

# Prediction of Third Covid Wave in India using ARIMA Model

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**Abstract.** Whole world has been battling against the novel Covid-19 pandemic that outbreaked from Wuhan, China during Dec 2019. Like most other countries, India has also witnessed two Covid-19 waves with second one, during April-May 2021, being more lethal. Important lessons learnt while fighting against Covid pandemic demands never relax attitude until the fight against the pandemic is completely over. To achieve this India launched world's biggest vaccination program. Continuous concerns are being expressed by different sections of health workers and the government regarding probable, and even more lethal, third wave in near future. Hence this work is undertaken to predict the possibility of third wave. Predictive analysis is based on progression of Covid-19 in the country thus far. Any such prediction shall offer multifaceted benefits in raising timely alarm for country to prepare itself and take measures to tap the onset of probable third wave. ARIMA model was selected for making prediction. Datasets provided by [1],[2] are utilized for the purpose. The model predicted that the latest spurt in Covid-19 cases is expected to continue and grow over the remaining part of current year. This spurt can in certain probabilities lead to third Covid-19 wave around the months of Nov-Dec 2021. These predictions are though limited by the recent seroprevalence findings by ICMR and humongous vaccination drive that may retard the onset of third wave. Moreover, confined nature of recent spike (to southern Indian states, mainly Kerala) may mean that the geographical extent of current spurt is comparatively small to become a countywide wave.

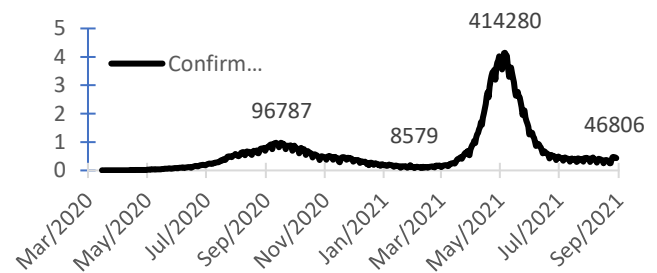
**Keywords:** Covid-19, ARIMA Model, Third Wave, Seroprevalence, Vaccination.

## 1 Introduction

During last 20 months, the world has been battling against the pandemic termed as Covid. It is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) [3][4]. The virus has caused over 0.3 million deaths in India itself with more than 32 million people falling ill. This pandemic is different for other diseases owing to its underlying spread mechanism. Its infectivity rate is main cause of concern. It can be transmitted through casual contacts. Only mantra to stop the spread is social distancing with proper hand hygiene. It broke out of blue from a city Wuhan in China. It caught the whole world and health workers unaware. The rate of spread was so much that, to tap its spread, most countries had to declare complete lockdown across the width and breadth of their territories. One irony being that countries with best medical

facilities were most affected. Moreover, tremor caused by its onset were felt more by the largest economies.

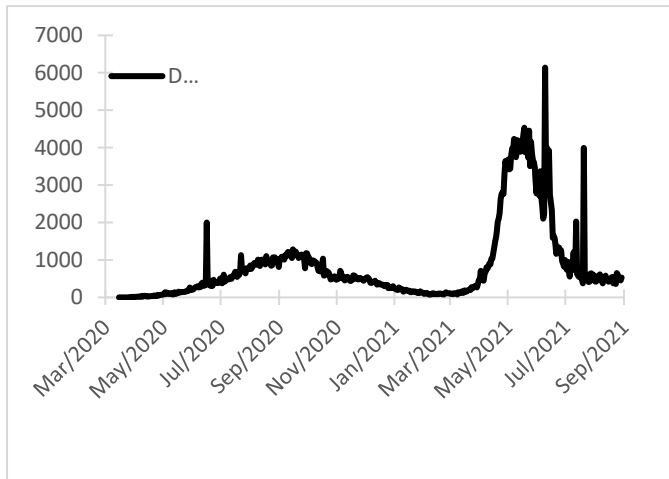
Although the disease has not caused that many deaths compared with number of infections. It proved fatal for patients with some underlying comorbidity like diabetes, heart disease, old age etc. Sigh of relief was felt, during the battle against pandemic, when various vaccinees were discovered. The countries across the world have undertaken massive vaccination drives to tap the spread of pandemic. Further relief came with the time when doctors/scientists across the world started understanding the disease, its onset and progression in human bodies. With better understanding of the disease, home isolation with teleconsultation became the preferred mode of treatment. This ensured social distancing thereby a natural inhibitor to the spread of disease. Another setback in fight against this disease came in form of underlying virus mutations, New pathogenic variants of Coronavirus like delta variant are more infective as well as fatal. Moreover, these variants are more resilient to the discovered vaccines.



**Fig. 1.** Covid Progression in India (In Lakhs; One Lakh=0.1 million) (\*Data Source: [1])

When, towards the end of year 2020, the world was relaxing after easing out of first wave, countries were struck by the onset of second wave. Moreover, this time around the pandemic was much more infectious and deadly. Multiple fold increase in reported cases was observed. Overall spread was much more compared with the first wave. The onset of second wave taught some important lessons to the world. These being never relax attitude until the battle against the pandemic is completely over and keep on following Covid specific.

India, in terms of GDP, is fifth largest economy across the world. India was also not spared by the pandemic. It has experienced two waves of pandemic during the years 2020 and 2021 respectively. Trends of daily confirmed cases and deaths are outlined in Fig 1 and Fig 2 respectively. Relative less ratio of death to infection is an important characteristic of pandemic spread in India.



**Fig. 2.** Deaths caused by onset of Covid-19 in India. (\* Data Source [1])

Perturbed with the losses caused by the onset of much more potent second wave, countries have started monitoring daily trends of disease more closely. They are preparing themselves for any eventuality & situations that may be prevalent after onset of third wave. Vaccination drives have been speeded up and peoples are being educated about the benefits of social distancing/hand hygiene through social media.

**Table 1.** Recent Covid Trends across India (\* Source [1])

SNo	Date	Number of Confirmed Cases	Kerala Contribution	Top 5 States
01	20-08-2021	34308	55.14%	83.49%
02	21-08-2021	31023	40.92%	68.3%
03	22-08-2021	25420	53.98%	83.82%
04	23-08-2021	24794	64.38%	86.76%
05	24-08-2021	37739	67.95%	88.32%
06	25-08-2021	46280	67.52%	88.67%
07	26-08-2021	44550	70.08%	89.33%
08	28-08-2021	45064	69.38%	89.2%
09	29-08-2021	43367	68.79%	89.59%

Although the second Covid wave has eased throughout India, yet various experts have already started alarming about the probable outbreak of third wave in near future. India this time around is more vigilant while relaxing restrictions and is taking all necessary steps to avoid the onset of third wave. Daily trends are being closely monitored and analyzed.

Recently, during Aug 23, 2021 – Aug 29, 2021, there has been sudden spurt in reported Covid cases (Table 1). So, it

becomes imperative to analyze this current spike considering experiences gained during last 20 months. It may help in timely prediction of probable third Covid wave. Early prediction with time in hand shall provide ample opportunity to prepare strategy to retard the onset and progression through established procedures. Hence this work.

In this work ARIMA model is employed to analyze the past trends and to make prediction about future course of spread of the Covid pandemic in India. Selection of ARIMA model is contributed by its popularity among research fraternity in time series analysis. The daily Covid cases form the input time series to the model. The trends are analyzed to predict daily cases for remaining part of the year 2021. Overall, this work is divided as:

Section 3 is devoted to the basics of ARIMA model and its implementation modalities during this work. Section 4 outlines the observations made during the work and major findings/predictions. Next section contains various limiting factors to the prediction made during this work. Remaining sections are devoted to conclusions, limitations, and future work.

Importance of this work lies in the bitter experience the world has faced due to outbreak of Covid pandemic and even more in the hard lesson taught by the second wave. Numerous researchers are working in this field and several predictions even using the ARIMA model have been made thus far regarding progression of pandemic. Yet there is little work as far as prediction of third Covid wave in India is concerned. Any prediction about onset of third Covid wave shall have far reaching benefits in not only averting but minimizing the effect of probable third Covid wave. Relevance of the work is more in current context when the country is planning to open all activities especially schools, colleges consequent upon the easing out of Covid second wave. It becomes critical to analyze the latest spike in Covid cases.

## 2 Related Work

[5] analyzed spread of Covid-19 in India, through models including ARIMA, during various unlock phases. They observed that the ARIMA model is the best-fitting model for COVID-19 cases in India. Authors in [6] deployed models like ARIMA and Prophet to check their effectiveness in predicting confirmed cases, deaths and recovery cases in India including states. They concluded that ARIMA model performs better than Prophet Model for forecasting the pandemic outbreak. [7] have proposed a model considering eight stages of infection: susceptible, infected, diagnosed, ailing, recognized, threatened, healed and extinct. They named it as SIDARTHE. The authors observed that social distancing should be complemented with widespread testing and contact tracing to control the Covid pandemic. [8] proposed their mathematical model to analyze the transmission dynamics of the COVID-19 pandemic in Bangkok (Thailand). Model was divided into seven classes viz. susceptible, exposed, symptomatically infected, asymptotically infected, quarantined, recovered and death. They observed the need for consistent use of face masks in reducing the COVID-19 pandemic. [9] studied the outbreak of pandemic in Ethiopia. They determined the basic reproduction number analytically. Then authors performed

stability analysis of the disease-free equilibrium in their proposed model. They concluded with the observation that to combat the disease, rate of transmission must decline below a desired level.

[10] have analyzed the pandemic in context with India. They observed that the ARIMA model correctly predicted deaths while the SARIMA model performed better in predicting new cases. Apart from these authors also employed prophet model for accuracy and forecasting. [11] compiled an article to evaluate different models for the early prediction of outbreak of Covid pandemic. They evaluated different models like LSTM, GRU and ARIMA.

Apart from these, some researchers have worked on prediction and forecasting regarding progress and spread of COVID-19 [12][13]. Another research work on prediction regarding India is presented in [14]. [15] identifies limitation of most, related, works. They observed that these were carried out during first half of 2020 when little data was available regarding spread of the epidemic.

[16][17] have analyzed the effect of temperature and humidity on the spread of Covid pandemic. It was observed that during winters transmission rate of COVID-19 may be slightly higher. While [18] has worked on role of weather in transmission of the disease in populated countries like India. [19] observed that weather may have only resulted in slowing down spread of COVID-19 but do not halt it.

Most of the related works were carried out in scenario prior to onset of second wave and authors have found that there is a research gap as far as prediction of third wave is concerned.

### 3 ARIMA Model for forecasting Time Series

Covid database used in this work consists of daily confirmed cases in India. Such databases are termed as time-series. In time series, a metric is recorded over a time - at regular interval. In case of pandemic like Covid one such metric is 'number of confirmed cases' (univariate time series). Next step is to analyze the time series and then make predictions based on analysis. Forecasting of time series data is precious. It can help to take timely decisions and divert unforeseen forecasted challenges. For an example, any forecast regarding third wave of Covid and its magnitude can help governments in preparing well in advance. Government may adopt strategies towards averting or minimizing the probable damage. The wrath caused by unexpected second wave has forced several states across India to build infrastructure well in advance to face any probable third wave. Country has realized the essence of complete vaccination to desist any future spread of disease which can be seen by the impetus given to vaccination program by the country. More than one crore (10 million) vaccines were administered in a single day on Aug 28, 2021.

Several different approaches have been adopted by the research fraternity for analysis and forecasting of Covid data. One of the most employed technique is ARIMA (Auto Regression Integrated Moving Average) model. It is suitable for deeper analysis of time series like Covid. It integrates two statistical approaches for regression and prediction. It integrates the time series based on values in hand (own lags) and lagged forecast errors thereby making more precise

predictions. In case the time series has seasonal variation, then the modified form SARIMA (Seasonal ARIMA) is employed. It is nearly established that coronavirus causing Covid is minimally affected by the temperature, so ARIMA is more suitable than SARIMA.

Forecasting through ARIMA model revolves around three parameters:

1. 'p': It represents the order of AR (Auto Regression term). AR represents number of lags of Y to be employed for prediction. Pure autoregression model where Y (at given time, t) depends only on its lags is represented as:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \dots + \beta_p Y_{t-p} + \epsilon_t \quad (1)$$

Where  $Y_{t-i}$  is lag<sub>i</sub> of the series and  $\beta_i$  is its coefficient.

2. 'q': It is the order of MA (Moving Average) term. In case of pure moving average model Y (at given time, t) depends only on lagged forecast errors as:

$$Y_t = \alpha + \epsilon_t + \phi_1 \epsilon_{t-1} + \phi_2 \epsilon_{t-2} + \dots + \phi_q \epsilon_{t-q} \quad (2)$$

Error terms being errors of the autoregressive models for respective lags.

3. 'd': Underlying assumption for applying ARIMA model is that the time series should be stationary, so number of differencing (denoted by 'd') steps are applied to series to make it stationary. For a stationary time-series 'd' is kept as zero.

In ARIMA model after making the time series stationary through successive differencing, predicted values consists of linear combination of p-lags, linear combination of q-lags forecasted errors and the constant terms. The equation for the same is:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \dots + \beta_p Y_{t-p} + \phi_1 \epsilon_{t-1} + \phi_2 \epsilon_{t-2} + \dots + \phi_q \epsilon_{t-q} \quad (3)$$

#### 3.1 Implementation of ARIMA Model

During this work Python scripts were written to apply ARIMA model on Covid data series. Implementation included

To start the daily data about number of cases reported and the deaths caused by the Covid was downloaded from [1]. Next the python script was written to evaluate various permutation and combinations of (p,d,f) values related with ARIMA model. Prebuilt libraries 'statsmodels' and 'sklearn' were used to implement ARIMA model and calculate MSE (Mean Squared Error) & MAPE (Mean Absolute Percentage Error) respectively. The model was iterated, in automated fashion, over several permutations/combinations of (p,q,d) values. Five best combination of (p,q,d) parameters were selected based on Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE). These were individually analyzed over the Covid data. The summarized results corresponding to various (p,q,d) values are presented in Table 2.

Afterwards combination (p=5, q=2, d=1) was selected for utilizing during final forecasting model based on significance of respective constant, AR, MA values with minimum p

(represented as  $P>[z]$ ) (less than 0.05 as far as possible). Apart from this analysis, models based on combinations (8,1,0) and

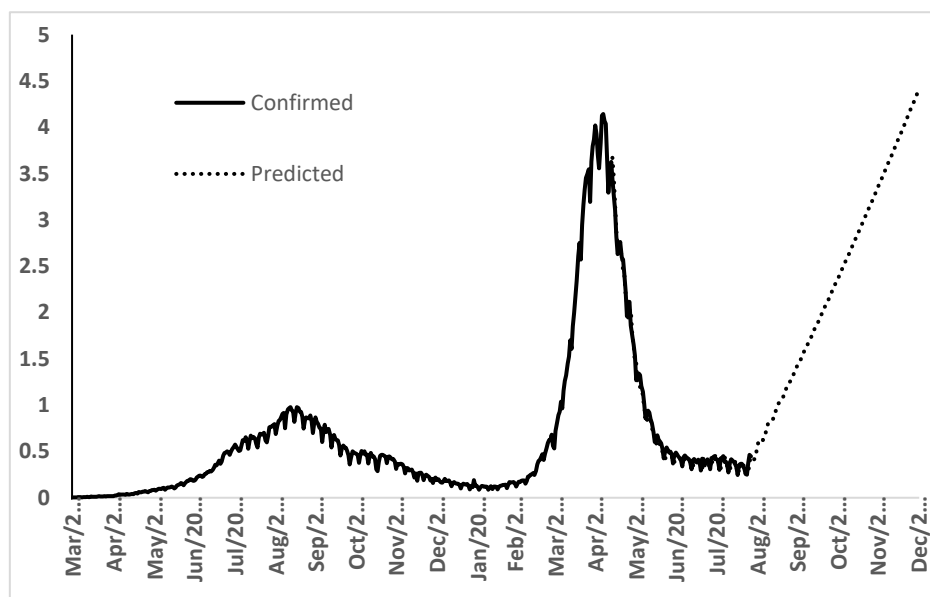
(10,1,0) were also discarded being devoid of differencing as underlying Covid data series is not inherently stationary.

**Table 2.** Best five (p,q,d) combinations based on MSE & MAPE compared

	ARIMA(8, 1, 0)			ARIMA(10, 1, 0)			ARIMA(5, 2, 1)		
	Coeff	Std Err	P>[z]	Coeff	Std Err	P>[z]	Coeff	Std Err	P>[z]
<i>const</i>	84.15	1408.1	0.952	84.151	1095.17	0.939	2.1889	32.705	0.947
<i>ar.L1.D.value</i>	-.014	0.043	0.745	-.0366	0.043	0.392	-.3190	0.043	0.000
<i>ar.L2.D.value</i>	-.032	0.027	0.235	0.099	0.042	0.019	-.4922	0.041	0.000
<i>ar.L3.D.value</i>	.020	0.027	0.440	0.162	0.042	0.000	-.3867	0.044	0.000
<i>ar.L4.D.value</i>	.015	0.027	0.575	0.029	0.026	0.270	-.3320	0.040	0.000
<i>ar.L5.D.value</i>	.005	0.027	0.836	-0.002	0.026	0.911	-.4603	0.040	0.000
<i>ar.L6.D.value</i>	.085	0.027	0.001	.0924	0.026	0.000			
<i>ar.L7.D.value</i>	.769	0.027	0.000	.7714	0.026	0.000			
<i>ar.L8.D.value</i>	.029	0.027	0.495	.0428	0.042	0.312			
<i>ar.L9.D.value</i>				-.1643	0.042	0.000			
<i>ar.L10.D.value</i>				-.1645	0.043	0.000			
<i>ma.L1.D2.value</i>							-0.6532	0.029	0.000

	ARIMA(6, 1, 1)			ARIMA(4, 2, 2)		
	Coeff	Std Err	P>[z]	Coeff	Std Err	P>[z]
<b>const</b>	84.151	1277.35	0.947	5.2643	55.937	0.925
<b>ar.L1.D.value</b>	0.656	0.045	0.000	0.409	0.044	0.000
<b>ar.L2.D.value</b>	-.179	0.048	0.000	-.475	0.043	0.000
<b>ar.L3.D.value</b>	0.094	0.048	0.051	-.094	0.043	0.028
<b>ar.L4.D.value</b>	0.045	0.048	0.346	-.444	0.044	0.000
<b>ar.L5.D.value</b>	-.135	0.048	0.004			
<b>ar.L6.D.value</b>	.446	0.040	0.000			
<b>ma.L1.D2.value</b>	-.643	0.031	0.000	-1.48	0.031	0.000
<b>ma.L1.D2.value</b>				.823	0.025	0.000

Afterwards another Python script was written for analysis of time series and predictions. Time series (comprising of daily confirmed cases) was divided into a ratio of 4:1 for training and testing purposes respectively.



**Fig. 3.** Progression of Covid in India with ARIMA Forecast (Cases in Lakh)

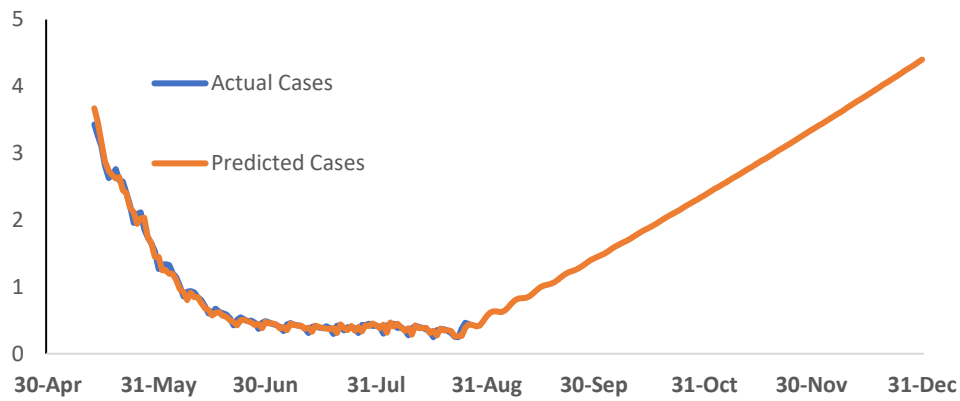


Fig. 4. Prediction of Covid in India with ARIMA (Cases in Lakh)

## 4 Observations

The ratio of training to test data set was 4:1. Number of confirmed cases (in Lakhs - One Lakh = 0.1 million), since the outbreak of pandemic with corresponding predictions up till 31 Dec 2021 are presented in Fig 3 (above). Fig 4 presents prediction about Covid spread.

Following observations can be made:

1. During the week (Aug 23-29, 2021), there was a gradual increase in number of daily cases reported across the country. This trend is confirmed in both figures 3 and 4. This increase has caused apprehension regarding onset of third wave.
2. It was predicted that this trend may continue, and the number of reported cases can rise during the coming months of September, October upto December 2021.
3. The predicted values and the actual observed values are quiet in agreement to each other, and the proposed model should be believed for making predictions.
4. The model forecasts:
  - During the month of September average number of reported daily cases are expected to remain around 90K.
  - During the month of October, average number of daily cases may cross the figure of 190K.
  - This trend will continue and average number of daily forecasted cases for the month of November are 280K.
  - Average daily cases may touch level of 400K, equal to peak during second wave, in December 2021.
5. There is a realistic probability, during next few months, regarding onset of third Covid wave across India. The intensity of probable third wave may be same or even higher than that of second wave. Likely onset of the predicted way is during the months of November-December.
6. If the trends predicted in the model are realized, then country may witness highest ever reported daily cases towards the fag end of the year 2021.

## 5 Limiting Factors

The model deployed during the work predicts onset of third Covid wave with gradually increasing probability starting with the month of October. Yet there are some important underlying developments that can retard present spread of Covid from becoming full fledge Covid wave including

1. **Vaccination:** Taking a leaf out of the setback caused by second wave, vaccination program has been upgraded to massive level throughout the country. Technology oriented world's largest Covid vaccination drive is going in full flow. The progress of the program is outlined in fig 5. The proportion of Indian population that has received single dose crossed 35% from a level below 10% before onset of second wave during April-May 2021. Moreover, proportion of fully vaccinated population has crossed 10% from meagre levels under 1% before onset of second wave. Central Government has undertaken the mission to vaccinate the whole population free of cost. Vaccine for children below 18 years are approved, and the vaccination drive have been schedule for them. Initially, children at higher risks that is with existing comorbidity will be vaccinated. India recently achieved a landmark where more than one crore (10 million) peoples were vaccinated in a single day.
2. **Seroprevalence:** ICMR (Indian Council of Medical Research) has conducted drive to find seroprevalence amongst population against Covid. The outcomes of four-drives conducted thus far are tabulated in Table 3. It shows the way antibodies against Coronavirus have developed among population. Till June-2021, less than 1% population had developed antibodies against Coronavirus whereas by July 2021 more than 67% population have developed the antibodies. Some striking findings of the fourth serosurvey are [20]:
  - More than two third of the population has developed antibodies, either via natural immunity or vaccination, against the deadly virus. It gives a remote hope to achieve herd immunity. The

impetus on vaccination is going to play a vital role in retarding the onset of the third wave.

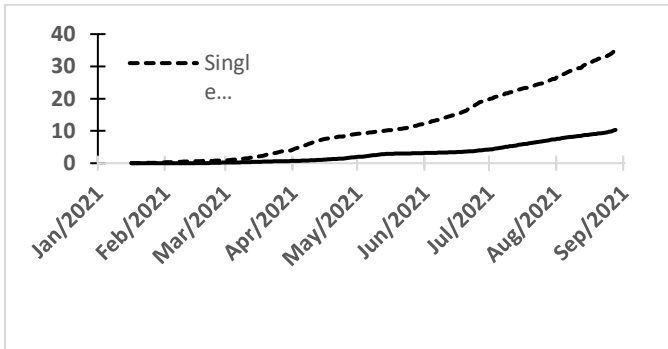


Fig. 5. Vaccination Progress in India (Source: Our World in Data)

- Around 62% of unvaccinated population have the antibodies in their blood.
- 81% persons with only the first vaccination dose have antibodies.
- 89.8% of fully vaccinated people have antibodies to fight the deadly virus.
- Around 40 crore unvaccinated people are still vulnerable to COVID-19 infection due to lack of antibodies.
- The survey covered 28,975 general population and 7,252 healthcare workers spanning 70 districts across 21 states.

Table 3. Seroprevalence Survey against Covid-19 in India by ICMR

SNo	Survey	Duration	Seroprevalence	Age Group
01	First Survey	11/05/2020-04/06/2020	0.73%	>18 y
02	Second Survey	17/08/2020-22/09/2020	6.60%	>10 y
03	Second Survey	17/08/2020-22/09/2020	7.10%	>18 y
04	Third Survey	17/12/2020-08/01/2021	25.30%	10-17y
05	Third Survey	17/12/2020-08/01/2021	24.10%	>18y
06	Fourth Survey	June-July 2021	67.60%	>6 y

3. **Confined Outbreak:** Another interesting feature of the current spurt in Covid cases is the localization of spread [Table 1]. Most of the spread is confined to few states leaving behind a major part of the country unaffected. So, there can be possibility of confined third wave with most part across the country following their normal routine.

All these factors are going to limit the forecast made during this work. With the forecast of outbreak of third Covid wave may be significantly affected by the facts that with more than 35% population is vaccinated (at least single dose) and above 67% people having seroprevalence against the deadly virus.

Yet the county and the people should not relax. There are 40 crore unvaccinated people devoid of antibodies to fight Covid virus. Citizens should keep on following precautionary measures like hand hygiene and social distancing until the complete battle against the pandemic is over.

## 6 Conclusions

India has witnessed two Covid waves, with second wave being deadlier. Onset of the second wave caught everyone unaware. Within no time it gripped the whole country. Since the cooling down of second wave, different cross sections of government & society are continuously raising concern regarding probable third wave during the months of October. Recent rise in Covid cases during second fortnight of August 2021 have further enhanced this apprehension. So, this work was undertaken.

During this work ARIMA model was deployed to analyze the outbreak of Covid-19 in India considering number of reported cases thus far. Model was employed to predict worrisome third wave.

ARIMA model is popular among research fraternity for time series analysis and prediction. Different permutation/combination of key ARIMA parameters (p,q,d) were initially iterated to finalize five best candidates based on Mean Squared Error & Mean Absolute Percentage Error. Finally, the model was run with best combination selected by comparing statistical output.

It was observed that the recent rise in Covid-19 cases is expected to continue and may convert into the third wave by the months of November/December. Same observation is also confirmed by [21]. Although this prediction is limited by various recent developments that were not there in case of earlier waves viz. ICMR seroprevalence survey results showing more than two third population (above 6 years) have antibodies against the coronavirus in their body, vaccination campaign undertaken with high priority (record vaccination, 10 million, administered in one single day). Moreover, the recent rise in cases is confined to four-five south Indian states mainly Kerala. Hence scenario is different from what it was at the time of onset of earlier waves. Earlier it was much more conducive for spikes/spurts to expand into full-fledge Covid wave. Now the scope of progression of disease into wave is quite limited. So, there is a probability that prediction based on analysis of earlier trends may not realize at all. One more important observation is that around 40 crore population is still unvaccinated i.e. devoid of antibodies thereby providing scope for future spread of pandemic.

Overall, based on the past trends and given the current spike, model employed during this work predicted a strong probability for India facing the third Covid wave by the end of current year. Hence, everyone should remain vigilant and keep on following Covid specific behavior like social distancing, hand hygiene.

## 7 Limitations

During this work past trends of Covid cases were analyzed using ARIMA model to predict future course of pandemic spread. But present scenario quite different from what it was

before earlier two waves. Major contributor to this difference are widespread seroprevalence against the virus and boosted vaccination drive. So, the observation made during this work may prove to be exaggeration.

There are some other models, apart from ARIMA, employed by researchers. Output of those models may be compared with present ARIMA based predictions for better forecast.

## 8 Further Scope

There may be two specific natural extension of this work viz.

Researchers interested in the field can developed multivariate (as against univariate based on daily reported cases), detailed model like SIR model encompassing other affecting parameters. Such parameters may include seroprevalence and vaccination rate.

Microlevel trend analysis and prediction may be more realistic. Rather than analyzing county level data, it can be bifurcated into groups based for micro level analysis. Moreover, India is a vast country, comprising different geographical entities with contrastingly different climatic conditions. Analysis of trends at micro level, that may be state or regional geographical unit level, has prospects for improvements in the predictability. For an example, if Kerala is studied individually, then the prediction may be more realistic than that for whole India in current scenario.

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