 1. This means the condition φ<1 leads to the values lying inside the unit circle representing stationarity of the AR process, the model is thus having stability property. The AR coefficients should then be less than unity or they should lie within the unit circle.

An ARIMA (p, q) process is the combination of AR and MA process, I being the order of integration which can be represented by 'd', number of differencing to convert the series from non-stationary to stationary. The model for ARMA (p, d, q) can then be written as-

$$x_t = \mu + \varphi_1 x_{t-1} + \varphi_2 x_{t-2} + \varphi_3 x_{t-3} + \varphi_4 x_{t-4} + \ldots\ldots + \varphi_p x_{t-p} + u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \theta_3 u_{t-3} + \theta_4 u_{t-4} + \ldots\ldots + \theta_q u_{t-q}$$

Using the Lag operator, we have

$$\left(1 - \varphi_1 L - \varphi_2 L^2 - \varphi_3 L^3 - \varphi_4 L^4 - \ldots - \varphi_p L^p\right) x_t = \mu + \left(1 + \theta_1 L + \theta_2 L^2 + \theta_3 L^3 + \theta_4 L^4 + \ldots + \theta_q L^q\right) u_t$$

$$Or,\ \varphi\left(L\right) x_t = \mu + \theta\left(L\right) u_t \ \ldots\ldots\ldots (3)$$

This relation (3) stands for invertibility between the AR and MA process which means AR and MA processes can be made invertible from one to the other.

Unit Roots Test of Stationarity-the Augmented Dickey-Fuller (ADF) Test

For a data set ($x_{i,t}$, i = 1, 2, …., n and t= 1, 2, ..., T), where t denotestime,let us consider the following linear regressionset up for unit root test for two versions of theADF(p)(1979) regression–viz.,

$$\Delta x_{i,t} = \alpha + \beta_i x_{i,t-1} + \sum_{j=1}^{p} \gamma_{i,j} \Delta x_{i,t-j} + u_{i,t}$$

$$\ldots\ldots\ldots\ldots\ldots (4)$$

for thewithout time trend case and

$$\Delta x_{i,t} = \alpha + \delta_i t + \beta_i x_{i,t-1} + \sum_{j=1}^{p} \gamma_{i,j} \Delta x_{i,t-j} + u_{i,t}$$

$$\ldots\ldots\ldots\ldots\ldots..(5)$$

for thewith time trend case.

If $\beta_i = 1$ is rejected by the ADF test statistic then we say that the series for the i^{th}identity is stationary. If this property holds for the series for 'x' then we can run regression without the chances of getting spurious results.

Forecasting in ARIMA Model: Box-Jenkins Method

The B-J model experiences several sub-models and it is thus requiredto determine which model is appropriate. It is thus an iterative process. The entire procedure follows four-steps:

Step 1: Identification: Here the appropriate values of p, d,and q are determined.

➢ The main tools in this search are thecorrelogram and partial correlogram where the values of autocorrelation coefficients (ACF) and partial autocorrelation coefficients (PACF) are generated. A steady declining trend of ACF indicates non stationary nature of the series. The appropriate values of ACF and PACF at different lags having spikes are considered as the possible combinations of the orders of AR and MA respectively. For example, if ACF has a spike at lag 3 and after that it dies out then the order of AR is 3, or the model becomes AR(3). Again, if PACF has the spike at lag 4 after that it dies out then it is called MA(4). Further, if the series is I(2) then the appropriate ARIMA will be of order (3,2,4). There can be more than one such spikes in both the cases and so we need to select the appropriate one by means of diagnostic checking.

Step 2: Estimation: Herethe parameters of the chosen model on AR and MA and a constant term are estimated using the ordinary least square (OLS) technique.

Step 3: Diagnostic Checking: In this step it is proceeded to check if the residuals from the fitted models are white noise. It is based on the statistical significance of the estimated values of AR and MA terms (following Step 2), the values of adjusted R square (which should be maximum), and lowest possible values of the information criterion such as Akaike Information Criteria (AIC) and Swartz Information Criteria (SIC).

➢ If they satisfy all the above, then we accept the chosen model; if not, we start afresh.That is why the BJ methodology is an iterative process.

Step 4: Forecasting: The ultimate test of a successful ARIMA model lies in its forecasting performance, within the sample period as well as outside the sample period. On the basis of the acceptable results obtained from Step 1 to 3, forecasting is made on the appropriate model of ARIMA. The forecasting results are accepted on the basis of the acceptable values of root mean square error (RMSE), bias proportion, variance proportions and covariance proportions. The acceptable forecasted values will be those whose RMSE will be minimum possible and

covariance proportions will be greater than the values of bias proportions and variance proportions.

Methodology for Objective 2

The test statistics for examining whether there are significant increases or decreases in the numbers of cases and deaths of the predicted values vis-à-vis the corresponding actual values in India and across its states is the student t statistics.

The formula for t statistics for the mean difference is-

$$t = (\mu_p - \mu_a)/\sqrt{(S_p^2/n_p + S_a^2/n_a)}$$

with degrees of freedom (n_p+n_a-2).

where 'μ' stands for mean value for predicted (p) and actual (a). S^2 represents variance of the predicted and actual values.

Computation of Results, Analysis and Discussion

Before going for the computations of the predicted values of the number of cases and deaths we present graphically the actual numbers of the two indicators for the period 01.02.2021 to 10.05.2021 for India and the ten major states. Figure 1 to Figure 4 present the data.

Figure 1 and Figure 2 respectively present the actual as well as predicted number of cases and deaths respectively for India. The data for the predicted values in both the figures are marked in the figures. It is observed that both the total number of affected persons and death are increasing during the actual period, 01.02.2021 to 10.05.2021 but the trends took steep rising shape from the mid of April 2021. Starting with 1.076 crore in 01.02.2021 the number of total cases in India reached 2.29 crore in 05.10.2021, a jump of 113% during the 99 days duration.

**Figure 1.Total Number of Actual and Forecast Cases in India**
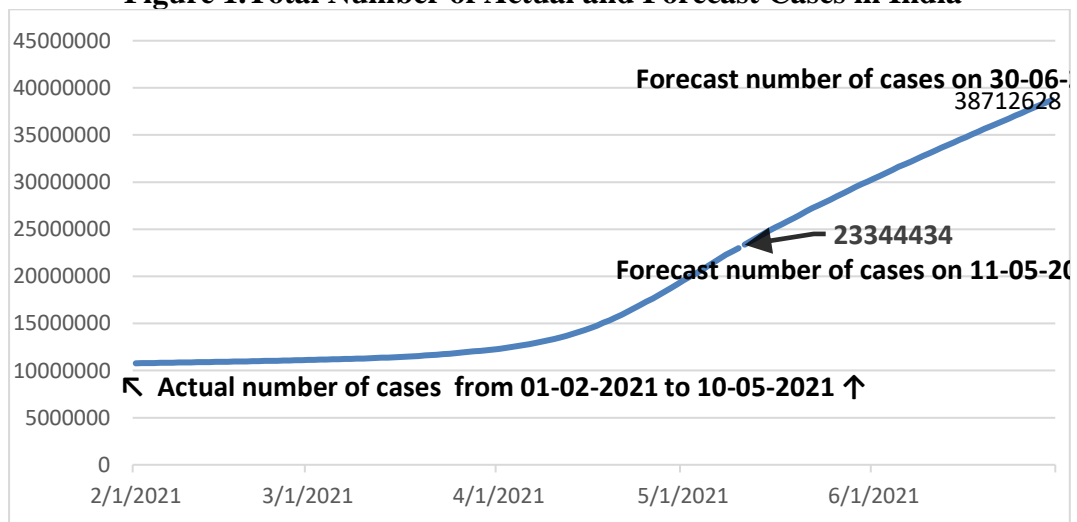
Source: Drawn by the author

On the other hand, total number of deaths in India (Figure 2) starts with 1.54 lacs in 01.02.2021 and reaches 2.46 lacs in 10.05.2021, a jump of 59 % for this 99-day phase. Although the rate of increase in number of deaths is less than that of the number of cases, the figure of 2.46 lacs is not a matter of joke so far as the human capital value of this dead population is concerned.

**Figure 2.Total Number of Actual and Forecast Deaths in India**
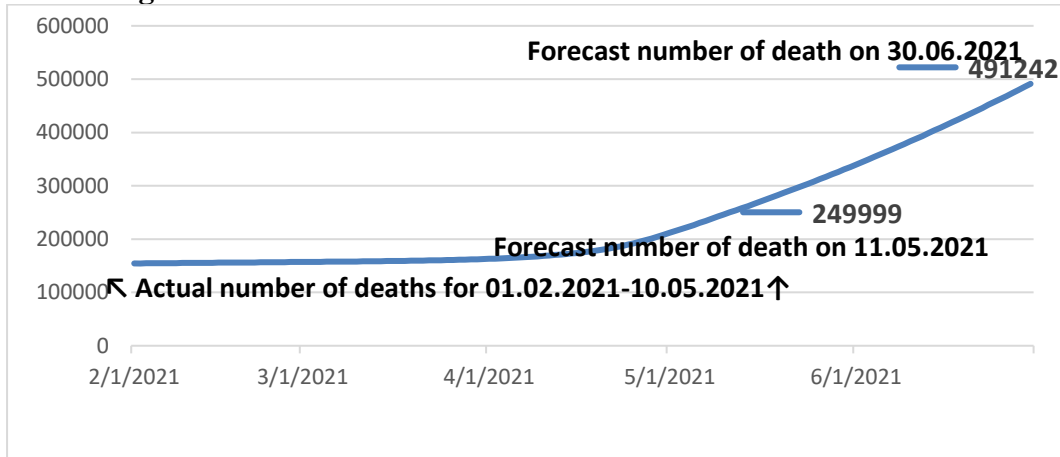
Source: Drawn by the author

Now come to the actual scenario of number of cases and number of deaths for the selected ten highly affected states in India. Figure 3 presents the data for number of incidences for the states. The total number of affected people has been increasing over the time for all the states. Unlike that of India, the severity in the increase starts from the late March for only Maharashtra, Delhi and Gujarat, but for rest of the states, the severity starts from the mid of April. But the level of incidence is much higher in Maharashtra compared to the other nine states. Maharashtra started with 20 lacs cases and ends with 51 lacs, a jump of 250 %. The states like West Bengal, Uttar Pradesh, Tamil Nadu and Kerala are now the highly affected states in India. Two causes are mentioned by the scientists, doctors and reports such as The Lancet (2021), Rao (2020), for the states. Except Uttar Pradesh, all the three states went through the assembly elections with no such restrictions for COVID protocol was imposed by the election commission of India. Most of the central level leaders from the BhartiyaJanta Party (BJP) including the Prime Minister, and the other political parties did lots of public rallies in an eight-phase election, particularly in West Bengal to throw out the ruling government, All India Trinamool Congress (AITMC), from the power. Although the political objective of the BJP was not fulfilled, the curse remained for the common people which showed the affected COVID cases of around 20000 per day. The Supreme Court of India and other High Courts did not miss to blame the central government and the Election Commission of India.

Figure 3.Total Number of Actual Cases in the States of India
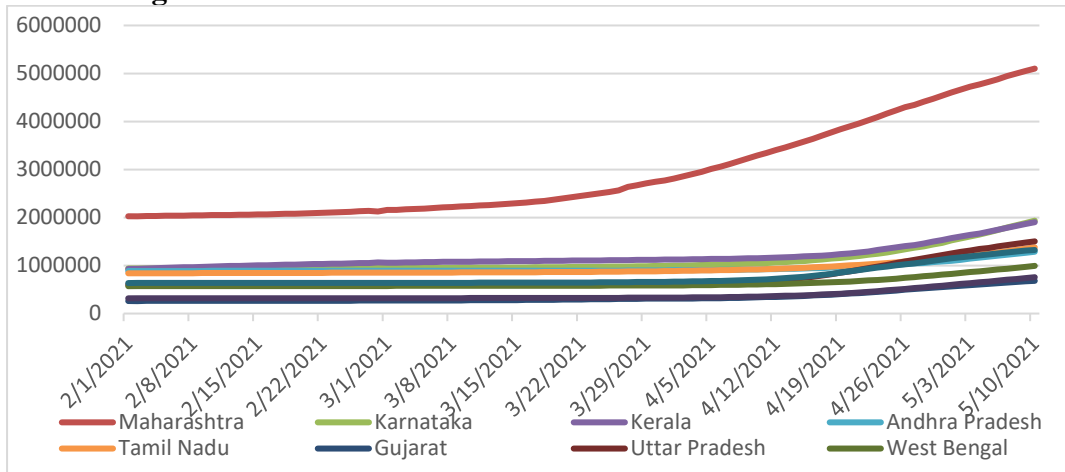
Source: Drawn by the author

The precarious situation of Uttar Pradesh has been identified by the reports as due to religious mass gathering like KumbhMela. According to a report in National Herald (www.https://www.nationalheraldindia.com) on May 4, 2021 that due to the Kumbh effect,60 out of 61 Kumbh returnees test positive for COVID in Madhya Pradesh.Besides all these causes, the continuity in air traffic flow, migrant labour movements, etc are identified as the other possible causes to support the data on incidence.

Now come to the scenario of number of deaths in the selected states. Figure 4 shows that Maharashtra is still with highest number of deaths in the entire period of actual data. Starting from 51000 total death in 01.02.2021, it ends up with 75000, which is a jump of 50% in the less than a three-and-a-half-month duration. The steep increasing trend for the state has started from the end of March like that in the number of cases.

Figure 4.Total Number of Actual Deaths in the States of India
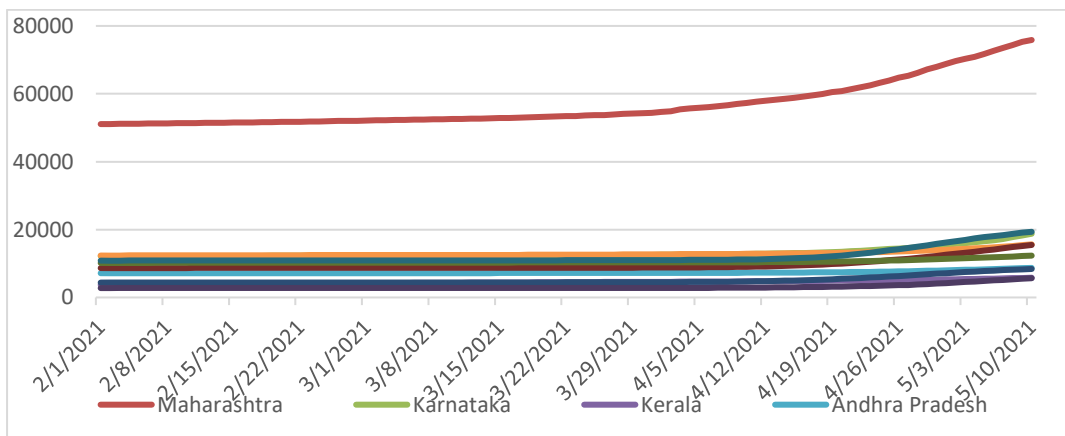
Source: Drawn by the author

The other states in the list are also with increasing trends in the number of deaths. Maharashtra is followed by Tamil Nadu, Delhi, Uttar Pradesh, Karnataka and West Bengal. Rajasthan is at the bottom level in both the number of cases and number of deaths. Most of the states in the list except Maharashtra and Delhi have experienced steep rise in the trends during the mid of April.

Objective 1-Prediction of Number of Cases and Deaths for INDIA and Its States

Let us come to our true aim of research. We proceed for presenting the empirical results on the forecasting through the B-J method in step by step.

Step 1-3 of prediction

The results of first three steps of prediction for both the number of cases and deaths are presented respectively in Table 1 and Table 2. First, we come to the results of prediction of number of cases. Column 2 of Table 1 presents the values of the Augmented Dickey-Fuller (ADF) teststatistic (a popular procedure for testing stationarity of a time series data) to show the stationarity of the series and order of integration, column 3 gives all possible forms of ARIMA based on the shapes of ACF and PACF functions as derived from the respective correlograms, column 4 shows the regression results which determine the values of AR and MA terms, column 5 gives the values of adjusted R square and column 6 and 7 respectively show the values of AIC and SIC information criteria.

TABLE 1. UNIT ROOT TEST AND ARIMA RESULTS FOR NUMBER OF CASES

Groups	ADF	Possible forms of ARIMA	Regression Co-effs. (Prob)	$\bar{R}^2$	AIC	SIC
India	-4.29 (0.00) I(2)	(1,2,1)	AR(1) = 1.03 (0.00) MA(1) = 0.99(0.00)	0.04	21.38	21.48
		(1,2,7)	AR(1) = 0.13 (0.23) MA(7) = 0.78(0.00)	0.40	21.30	21.38
		(7,2,1)	AR(7) = 1.03 (0.00) MA(1) = 0.64(0.00)	0.45	21.58	21.68
		(7,2,7)	AR(7)=0.92(0.00) MA(7)= -0.03(0.82)	0.54	21.07	21.11
		(14,2,7)	**AR(14)=0.71(0.00) MA(7)=0.85(0.00)**	0.54	21.16	21.24
Maharashtra	-17.71(0.00) I(2)	(1,2,1)	AR(1) = -0.13 (0.37) MA(1) = -0.62 (0.00)	0.36	20.70	20.79
		(1, 2,2)	AR(1) = -0.73(0.00) MA(2) = -0.42 (0.00)	0.36	20.70	20.78
		(7,2,1)	**AR(7) = 0.27(0.01) MA(1) = -0.72(0.00)**	0.39	20.71	20.79
		(7,2,7)	AR(7) = 0.88(0.00)	0.14	21.05	21.13

		MA(7) = -0.91(0.00)			
Karnataka	-14.14(0.00) I(2) No	(1,2,1)	AR(1) = -0.29 (0.20) MA(1) = -0.14 (0.54)	0.16	18.29	18.37
		(5,2,1)	**AR(5) = 0.65(0.00) MA(1) = -0.59(0.00)**	0.40	17.99	18.07
		(5,2,5)	AR(5) = 0.70 (0.02) MA(5) = -0.29(0.42)	0.19	18.29	18.37
		(5,2,7)	AR(5) = -0.45 (0.00) MA(7) = 0.10 (0.00)	0.18	18.30	18.38
Kerala	-3.05(0.05) I(2)	(1,2,1)	AR(1) = 0.12 (0.67) MA(1) = -0.46 (0.08)	0.07	18.82	18.90
		(7,2,1)	**AR(7) = 0.69 (0.00) MA(1) = -0.52(0.00)**	0.38	18.48	18.56
		(1,2,7)	AR(1) = -0.40 (0.00) MA(7) = 0.53 (0.00)	0.29	18.56	18.64
Andhra Pradesh	-3.65(0.05) I(2)	(1,2,1)	AR(1) = 0.13 (0.75) MA(1) = -0.36 (0.37)	0.02	17.01	17.10
		(1,2,2)	AR(1) = -0.19 (0.06) MA(2) = -0.13 (0.19)	0.03	17.01	17.09
		(4,2,2)	AR(4)=0.41(0.00) MA(2)=-0.07(0.45)	0.12	16.94	17.02
		(4.2,4)	AR(4)=0.75(0.00) MA(4)=-0.33(0.34)	0.13	16.92	17.01
		(7,2,10)	**AR(7) = 0.62(0.00) MA(10) = 0.41(0.01)**	0.19	16.88	16.97
		(11,2,10)	AR(11)= 0.63(0.00) MA(10) = 0.24(0.15)	0.13	17.01	17.09
Tamil Nadu	-4.05(0.01) I(2)	(2,2,2)	AR(2) = 0.99(0.00) MA(2) = -0.95(0.00)	0.26	15.45	15.53
		(2,2,7)	AR(2) = 0.33(0.00) MA(7) = 0.21(0.05)	0.16	15.57	15.65
		(7,2,2)	AR(7) = 0.41(0.00) MA(2) = 0.22(0.03)	0.19	15.58	15.66
		(7,2,7)	**AR(7) = 0.98(0.00) MA(7) = -0.88(0.00)**	0.31	15.42	15.50
Gujarat	-5.17(0.00) I(2)	(2,2,2)	AR(2) = 0.73(0.00) MA(1) = -0.52(0.05)	0.05	15.47	15.55
		(6,2,2)	AR(6) = -0.52(0.00) MA(2) = -0.32(0.00)	0.12	15.44	15.52
		(2,2,6)	**AR(2) = 0.20(0.05) MA(6) = 0.36(0.00)**	0.14	15.38	15.46
		(11, 2, 11)	AR(11)=-0.43(0.00) MA(11)=0.89(0.00)	0.18	15.43	15.52
		(11, 2, 6)	AR(11)=0.25(0.02) MA(6)=0.40(0.00)	0.16	15.46	15.54
Uttar Pradesh	-3.65(0.05) I(2)	(3,2,3)	AR(3)=0.65(0.01) MA(3)=-0.31(0.30)	0.12	17.62	17.70
		(3,2,6)	AR(3)=0.30(0.00) MA(6)= 0.32(0.00)	0.19	17.55	17.63
		(6,2,3)	AR(6)=0.47(0.00)	0.19	17.57	17.66

		MA(3)= 0.28(0.01)				
		(8,2,3)	AR(8)=0.39(0.00) MA(3)=0.17(0.12)	0.15	17.65	17.73
		(8,2,6)	AR(8)=0.36(0.00) MA(6)= 0.29(0.01)	0.19	17.60	17.68
		(8,2,10)	**AR(8)=0.28(0.01) MA(10)=-0.84(0.00)**	0.22	17.56	17.65
West Bengal	-6.55(0.00) I(2)	(1,2,1)	**AR(1)=0.93(0.00) MA(1)=-0.66(0.00)**	0.38	14.26	14.34
		(2,2,1)	AR(2)=0.38(0.00) MA(1)=0.37(0.00)	0.29	14.41	14.50
		(3,2,1)	AR(3)=0.47(0.00) MA(1)=0.20(0.05)	0.31	14.38	14.46
		(7,2,7)	AR(7)=0.93(0.00) MA(7)=-0.91(0.00)	0.28	14.47	14.55
		(7,2,1)	AR(7)=0.38(0.00) MA(1)=0.33(0.00)	0.28	14.46	14.55
Rajasthan	-3.97(0.00) I(2)	(2,2,2)	AR(2)=0.61(0.00) MA(2)=-0.19(0.36)	0.19	15.09	15.17
		(2,2,3)	AR(2)=0.45(0.00) MA(3)=0.14(0.19)	0.20	15.07	15.15
		(7,2,2)	**AR(7)=0.25(0.02) MA(2)=0.42(0.00)**	0.19	15.14	15.22
Delhi	-9.54(0.00) I(2)	(3,2,3)	AR(3)=0.43(0.20) MA(3)=-0.14(0.68)	0.06	17.49	17.57
		(3,2,7)	AR(3)=0.29(0.00) MA(7)=0.21(0.04)	0.10	17.44	17.52
		(7,2,3)	AR(7)=0.29(0.01) MA(3)=0.20(0.06)	0.10	17.49	17.58
		(7,2,7)	AR(7)=0.54(0.22) MA(7)=-0.24(0.59)	0.05	17.54	17.63
		(2,2,9)	AR(2)=0.13(0.22) MA(9)=-0.33(0.00)	0.02	17.51	17.60
		(7,2,9)	**AR(7)=0.35(0.00) MA(9)=-0.40(0.00)**	0.11	17.48	17.56

Note: Bold marks indicate significant results and the accepted ARIMA structures for which forecasting are made.

Source: Computed by the author

The appropriate ARIMA model for India is derived as ARIMA (14,2,7) where 14 stands for the order of AR chosen from ACF, 2 is the order of integration that is the series is stationary at its second difference, and 7 stands for the order of MA chosen from the PACF. The model gives maximum adjusted R^2 value and lowest AIC and SIC values. All other possible models are there but they are not as best as ARIMA (14,2,7). It is to further describe ARIMA (14,2,7) as the 14th lag in the historical values of the number of cases (xt in the equations) in AR and 7th lag in MA of the respective series for the error term (μ) are significant out of the 99 values in the series. For all the states, the bold marked indicate significant results

and the accepted ARIMA structures for which predictions for the number of cases are made. For example, the appropriate model for Maharashtra is ARIMA (7, 2, 1).

TABLE 2. UNIT ROOT TEST AND ARIMA RESULTS FOR NUMBER OF DEATHS

Groups	ADF	Possible forms of ARIMA	Regression Co-effs. (Prob)	$\bar{R}^2$	AIC	SIC
India	-4.39 (0.00) I(2)	(3,2,3)	AR(3) = 0.61 (0.05) MA(3) = -0.38(0.28)	0.04	12.60	12.68
		(3,2,7)	**AR(3) = 0.16 (0.05) MA(7) = 0.53(0.00)**	0.25	12.35	12.43
		(7,2,3)	AR(7) = 0.56 (0.00) MA(3) = 0.07(0.52)	0.25	12.38	12.47
		(7,2,7)	AR(7)=0.55(0.01) MA(7)= 0.03(0.82)	0.25	12.39	12.47
Maharashtra	-3.44(0.01) I(2)	(1,2,1)	AR(1) = 0.11 (0.54) MA(1) = -0.62 (0.00)	0.19	11.87	11.95
		(1, 2,2)	AR(1) = -0.54(0.00) MA(2) = -0.42 (0.00)	0.20	11.86	11.94
		(7,2,1)	**AR(7) = 0.55(0.00) MA(1) = -0.55(0.00)**	0.37	11.69	11.77
		(7,2,7)	AR(7) = -0.16(0.14) MA(7) = 0.88(0.00)	0.30	11.78	11.86
Karnataka	-15.66(0.00) I(2)	(1,2,1)	AR(1) = -0.32 (0.19) MA(1) = -0.09 (0.72)	0.14	9.86	9.94
		(2,2,1)	AR(2) = 0.16(0.15) MA(1) = -0.40(0.00)	0.14	9.87	9.95
		(6,2,1)	AR(6) = 0.48 (0.01) MA(1) = -0.37(0.42)	0.18	9.87	9.95
		(1,2,9)	**AR(1) = -0.40 (0.00) MA(9) = 0.11 (0.00)**	0.15	9.85	9.93
Kerala	-15.34(0.05) I(2)	(1,2,1)	AR(1) = -0.22 (0.31) MA(1) = -0.27 (0.22)	0.18	5.62	5.70
		(1,2,7)	AR(1) = -0.44 (0.00) MA(7) = 0.10 (0.00)	0.17	5.63	5.71
		(1,2,11)	AR(1) = -0.42 (0.00) MA(11) = 0.24 (0.04)	0.20	5.59	5.67
		(11,2,1)	**AR(11) = 0.31 (0.01) MA(1) = -0.47 (0.00)**	0.22	5.65	5.73
		(11, 2,11)	AR(11) = -0.43 (0.00) MA(11) = 0.84 (0.00)	0.14	5.74	5.83
Andhra Pradesh	-3.35(0.05) I(2)	(1,2,1)	AR(1) = -0.31 (0.12) MA(1) = -0.24 (0.24)	0.24	6.33	6.41
		(1,2,7)	AR(1) = -0.48 (0.00) MA(7) = 0.56 (0.00)	0.41	6.07	6.15
		(7,2,1)	**AR(7)= 0.64(0.00) MA(1)= -0.59(0.00)**	0.46	6.04	6.13
		(7,2,7)	AR(7)=0.08(0.69)	0.23	6.39	6.48

			MA(7)=0.59(0.00)			
Tamil Nadu	-3.55(0.05) I(2)	(3,2,3)	**AR(3) = 0.89(0.00)** **MA(3) = -0.80(0.00)**	0.14	7.14	7.22
		(3,2,6)	AR(3) = 0.22(0.05) MA(6) = 0.35(0.01)	0.11	7.17	7.25
		(6,2,3)	AR(6) = 0.51(0.00) MA(3) = 0.21(0.05)	0.14	7.16	7.25
		(2,2,8)	AR(2) = 0.009(0.94) MA(8) = 0.40(0.01)	0.04	7.24	7.32
		(8,2,2)	AR(8) = 0.38(0.02) MA(2) = -0.01(0.89)	0.03	7.30	7.38
		(8,2,8)	AR(8) = 0.35(0.53) MA(8) = 0.02(0.96)	0.03	7.30	7.38
Gujarat	-3.26(0.02) I(2)	(2,2,2)	AR(2) = 0.58(0.00) MA(2) = -0.05(0.79)	0.28	5.88	5.96
		(6,2,2)	AR(6) = 0.14(0.22) MA(2) = 0.46(0.00)	0.24	5.98	6.06
		(14,2,2)	AR(14) = -0.14(0.34) MA(2) = 0.49(0.00)	0.24	6.07	6.16
		(17, 2, 17)	AR(17)= 0.29(0.04) MA(17)= -0.82(0.00)	0.18	6.18	6.27
		(17, 2, 2)	**AR(17)= -0.24(0.08)** **MA(2)= 0.46(0.00)**	0.25	6.09	6.18
Uttar Pradesh	-11.32(0.05) I(2)	(1,2,1)	AR(1)= -0.30(0.67) MA(1)= 0.15(0.83)	0.003	8.34	8.42
		(1,2,7)	AR(1)= -0.22(0.02) MA(7)= 0.46(0.00)	0.15	8.18	8.26
		(7,2,1)	**AR(7)=0.60(0.00)** **MA(1)= -0.35(0.00)**	0.16	8.22	8.31
		(11,2,11)	AR(11)=0.99(0.00) MA(11)=-0.80(0.00)	0.10	8.34	8.43
		(1,2,11)	AR(1)=-0.11(0.28) MA(11)= 0.52(0.00)	0.08	8.25	8.33
		(11,2,1)	AR(11)=0.47(0.00) MA(1)=-0.09(0.37)	0.08	8.36	8.45
West Bengal	-6.55(0.05) I(2)	(2,2,2)	AR(2)= 0.46(0.16) MA(2)=-0.17(0.61)	0.06	5.69	5.77
		(2,2,7)	AR(2)=0.12(0.26) MA(7)=0.55(0.00)	0.25	5.46	5.54
		(7,2,2)	AR(7)=0.59(0.00) MA(2)=0.10(0.35)	0.27	5.45	5.54
		(2,2,8)	AR(2)=0.24(0.00) MA(8)=0.19(0.13)	0.06	5.68	5.76
		(10,2,10)	AR(10)=-0.21(0.14) MA(10)=0.80(0.00)	0.18	5.60	5.68
		(17,2,7)	**AR(17)=0.56(0.00)** **MA(7)= 0.42(0.00)**	0.32	5.48	5.57
Rajasthan	-11.21(0.00) I(2)	(2,2,2)	AR(2)=0.16(0.73) MA(2)=0.03(0.94)	0.02	6.86	6.94
		(2,2,3)	**AR(2)=0.27(0.00)**	0.07	6.81	6.89

			MA(3)=0.27(0.01)			
		(3,2,2)	AR(3)=0.20(0.04) MA(2)=0.22(0.00)	0.06	6.83	6.91
		(2,2,8)	AR(2)=0.19(0.04) MA(8)=0.14(0.16)	0.03	6.85	6.93
		(2,2,15)	AR(2)=0.21(0.03) MA(15)=0.28(0.04)	0.05	6.83	6.91
		(18,2,3)	AR(18)=0.41(0.01) MA(3)=0.24(0.03)	0.07	6.99	7.08
Delhi	-3.10(0.02) I(2)	(4,2,4)	AR(4)=-0.03(0.93) MA(4)=0.40(0.24)	0.09	8.82	8.90
		(4,2,7)	AR(4)=0.31(0.00) MA(7)=0.37(0.04)	0.14	8.76	8.84
		(7,2,7)	AR(7)=0.40(0.24) MA(7)=0.06(0.86)	0.08	8.86	8.95
		(15,2,4)	**AR(15)=-0.64(0.00) MA(4)=0.46(0.00)**	0.25	8.75	8.84
		(15,2,7)	AR(15)= -0.61(0.00) MA(7)=0.34(0.01)	0.20	8.81	8.90

Note: Bold marks indicate significant results and the accepted ARIMA structures for which forecasting are made.

Source: Computed by the author

Like Table 1, Table 2 gives the appropriate models of predictions for number of deaths in India and its states. The appropriate model for India is ARIMA (3, 2, 7) and ARIMA (7, 2, 1). The appropriate models for Maharashtra for both the number of cases and number of deaths are identical which indicate that both the series follow the same path and there is a balance between the two in terms of times and magnitudes of occurrence.

Step 4 of Predictions of the Number of Cases and Deaths

On the basis of the acceptable models obtained from Step 1 to 3 and presented in Table 1 and 2, predictions are made on these appropriate models of ARIMA. The predicted results are accepted on the basis of the desirable values of root mean square errors (RMSE), bias proportions, variance proportions and covariance proportions. Figure 1 and 2 present the graphical plots of predicted values of number of cases and number of deaths for India and Figure 6 and 7for the selected countries in respective ways. The numerical values of the forecasted series are given in the Appendix (Table A1 and A2).

It is observed from Figure 1 that there will be continuity in the rising trend of the number of cases for India during the period of prediction, May 11 – June 30, although the rate of increase will be diminishing day by day. The predicted number of cases in India is expected to reach 3.87 crore in June 30 with respect to 2.29 crore in May 10 which is around 1.5 crore higher in just a 51-day gap.

With respect to the predicted number of deaths in India it is evidenced from Figure 2 that it will reach 4.9 lacs in June 30 with respect to 2.5 lacs in May 10. There is a jump of around 100 % in case of death as predicted. Hence, the claim of one million death in India on August 1 by The Lancet (2021) may be justified if the rate of death continues in the same ratio throughout the period May 11-July 30. But, from the trend of new death rates for the period 01.02.2021-10.05.2021, it is observed that it started declining after May 8 (Figure 5), and hence, reaching one million death figures may be subject to further investigation.

Figure 5. Actual Number of New Deaths in India for 01.02.2021-10.05.2021
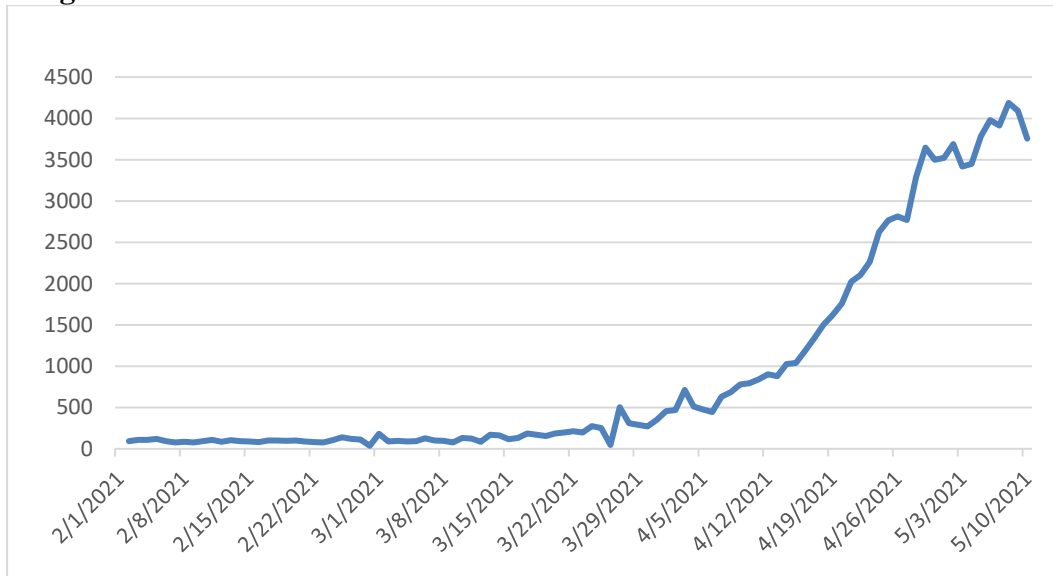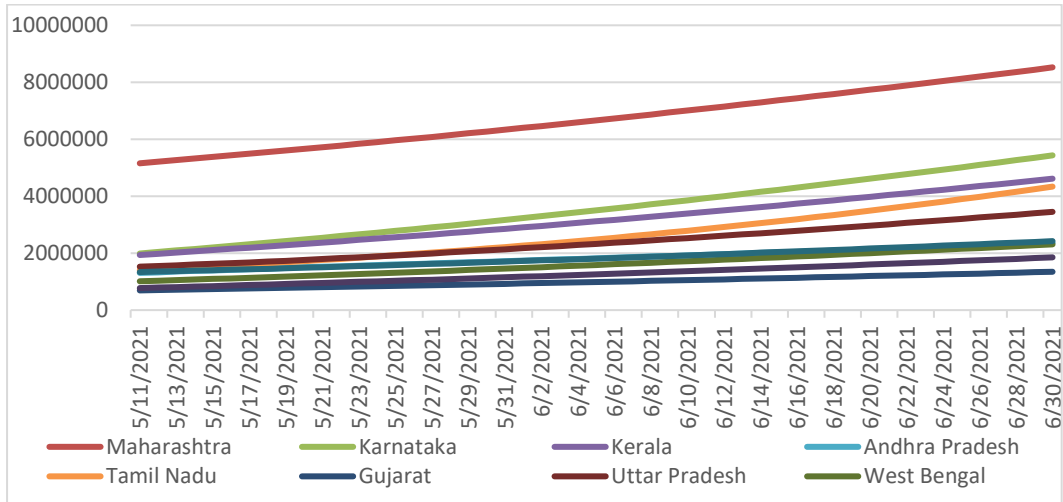

Source: Drawn by the author

The possible causes for this increasing number of predicted cases and deaths may be very slow vaccination programme in India, besides the causes such as elections, religious programmes, government's failure in planning, etc. Up to May 10, around 15% of total India's population has been vaccinated. The good effect of vaccination has been proved right as the people over 60 years of age and the frontline health and administrative workers are affected in a very low rate (www.https://swachhindia.ndtv.com/).

Now come to the forecasting results of number of cases across the selected states in India. Figure 6 presents the data. All the states are showing increasing trends of predicted number of cases for the period 11.05.2021-30.06.2021. Maharashtra still remains in the top slot throughout the entire period of forecasting. Starting from 51.5 lacs on 11.05.2021, it is expected to reach 85.2 lacs on 30.06.2021, around 34 lacs more which is an 67% increase. The second to follow Maharashtra is Karnataka with a predicted number of cases of 54 lacs. The rate of increase in the predicted number of cases for both Maharashtra and Karnataka are almost similar.

Figure 6. Predicted Number of Cases for the States of India for May 11-June 30, 2021

Source: Drawn by the author from the derived results

Kerala is in the third slot and Tamil Nadu in the fourth slot. Gujarat and Rajasthan are at the bottom level in this regard. West Bengal, Andhra Pradesh and Delhi are expected to reach the same number of cases (around 24 lacs) in June 30.

Now come to the precited number of deaths across the states. Figure 7 presents the state-wise predicted data on the number of deaths. All the states are predicted to experience increasing death rates over the coming 51 days. Maharashtra is again at the top of the list. It starts with around 76 thousand in May 11 and ends up with 1.21 lacs deaths in June 30. The states to follow Maharashtra are Karnataka, Delhi and Uttar Pradesh. Karnataka is expected to reach the toll of around 52 thousand.

Figure 7. Predicted Number of Deathsfor the States of India for May 11-June 30, 2021
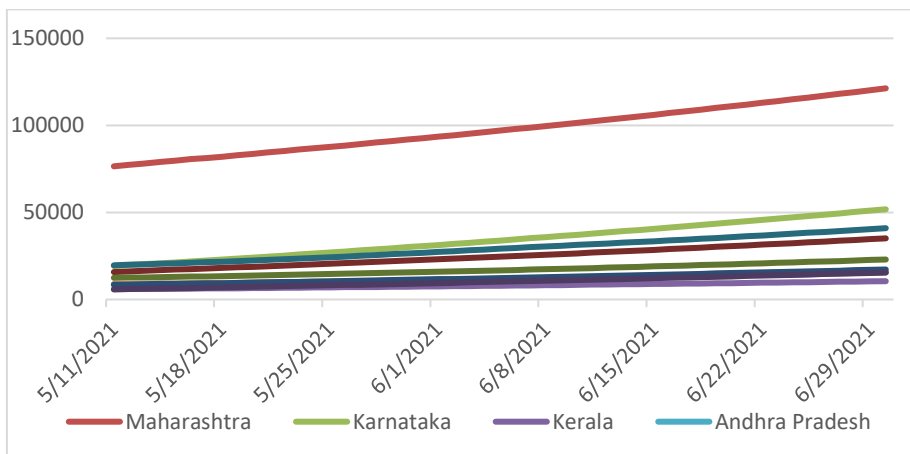
Source: Drawn by the author from the derived results

West Bengal is in the fifth position of the group with a predicted toll of around 23 thousand on June 30. Kerala stays at the bottom of the list with a predicted number of deaths of 10 thousand in the same time point.

Objective 2-Significance Tests for differences between Actual and Predicted Values

In order to test whether the mean differences of the predicted values are greater than that of the actual values for the number of cases and number of deaths we follow the student's t statistic. The mean and standard deviation (SD), mean differences and t values for both the level and growth forms are respectively given in Panel A and Panel B of Table 3.Panel A presents the results for the number of cases and Panel B the number of deaths. It is evident that the mean values of the actual scenario is much lesser that that of the predicted scenario for both the number of cases and deaths for India and its states except that, for Tamil Nadu, the number of predicted deaths is lesser than its number of actual deaths, putting thus a negative values before the calculated 't' statistic.

TABLE 3. MEAN DIFFERENCE RESULTS FOR INDIA AND ITS STATES

Panel A					
	Actual Mean (Cases)	Forecast Mean (Cases)	Actual SD (Cases)	Forecast SD (Cases)	t(Forecast-Actual) Cases
India	13370750	31398700	3373655	4521746	**25.10012784**
Maharashtra	2921107	6724959	968709	1001605	**22.27959565**
Karnataka	1092455	3573249	246527	1027947	**16.98495047**
Kerala	1175804	3172149	224193	797369	**17.52642807**
Andhra Pradesh	942509	1825857	97243	308348	**19.95378528**
Tamil Nadu	934044	2618707	134726	871699	**13.717523**
Gujarat	347619	998497	116869	193974	**21.99452588**
Uttar Pradesh	749027	2379642	259162	579820	**19.12368589**
West Bengal	634150	1610934	107464	386050	**17.71904904**
Rajasthan	385089	1276126	115670	320509	**19.21935572**
Delhi	758212	1833772	201415	324269	**21.63464332**
Panel B					
	Actual Mean (Deaths)	Forecast Mean (Deaths)	Actual SD (Deaths)	Forecast SD(Deaths)	t(Forecast-Actual) Deaths
India	170918	362944	23044	71713	**18.63340914**
Maharashtra	56624	97671	6692	13220	**20.84044448**
Karnataka	13120	34421	1470	9705	**15.58277463**
Kerala	4541	8019	509	1380	**17.3936143**
Andhra Pradesh	7367	11844	370	2016	**15.7227138**
Tamil Nadu	12912	11844	730	2016	**-3.66259854**

Gujarat	5033	12500	1114	2611	**19.52727747**
Uttar Pradesh	9594	24861	1693	5721	**18.64097902**
West Bengal	10517	17063	496	3145	**14.77081191**
Rajasthan	3119	10346	685	2881	**17.66175455**
Delhi	12036	29368	2229	6428	**18.68474931**

Note: The bold figures show statistically significant results at 1% level of significance.

Source: Author's calculations

It is also evident that the computed 't' values for India and its states are positive and significant at 1 % level of significance as noted in the bold marks. This means, the predicted number of cases and deaths for India and all its states (except Tamil Nadu in case of death) are much larger that their actual values. It is thus still an alarming scenario to India and its major states at least up to June 30, the end time point of the forecasting period. Tamil Nadu is expected of reducing its death rate significantly, although its number if cases will continue to be alarming.

DISCUSSION

Using the appropriate model of ARIMA in the B-J line of forecasting it is now evident that India and its ten highly affected states will be facing the gloomy scenario in the number of cases and deaths in the coming 51 days. The claim of The Lancet in this regard may not be justified at this juncture. Tamil Nadu is an exception with regard to the number of deaths. India will reach around 3.87 crore of number of cases and 4.9 lacs of death on June 30. Maharashtra will be the leader in the group keeping all the remaining states well behind in both the number of cases and deaths. It has been proved that after vaccination the older age people have been least affected in the second wave. Hence, effective and large-scale vaccination can save the people of the country from the ill effects of the second wave of the virus. But, the rate of vaccination in India and its states is very slow due to low level of production. In addition to that the country could not maintain the COVID protocol like physical distancing, use of masks and sanitizers, allowed public gatherings such as in religious places like KumbhMela, and long phase assembly elections in certain states. It also did not put restrictions upon traffic movements, and could not perceive the severity of the second-round effect of the virus. The country became complacent in this regard which paid a huge sum in terms of loss of lives, and increasing health costs. And finally, there was a massive policy failure on the part of the central as well as state governments of the country.

CONCLUSION

Venturing with two objectives the present study attempted to predict the number of cases and deaths for India and its leading states for the period May 11-Jume 30, 2021, and also to test whether the predicted values are greater than that of their actual values. Using the appropriate model of ARIMA in the B-J line of

forecasting it is derived that India and its ten highly affected states will be facing the gloomy scenario in the number of cases and deaths in the coming 51 days. Tamil Nadu is an exception with regard to the number of deaths. India will reach around 3.87 crore of number of cases and 4.9 lacs of death on June 30. Maharashtra will be the leader in the group keeping all the remaining states well behind in both the number of cases and deaths. Mass scale vaccination is recommended to save the people of country from the ill effects of the virus.

Conflict of Interests

In preparing the manuscript the author did not face any conflict of interests and did not use any such materials of others where such conflict would at all arise.

Funding Information

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Appendix

TABLE A1. PREDICTED NUMBER OF CASES

Forecast Date	India	Maharashtra	Karnataka	Kerala	Andhra Pradesh	Tamil Nadu	Gujarat	Uttar Pradesh	West Bengal	Rajasthan	Delhi
11-05-2021	23344435	5154217	1987582	1935669	1307115	1409747	692311	1526058	1012845	774167	1336585
12-05-2021	23722240	5208018	2040314	1976635	1328057	1439858	703482	1549885	1032776	791425	1352542
13-05-2021	24102217	5263833	2093085	2021064	1351979	1471108	714550	1574397	1052951	808781	1369992
14-05-2021	24471485	5321328	2145275	2066001	1374427	1503304	725582	1599213	1073372	826461	1386903
15-05-2021	24847742	5376978	2197927	2108307	1394054	1536870	736735	1625195	1094037	844459	1404117
16-05-2021	25188364	5433754	2254266	2153206	1415454	1571342	747686	1648417	1114946	862534	1420753
17-05-2021	25498258	5488684	2310516	2193967	1438515	1606960	758745	1674528	1136101	880731	1435918
18-05-2021	25827798	5545162	2367011	2232963	1457444	1643257	769846	1701304	1157500	898948	1451962
19-05-2021	26179179	5602424	2423345	2277619	1477443	1680264	781052	1730089	1179143	917252	1469954
20-05-2021	26532268	5660663	2480203	2324837	1499108	1718498	792350	1761056	1201031	935720	1488611
21-05-2021	26876379	5719786	2539705	2372559	1519912	1757765	803753	1792528	1223164	954410	1507209
22-05-2021	27226610	5778816	2599368	2418604	1539009	1798489	815258	1824396	1245541	973322	1526047
23-05-2021	275465	5838576	2659414	246660	1559284	1840205	826868	1856906	1268162	992391	154481

	98			5							3
24-05-2021	27840510	5898244	2719574	2511881	1580669	1883154	838581	1888949	1291028	1011632	1563185
25-05-2021	28151296	5958758	2780298	2556082	1599522	1926870	850399	1922118	1314138	1031016	1582004
26-05-2021	28480606	6019909	2842982	2604371	1619112	1971384	862321	1955787	1337493	1050562	1601651
27-05-2021	28811881	6081748	2905992	2654593	1639815	2017212	874347	1990333	1361092	1070289	1621670
28-05-2021	29135895	6144251	2969473	2705318	1660042	2064159	886478	2025807	1384935	1090212	1641800
29-05-2021	29465323	6207147	3033250	2755029	1679260	2112649	898714	2061735	1409023	1110331	1662148
30-05-2021	29769641	6270663	3097619	2806253	1699285	2162219	911054	2098087	1433355	1130630	1682604
31-05-2021	30052361	6334572	3163495	2855734	1720072	2213108	923498	2134931	1457931	1151112	1703051
01-06-2021	30349560	6399135	3229807	2904620	1739333	2264852	936047	2171955	1482752	1171769	1723792
02-06-2021	30662808	6464291	3296649	2956500	1759122	2317482	948700	2209608	1507816	1192607	1744961
03-06-2021	30977688	6530058	3363906	3009877	1779676	2371511	961458	2247714	1533125	1213631	1766395
04-06-2021	31286548	6596426	3431772	3063756	1799995	2426747	974321	2286380	1558679	1234844	1788002
05-06-2021	31600198	6663322	3500850	3117082	1819746	2483612	987287	2325618	1584476	1256247	1809819
06-06-2021	31892599	6730808	3570434	3171612	1840068	2541644	1000358	2365296	1610518	1277835	1831808
07-06-2021	32166736	6798821	3640587	3225083	1860935	2601081	1013534	2405406	1636803	1299608	1853927
08-06-2021	32453364	6867434	3711233	3278292	1880908	2661460	1026814	2445966	1663333	1321566	1876283
09-06-2021	327536	6936630	3782501	333373	1901278	2722813	1040019	2486888	1690108	1343710	189892

				68				6			9				5
10-06-2021	33055787	7006413	3854785	3390372	1922194	2785652	1053688	2528300	1717126	1366040	1921795
11-06-2021	33353115	7076781	3927622	3447510	1943027	2849784	1067281	2570151	1744389	1388557	1944859
12-06-2021	33654729	7147714	4001054	3504415	1963568	2915630	1080979	2612471	1771895	1411263	1968131
13-06-2021	33938769	7219229	4075031	3562310	1984534	2982730	1094782	2655265	1799646	1434155	1991597
14-06-2021	34207751	7291309	4149636	3619621	2005907	3051322	1108688	2698495	1827641	1457234	2015243
15-06-2021	34487510	7363973	4225130	3676902	2026783	3120943	1122700	2742158	1855880	1480499	2039106
16-06-2021	34779172	7437217	4301208	3735889	2047974	3191625	1136816	2786259	1884363	1503951	2063204
17-06-2021	35072411	7511042	4377898	3795858	2069573	3263879	1151036	2830775	1913091	1527590	2087516
18-06-2021	35361747	7585448	4455165	3856327	2091185	3337512	1165361	2875740	1942062	1551416	2112030
19-06-2021	35654923	7660428	4533067	3916787	2112679	3412946	1179790	2921140	1971278	1575430	2136752
20-06-2021	35933290	7735988	4611773	3978087	2134504	3489720	1194323	2966985	2000737	1599630	2161676
21-06-2021	36198986	7812124	4691083	4039134	2156651	3568072	1208961	3013275	2030441	1624018	2186796
22-06-2021	36474036	7888839	4771016	4100313	2178550	3647540	1223704	3060000	2060389	1648592	2212127
23-06-2021	36759288	7966134	4851549	4162829	2200713	3728156	1238551	3107158	2090581	1673354	2237675
24-06-2021	37046250	8044008	4932720	4226180	2223197	3810429	1253502	3154752	2121017	1698302	2263432
25-06-2021	37330189	8122461	5014639	4290032	2245754	3894169	1268558	3202775	2151697	1723438	2289394
26-06-2021	376176	8201492	5097176	4354403	2268302	3979794	128371	3251236	2182622	1748761	231556

	06			0			9				3
27-06-2021	378 928 46	82811 02	5180 343	441 876 4	229112 4	4066 846	129 898 4	33001 31	22137 90	1774 271	234 193 7
28-06-2021	381 577 11	83612 90	5264 125	448 347 4	231421 3	4155 562	131 435 3	33494 63	22452 02	1799 968	236 851 4
29-06-2021	384 307 03	84420 57	5348 546	454 842 8	233721 1	4245 481	132 982 7	33992 33	22768 59	1825 852	239 529 9
30-06-2021	387 126 28	85234 03	5433 681	461 446 5	236044 0	4336 634	134 540 5	34494 37	23087 60	1851 923	242 229 4

TABLE A2. PREDICTED NUMBER OF DEATHS

Foreca st Date	In dia	Maha rashtr a	Karn atak a	Ke ral a	Andhra Pradesh	Tamil Nadu	Guj ara t	Uttar Prades h	West Benga l	Raja stha n	De lhi
11-05-2021	249 999	76491	1927 3	58 83	8796	8796	851 7	15764	12454	5824	19 62 5
12-05-2021	253 940	77315	1976 9	59 53	8892	8892	864 3	16105	12583	5983	19 90 6
13-05-2021	257 888	78158	2027 2	60 23	8991	8991	877 0	16448	12712	6141	20 21 1
14-05-2021	261 891	78968	2078 6	60 94	9082	9082	889 9	16791	12849	6300	20 50 8
15-05-2021	266 097	79806	2131 1	61 65	9173	9173	902 6	17149	12986	6460	20 79 5
16-05-2021	270 237	80629	2183 9	62 39	9281	9281	915 5	17463	13128	6621	21 10 1
17-05-2021	274 301	81295	2240 2	63 14	9386	9386	928 4	17777	13278	6784	21 38 9
18-05-2021	278 431	82003	2295 7	63 92	9490	9490	941 7	18095	13434	6949	21 68 6
19-05-2021	282 583	82815	2351 7	64 67	9599	9599	955 2	18440	13595	7115	21 96 3
20-05-2021	286 755	83641	2408 3	65 46	9710	9710	969 4	18788	13750	7282	22 31 7
21-05-2021	290 970	84452	2465 4	66 26	9816	9816	984 0	19136	13911	7451	22 69

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22-05-2021	295221	85283	25230	6707	9923	9923	9992	19496	14077	7622	23064
23-05-2021	299508	86108	25811	6789	10041	10041	10144	19830	14243	7794	23435
24-05-2021	303834	86851	26398	6872	10159	10159	10301	20165	14417	7968	23818
25-05-2021	308199	87621	26990	6956	10275	10275	10461	20504	14590	8144	24246
26-05-2021	312603	88451	27587	7039	10396	10396	10623	20861	14772	8320	24674
27-05-2021	317045	89292	28189	7125	10518	10518	10787	21221	14954	8499	25109
28-05-2021	321527	90129	28797	7211	10638	10638	10952	21583	15139	8679	25535
29-05-2021	326047	90980	29410	7298	10759	10759	11118	21953	15326	8861	25971
30-05-2021	330606	91832	30028	7386	10887	10887	11286	22309	15514	9044	26420
31-05-2021	335204	92642	30651	7474	11016	11016	11455	22667	15709	9229	26863
01-06-2021	339841	93471	31280	7564	11144	11144	11627	23029	15903	9415	27324
02-06-2021	344517	94336	31914	7655	11275	11275	11801	23404	16102	9603	27785
03-06-2021	349232	95211	32553	7746	11408	11408	11976	23781	16307	9793	28266
04-06-2021	353985	96087	33198	7838	11540	11540	12153	24161	16517	9984	28702
05-06-2021	358778	96975	33847	7931	11673	11673	12330	24547	16730	10176	29130
06-06-2021	363609	97866	34502	8024	11812	11812	12509	24926	16941	10371	29569
07-06-2021	368480	98738	35162	8119	11951	11951	12688	25308	17156	10567	30001

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08-06-2021	373389	99624	35828	8214	12090	12090	12868	25694	17376	10764	30456
09-06-2021	378338	100553	36499	8310	12232	12232	13049	26088	17597	10963	30876
10-06-2021	383325	101452	37175	8407	12375	12375	13232	26486	17823	11163	31301
11-06-2021	388351	102375	37856	8504	12518	12518	13415	26887	18050	11366	31729
12-06-2021	393416	103307	38542	8602	12663	12663	13600	27293	18284	11569	32168
13-06-2021	398520	104245	39234	8701	12811	12811	13787	27696	18518	11774	32607
14-06-2021	403663	105177	39931	8801	12960	12960	13976	28102	18756	11981	33044
15-06-2021	408845	106119	40633	8902	13110	13110	14166	28511	18995	12190	33491
16-06-2021	414065	107078	41341	9003	13262	13262	14357	28928	19237	12400	33932
17-06-2021	419325	108045	42053	9105	13415	13415	14551	29348	19483	12611	34379
18-06-2021	424624	109018	42771	9208	13569	13569	14745	29771	19730	12824	34820
19-06-2021	429961	110001	43495	9311	13724	13724	14941	30199	19982	13039	35296
20-06-2021	435338	110990	44223	9416	13882	13882	15139	30626	20237	13255	35784
21-06-2021	440753	111979	44957	9520	14041	14041	15339	31057	20496	13473	36270
22-06-2021	446207	112977	45696	9626	14202	14202	15540	31491	20759	13692	36760
23-06-2021	451700	113988	46440	9733	14363	14363	15743	31931	21022	13913	37256
24-06-2021	457232	115007	47190	9840	14527	14527	15948	32374	21288	14136	37777

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25-06-2021	462803	116034	47945	9948	14691	14691	16154	32820	21557	14360	38294
26-06-2021	468413	117068	48705	10056	14856	14856	16362	33271	21829	14586	38819
27-06-2021	474062	118110	49470	10166	15024	15024	16572	33723	22105	14813	39342
28-06-2021	479750	119156	50240	10276	15193	15193	16784	34178	22382	15042	39871
29-06-2021	485477	120210	51016	10387	15363	15363	16997	34637	22664	15272	40409
30-06-2021	491242	121275	51797	10498	15535	15535	17212	35101	22948	15504	40946