Analysis of case Fatality Rate due to COVID-19 for the northern region of India

Project Name:

Analysis of Case Fatality Rate due to COVID-19 for the northern region of India

Project Submitted by:

Subhrojit Das

Registration No.: 115-1111-0998-18

Roll No. : 183115-21-0219

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✞ **Overview**:

Fitting appropriate curves of Case Fatality Rate, Forecasting Case Fatality Rate for the next few months, Interpreting the likely conditions of Northern part of India including the states(Himachal Pradesh, Jammu and Kashmir, Ladakh, Sikkim, Uttar Pradesh, Uttarakhand) during COVID-19 situation (April'20-June'25) .

✞ Abstract

India is one of the severely affected countries in the world due to COVID19. During the pandemic situation it has become a tough challenge to stabilise sectors like agriculture, industry for economical purpose. It is also very challenging for a developing country like India having such a large population to prevent such infectious disease. As human resource is one of the pillars of India's development, the no. of deaths during COVID-19 is a thing to be concerned. The govt. of India keeps the record of no. of confirmed cases, active cases, deaths and cures of each state. Here, our intention is to forecast the case fatality rate of northern region of India(included states: Himachal Pradesh, Jammu and Kashmir, Ladakh, Sikkim, Uttar Pradesh, Uttarakhand) for the next few years and observe the probable figures when case fatality rate will be the lowest or the highest. Forecasting of case fatality rate will help Govt. to plan the health policies, to reform the health structure for the upcoming obstacles. In project, the Case Fatality Rate is calculated from the no. of deaths and confirmed cases. Then, an appropriate polynomial curve is fitted after observing the pattern of line diagram of case fatality rate for the months April"20-May"21. From this, we forecast the probable trend of COVID-19 over the Northern Region of India including the states. It has been noticed that the case fatality rate is sometimes high and sometimes low. Therefore, we notice that there are several waves of COVID-19 disease are going to effect India.

✞ Introduction:

Corona Virus Disease 2019 (COVID-19) was reported in Hubei, China on 31 December 2019 and the WHO declared a global pandemic disease after one month. The infection was spreading at an alarming rate both domestically and internationally. According to the WHO, more than 17 Cr confirmed cases of COVID-19 and 36 lakh deaths have been reported globally as of 31 May 2021. The first case of COVID-19 in India, which originated from China, was reported on 30 January 2020.Consequently, all commercial domestic and international flights were suspended in March. On 24 March, with 519 confirmed cases and 9 deaths in the country, the Prime Minister announced that India would be placed under a "total lockdown" for at least three weeks. All non-critical businesses and services were ordered closed except for hospitals, grocery stores, and pharmacies, and there was a "total ban" on leaving the home for non-essential purposes. All public transport was suspended. On 16 April, districts were divided into zones using a colourcoded tier system based on incidence rates, classified as a "Red" (hotspot), "Orange", or "Green" (little to no transmission) zone. All of India's major cities fell into Red zones. Beginning 20 April, agricultural businesses and stores selling farming supplies were allowed to resume operation, as well as public works programmes, cargo transport, and banks and government centres distributing benefits. Phase 3 and 4 of the lockdown extended till 31 May, with incremental relaxations and changes. People infected with COVID-19 may have little or no symptoms and the symptoms ranged from mild symptoms to severe illnesses, and the incubation period of COVID- 19 may last 2 weeks or longer. The disease may still be infectious during the latent period of infection and the virus can spread through respiratory droplets and close contact from person to person. In the fight against the pandemic, it is crucial to be able to identify the rate at which the epidemic spreads. Awareness at the level of spread at any given time has the ability to help governments

Plan and develop public health policies to deal with the consequences of the pandemic. The way to be aware of the magnitude of the spread, and thus the timing of its peak, is to be able to accurately predict the number of active cases at any given time. Epidemic mathematical models are best possible technique in analysing the control and spread of infectious diseases. Time-series analysis is a tool to extrapolate forecasts, in which the mathematical model is established based on to the regularity and trend of the historical values observed over time and has been commonly used in predicting the spread of COVID-19. Modelling the disease and providing future forecasts of the possible number of cases per day may help the health care system to prepare for new patients. The statistical prediction models are therefore useful both in predicting and monitoring the global threat of pandemic. Therefore, it is extremely important to create models that are both computationally competent and practical in order to help policy makers and medical staff.

There are two measures used to assess the proportion of infected individuals with fatal outcomes. The first is infection fatality rate (IFR), which estimates this proportion of deaths among all infected individuals. The second is case fatality rate (CFR), which estimates this proportion of deaths among identified confirmed cases. (Here our only interest is Case Fatality Rate)

- **Dataset Description**: Regular updates of officially confirmed cases of COVID- 19 were collected from the website https://www.covid19india.org/ . A daily dataset of North East region of India is collected from April 2020 to May 2021. Here I include Himachal Pradesh, Jammu and Kashmir, Ladakh, Sikkim, Uttar Pradesh, Uttarakhand as Northern region of India. From this website I collect confirmed cases, Active cases, recovered cases, number of deaths.
- ***Case Fatality Rate:*** It the proportion of persons with a particular condition (e.g., patients) who die from that condition. The denominator

is the number of persons with the condition; the numerator is the number of cause-specific deaths among those persons. ***Formula:***

$$\text{CFR} = \frac{\textit{Number of deaths from disease}}{\textit{Number of confirmed cases of disease}} * 1000$$

- ***Line Diagram:*** When the data vary over time, we take recourse to line diagram. In a simple line diagram, we plot each pair of values of (x, y), "y" representing the time series at the time point t in the "x–y" plane. The plotted points are then joined successively by line segments and the resulting chart is known as line-diagram.
- ***Polynomial Trend:*** If a polynomial is fitted to whole series by least squares, it evidently gives the curvilinear regression of $\mathbf{U_t}$ on the variable '**t**'. Let, polynomial of degree '**p**' in '**t**' is chosen to represent the trend movement, viz, $\mathbf{U_t = a_0 + a_1 t + \ldots + a_p t^p}$,where, $\mathbf{a_0, a_1, \ldots, a_p}$ are constants. **'t'** is time point. Polynomial trending describes a pattern in data that is curved or breaks from a straight linear trend. It often occurs in a large set of data that contains many fluctuations. As more data becomes available, the trends often become less linear, and a polynomial trend takes its place. Graphs with curved trend lines are generally used to show a polynomial trend.

- ***Forecasting:*** Forecasting is a technique that uses historical data as inputs to make informed estimates that are predictive in determining the direction of future trends. It is an uncertain process as a whole and even more so if the dataset doesn't have an excellent trade line or if the dataset is affected by too much variables in the real world.

- ***Northern Region of India:*** In the project work here we have consider six states(Himachal Pradesh, Jammu and Kashmir, Ladakh, Sikkim, Uttar Pradesh, Uttarakhand) as northern part of India. The Govt. Of India keeps the records of COVID-19 disease on daily basis for the states individually. Thus, we calculate the figures of active cases, deaths and cures combining the states' figures based on per month.

- ***Included States:*** We have taken Himachal Pradesh, Jammu and Kashmir, Ladakh, Sikkim, Uttar Pradesh, Uttarakhand as Northern Region of India. The figures of Confirmed case and Death are different for every state for each month. The main data is given in cumulative figures. We have calculated the actual figures from the data.

✞ *Methodology:*

- **Identification of the variable:** Here according to the collected data, the number of confirmed cases, death cases and CFR are dependent. And the time point is independent.

- **Data Processing:** In the collected dataset the confirmed cases and the number of deaths were given in cumulated form per day basis. We take the cumulative figures of last date of each month as the final cumulative figure per month. Then we converted that into actual figures(given in **Table:2, Table:4, Table:6, Table:8, Table:10, Table:12, Table:14**)by this-

  Frequency of k-th timepoint= (Cumulative frequency of k th timepoint – Cumulative frequency of (k-1) th timepoint)

- **Case Fatality Rate :** Here we consider the denominator of CFR i.e number of persons with disease in a certain period as confirmed cases. Here confirmed cases is defined as:
  Confirmed cases=No. of active cases + No. of deaths + No. of recovered cases.
  And the numerator of the given ratio is No of deaths in a certain period. Here we calculated CFR without any multiplier. Thus, we calculate CFR by using formula-

$$\text{CFR} = \frac{\textit{Number of deaths from disease}}{\textit{Number of confirmed cases of disease}}$$

- **Diagrammatic Representation Of Data:** Representation of statistical data by diagram is very effective and being easily convincible to the

general public. It must be stated, however the information for a limited no. of topics only can be presented in a single diagram so as to maintain its neatness. The most convenient and effective method of representing case fatality rate is to use a line diagram because it is a time series data. Now we consider the months(April 2020- May-2021) along the horizontal axis(x axis) and the value of CFR along the vertical axis(y axis) for the states of northern region of India. The values of the 14 months represent 14 points on the graph which are next joined by line segment.

- **Curve Fitting:** Curve fitting is one of the most powerful and most widely used analysis tools in origin. The curve fitting examines the relationship between independent variable and dependent variable, with the goal of defining "Best Fit" mode of the relationship. The objective of curve fitting is theoretically described experimental data with a model (function or equation) and to find the parameter associated with the model. Here we fit 2^{nd} degree, 3^{rd} degree, 4^{th} degree, 5^{th} degree and 6^{th} degree polynomial and find out the fittest.
- **Forecasting:** The dataset is forecasted up to June'25 using the FORECAST SHEET function in MS EXCEL where we get a line graph with forecasted values with the upper and lower confidence intervals where the confidence interval is set at 95% and seasonality 8. It also shows a forecasted value along almost in a fluctuating basis since the graph is too haphazard to predict.
- **Functions Used in Forecasting ->**
  - ✦ **FORECAST.ETS ->** Calculates or predicts a future value based on existing (historical) values by using the AAA version of the Exponential Smoothing (ETS) algorithm. The predicted value is a continuation of the historical values in the specified target date, which should be a continuation of the timeline. You can use this function to predict future sales, inventory requirements, or consumer trends. This function requires the timeline to be organized with a constant step between the different points. For example, that could be a monthly timeline with values on the 1st of

every month, a yearly timeline, or a timeline of numerical indices. For this type of timeline, it's very useful to aggregate raw detailed data before you apply the forecast, which produces more accurate forecast results as well.

- **Syntax->** FORECAST.ETS (target_date, values, timeline, [seasonality], [data_completion], [aggregation]).
- **FORECAST.ETS.CONFINT ->** Returns a confidence interval for the forecast value at the specified target date. A confidence interval of 95% means that 95% of future points are expected to fall within this radius from the result FORECAST.ETS forecasted (with normal distribution). Using confidence interval can help grasp the accuracy of the predicted model. A smaller interval would imply more confidence in the prediction for this specific point.
- **Syntax->** FORECAST.ETS.CONFINT(target_date, values, timeline, [confidence_level], [seasonality], [data_completion], [aggregation]). The Upper Confidence Bound is found by adding the following syntax with it's respective values to the corresponding row of its forecast value.The Lower Confidence Bound is found by subtracting the following syntax with it's respective values from the corresponding row of its forecast value.

✞ Data Analysis:

- **Tabular and Graphical Representation with Analysis:**

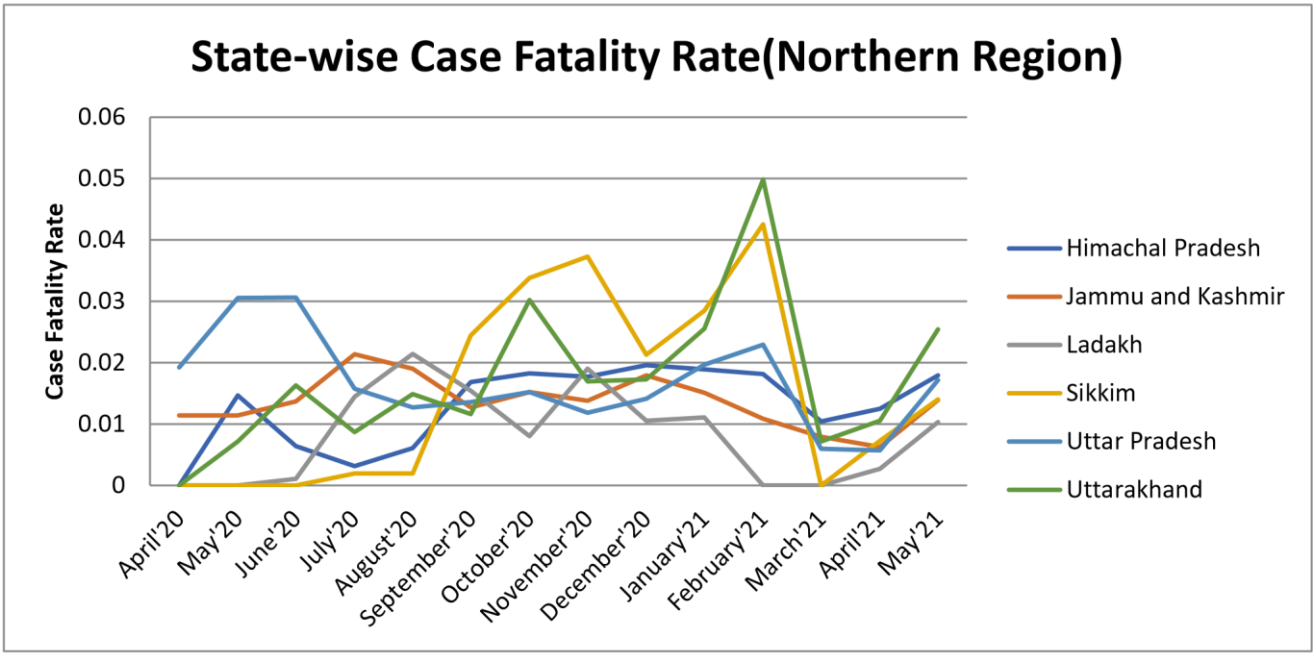
Comparison of State-wise Case Fatality Rate

Table:1

Month wise Case Fatality Rate of States and North India(without multiplier)

Months	Himachal Pradesh	Jammu and Kashmir	Ladakh	Sikkim	Uttar Pradesh	Uttarakhand	Northern Region
April'20	0	0.011385199	0	0	0.019183473	0	0.016955539
May'20	0.014652015	0.011363636	0	0	0.03050273	0.007204611	0.023606476
June'20	0.0063593	0.013684641	0.001123596	0	0.030618215	0.016330451	0.024074769
July'20	0.003196931	0.021374288	0.014492754	0.001915709	0.015718679	0.008738781	0.015906776
August'20	0.006106426	0.019023939	0.021428571	0.001966568	0.01269771	0.014872638	0.013327919
September'20	0.01681436	0.012726091	0.015414258	0.024427481	0.013544178	0.011613352	0.013382809
October'20	0.018295277	0.015171732	0.008004002	0.033811475	0.015159693	0.030172414	0.016977443
November'20	0.017742378	0.013785107	0.019013128	0.037313433	0.011894936	0.016981891	0.014070451
December'20	0.019588379	0.017906336	0.010536398	0.021300448	0.014155431	0.017326124	0.016184455
January'21	0.018907563	0.01511471	0.011029412	0.028436019	0.019718123	0.025495231	0.020159953
February'21	0.018112488	0.010887316	0	0.042553191	0.022928768	0.049844237	0.022577093
March'21	0.010449321	0.007905138	0	0	0.005930729	0.00712666	0.007176844
April'21	0.012529389	0.006267277	0.002668802	0.007265522	0.005711381	0.010555325	0.006510625
May'21	0.017949771	0.013893065	0.010364932	0.014008621	0.017175637	0.025405451	0.018235944

Figure:1



*The figures of CDR are given in **Table:1**

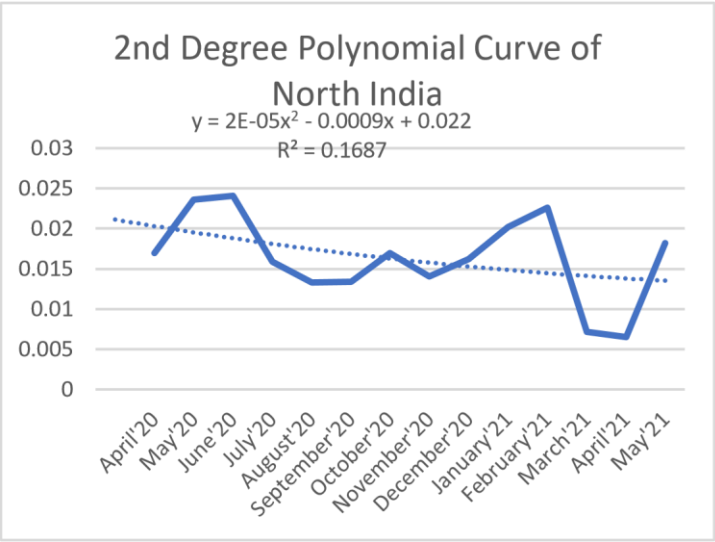
We have considered the states Himachal Pradesh, Jammu and Kashmir, Ladakh, Sikkim, Uttar Pradesh and Uttarakhand as the Northern Region of India. In **Table:1** all the figures of case fatality rate per month for each state has been given. **Figure:1** represents the graph for the given data in **Table:1.** We have plotted the months in X-Axis and the case fatality rates(without multiplier) in Y-Axis.

We can see from **Table:1** and **Figure:1** at the initial stage, the case fatality rate of Jammu and Kashmir and Uttar Pradesh are positive and for the rest of the states are zero. In April'20 around 11 per 1000 infected people have died in Jammu and Kashmir and around 19 per 1000 infected people have died in Uttar Pradesh during COVID-19. Uttar Pradesh has the highest case fatality rate during the first three months. Around 30 per 1000 infected people have died in months May'20 and June's on average for Uttar Pradesh due to COVID-19. Jammu and Kashmir and Ladakh have reached their peaks in July'20 and August'20 respectively with case fatality 21 per 1000 infected people. From the initial state, Sikkim has lower CFRs. During the period of August'20 to January'21, it has the highest case fatality rate. In the month

of November'20 around 37 per 1000 infected people have died. Uttarakhand and Sikkim have reached their peaks in the month of February'21 with case fatality around 49 per 1000 infected people and 42 per 1000 infected people respectively. During the period March'21 to April'21 the case fatality rates have decreased for all the states and after April'21 the case fatality rates have increased again for all the states, where Uttarakhand has the highest case fatality, 18 per 1000 infected people during COVID-19.

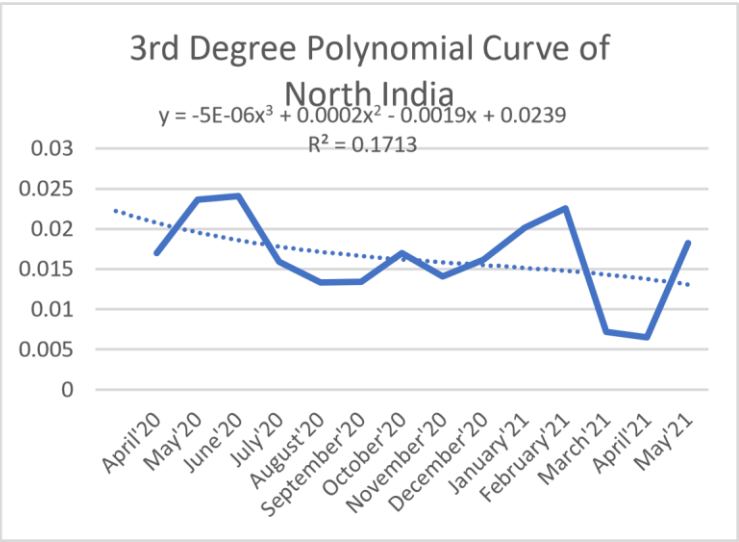
Choice of the appropriate curve

Figure:2



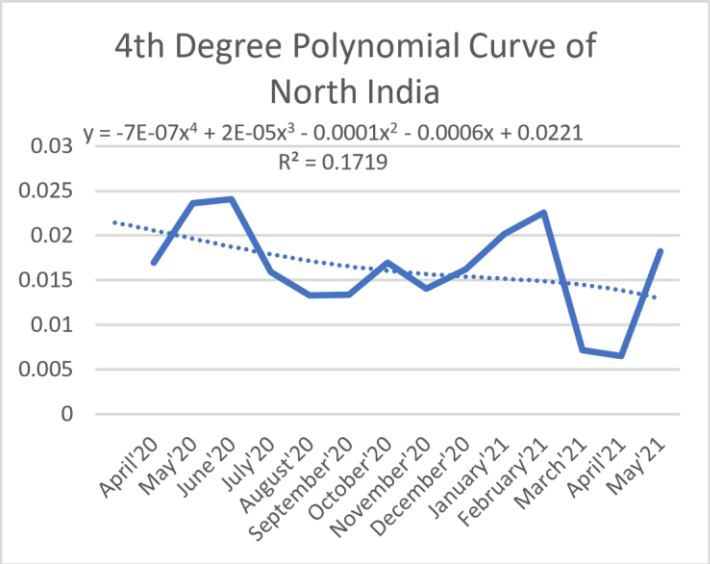
*The figures of CDR are given in **Table:1**

Figure:3



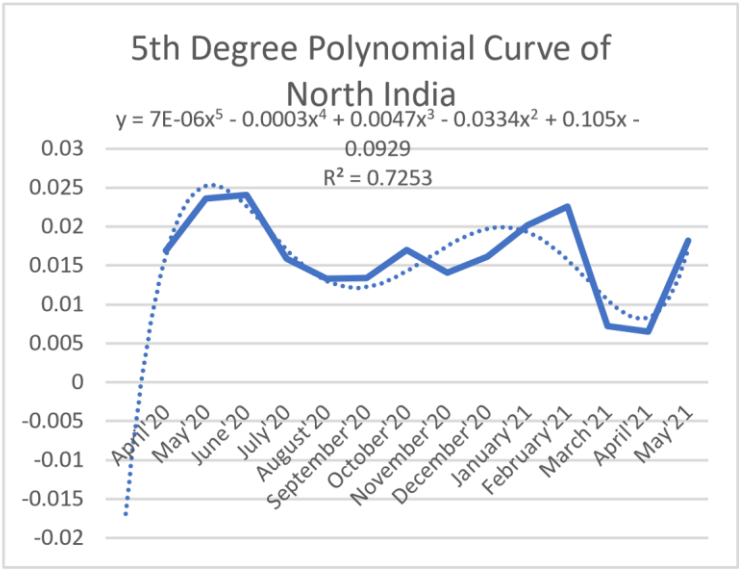
*The figures of CDR are given in **Table:1**

Figure:4



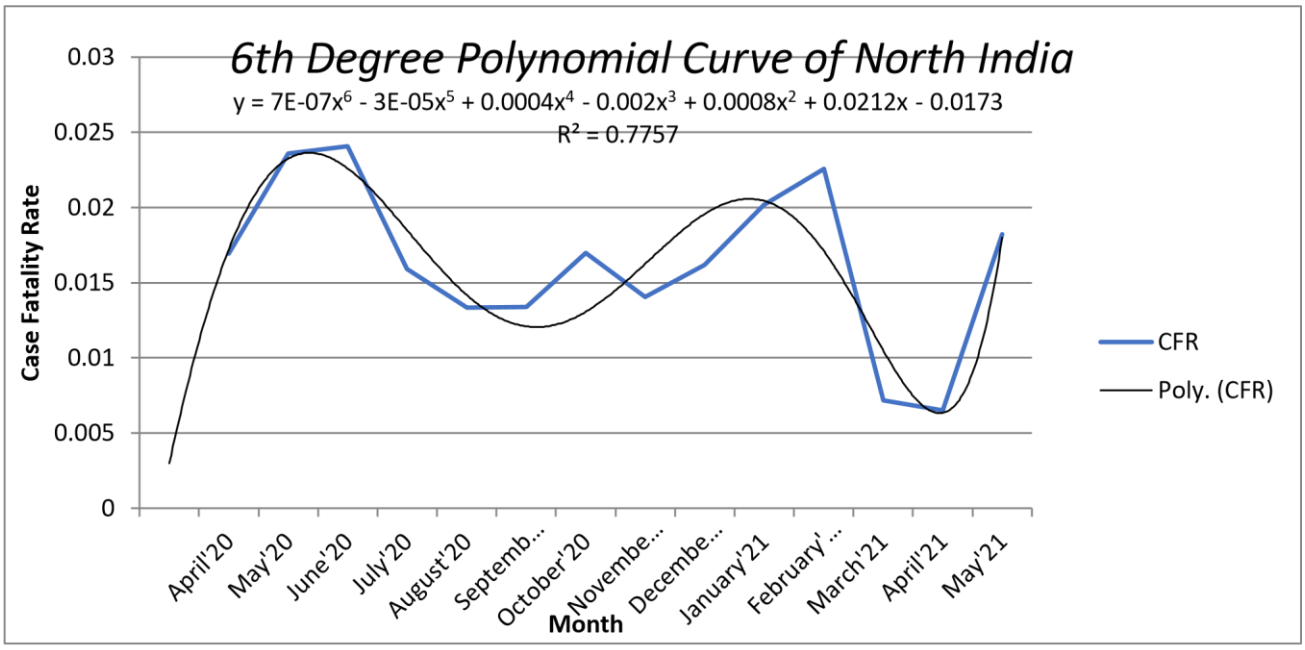
*The figures of CDR are given in **Table:1**

Figure:5



*The figures of CDR are given in **Table:1**

Figure:6



*The figures of CDR are given in **Table:1**

We have plotted the months in X-Axis and the case fatality rates(without multiplier) in Y-Axis for the northern region. Now, we see the best fitted curve is 6^{th} degree polynomial curve. So, we will use the 6^{th} degree polynomial curve for further calculation and rest of the project work.

State-wise Case Fatality Rate and Forecasting

Himachal Pradesh

Table:2

The COVID-19 figures of Himachal Pradesh

Month	Confirmed Case	Death	Case Falatity Rate(without multiplier)
Apr-20	37	0	0
May-20	273	4	0.014652015
Jun-20	629	4	0.0063593
Jul-20	1564	5	0.003196931
Aug-20	3439	21	0.006106426
Sep-20	8802	148	0.01681436
Oct-20	7051	129	0.018295277
Nov-20	18205	323	0.017742378
Dec-20	15111	296	0.019588379
Jan-21	2380	45	0.018907563
Feb-21	1049	19	0.018112488
Mar-21	4785	50	0.010449321
Apr-21	33601	421	0.012529389
May-21	92536	1661	0.017949771

Figure:7

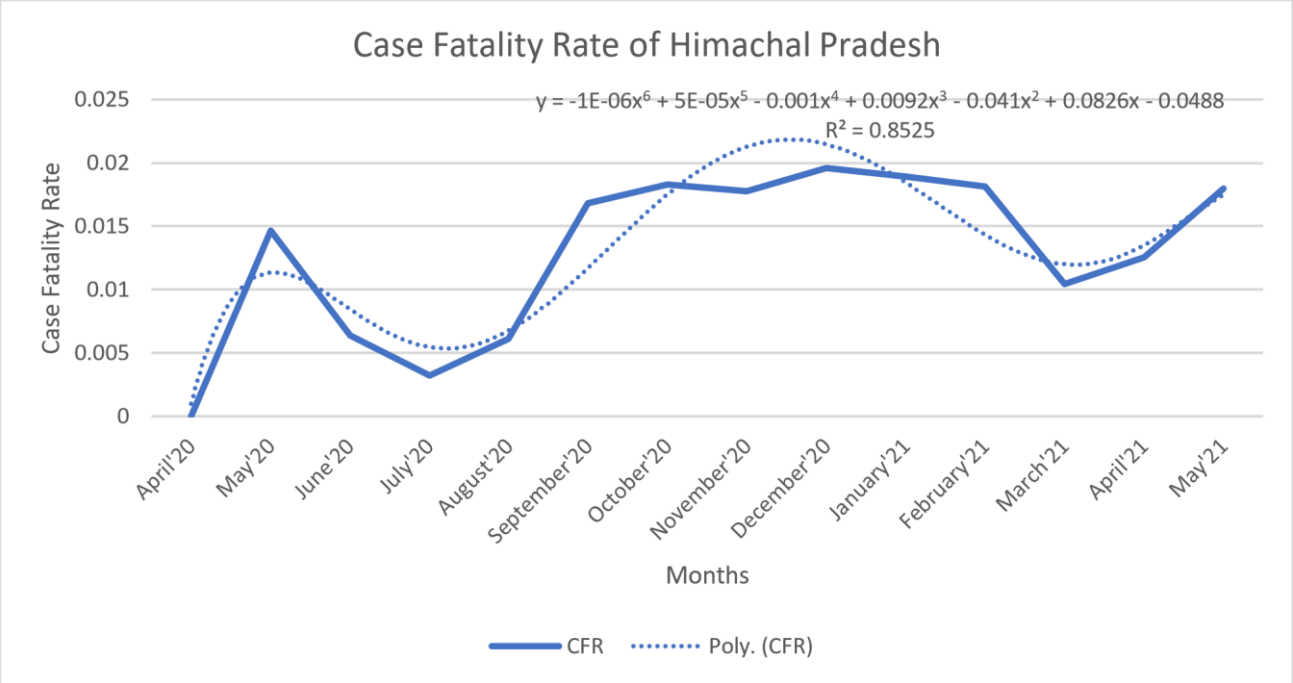


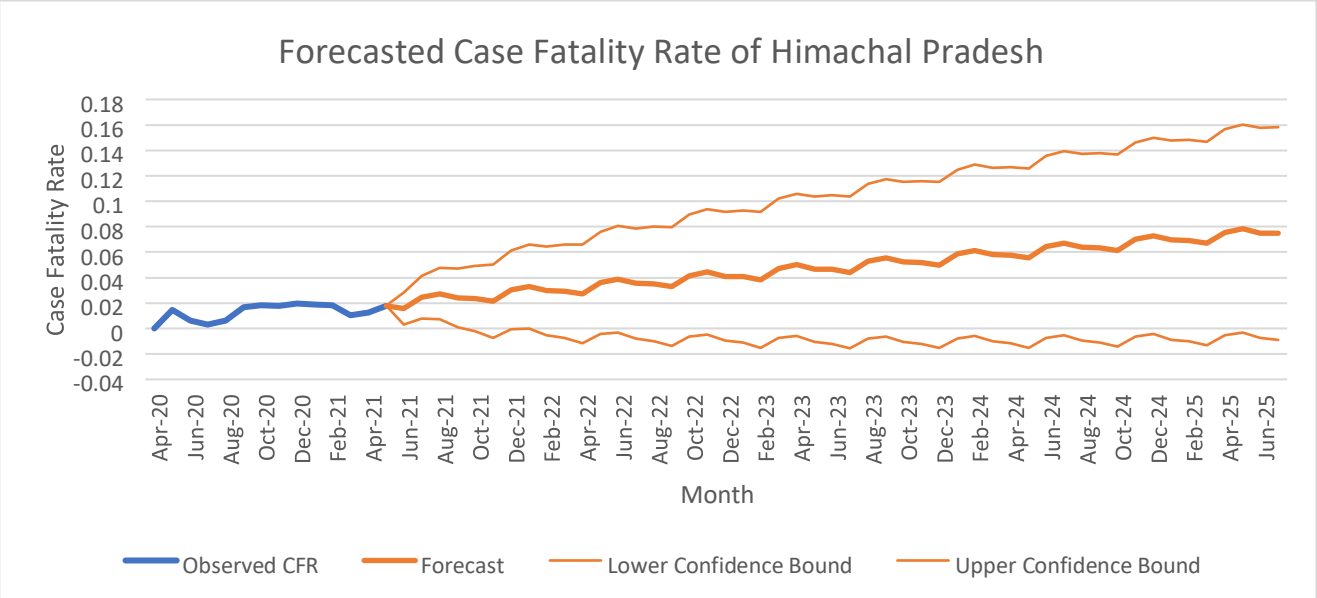
Table:3

Forecasted CFR of Himachal Pradesh

Months	Forecasted CFR	Lower Confidence Bound	Upper Confidence Bound
May-21	0.017949771	0.02	0.02
Jun-21	0.015668004	0.00	0.03
Jul-21	0.024472358	0.01	0.04
Aug-21	0.027320821	0.01	0.05
Sep-21	0.023947538	0.00	0.05
Oct-21	0.02362083	0.00	0.05
Nov-21	0.021345455	-0.01	0.05
Dec-21	0.030149809	0.00	0.06
Jan-22	0.032998272	0.00	0.07
Feb-22	0.029624989	-0.01	0.06
Mar-22	0.029298281	-0.01	0.07
Apr-22	0.027022906	-0.01	0.07
May-22	0.03582726	0.00	0.08
Jun-22	0.038675723	0.00	0.08
Jul-22	0.03530244	-0.01	0.08
Aug-22	0.034975732	-0.01	0.08
Sep-22	0.032700357	-0.01	0.08
Oct-22	0.041504711	-0.01	0.09

Nov-22	0.044353174	-0.01	0.09
Dec-22	0.040979891	-0.01	0.09
Jan-23	0.040653183	-0.01	0.09
Feb-23	0.038377808	-0.02	0.09
Mar-23	0.047182162	-0.01	0.10
Apr-23	0.050030625	-0.01	0.11
May-23	0.046657342	-0.01	0.10
Jun-23	0.046330634	-0.01	0.10
Jul-23	0.044055259	-0.02	0.10
Aug-23	0.052859613	-0.01	0.11
Sep-23	0.055708076	-0.01	0.12
Oct-23	0.052334793	-0.01	0.12
Nov-23	0.052008085	-0.01	0.12
Dec-23	0.04973271	-0.02	0.12
Jan-24	0.058537064	-0.01	0.12
Feb-24	0.061385527	-0.01	0.13
Mar-24	0.058012244	-0.01	0.13
Apr-24	0.057685536	-0.01	0.13
May-24	0.055410161	-0.02	0.13
Jun-24	0.064214515	-0.01	0.14
Jul-24	0.067062978	-0.01	0.14
Aug-24	0.063689695	-0.01	0.14
Sep-24	0.063362987	-0.01	0.14
Oct-24	0.061087612	-0.01	0.14
Nov-24	0.069891966	-0.01	0.15
Dec-24	0.072740429	0.00	0.15
Jan-25	0.069367146	-0.01	0.15
Feb-25	0.069040437	-0.01	0.15
Mar-25	0.066765063	-0.01	0.15
Apr-25	0.075569417	-0.01	0.16
May-25	0.07841788	0.00	0.16
Jun-25	0.075044597	-0.01	0.16

Figure:8



We have plotted the months in X-Axis and the observed or forecasted case fatality rates(without multiplier) in Y-Axis. Now, for **Himachal Pradesh** **Table:2** and **Figure:7** represent observed CFRs ,**Table:3** and **Figure:8** represent forecasted CFRs. From **Figure:7** we can see that the line graph is fluctuated over the time. The graph is increased upto December'20 and reached its peak at case fatality around 20 per 1000 infected people. Then it has suddenly decreased at March'21 with case fatality 10 per 1000 infected people. Again, it has been increased and during May'21 it has case fatality rate 0.017949771. Overall the graph has an upward trend. Thus, in **Figure:8** the forecasted CFRs are increasing over time with some fluctuations. But, the lower confidence bound of CFRs is steadily showing negative values(which we assume to be zero) from July'22. Thus, we can state as per forecast that the death due to COVID-19 won't come to an end till December'22 and so on but there is a mild chance that there may not exist any death cases from July'22 due to COVID-19.

Jammu and Kashmir

Table:4

The COVID-19 figures of Jammu and Kashmir

Months	Confirmed Cases	Deaths	Case Fatality Rate(without multiplier)
Apr-20	527	6	0.011385199
May-20	1760	20	0.011363636
Jun-20	4896	67	0.013684641
Jul-20	12632	270	0.021374288
Aug-20	17294	329	0.019023939
Sep-20	36932	470	0.012726091
Oct-20	20235	307	0.015171732
Nov-20	15524	214	0.013785107
Dec-20	10890	195	0.017906336
Jan-21	3705	56	0.01511471
Feb-21	1837	20	0.010887316
Mar-21	4301	34	0.007905138
Apr-21	41964	263	0.006267277
May -21	116389	1617	0.013893065

Figure:9

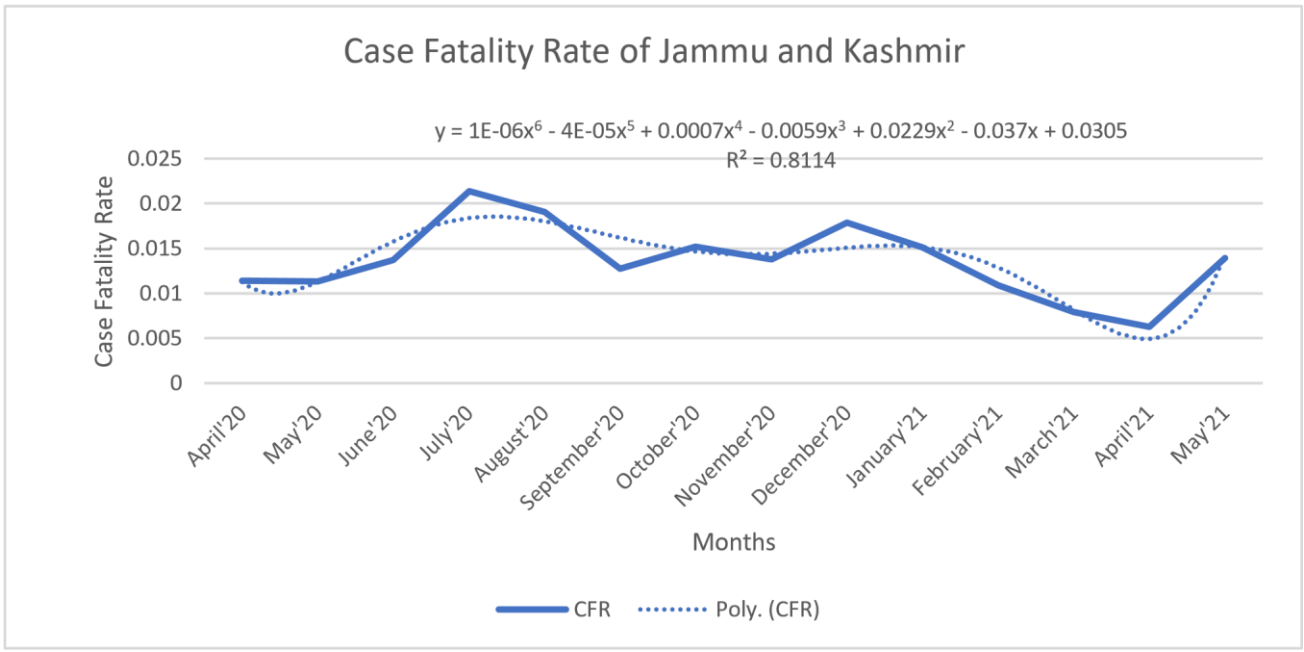


Table:5

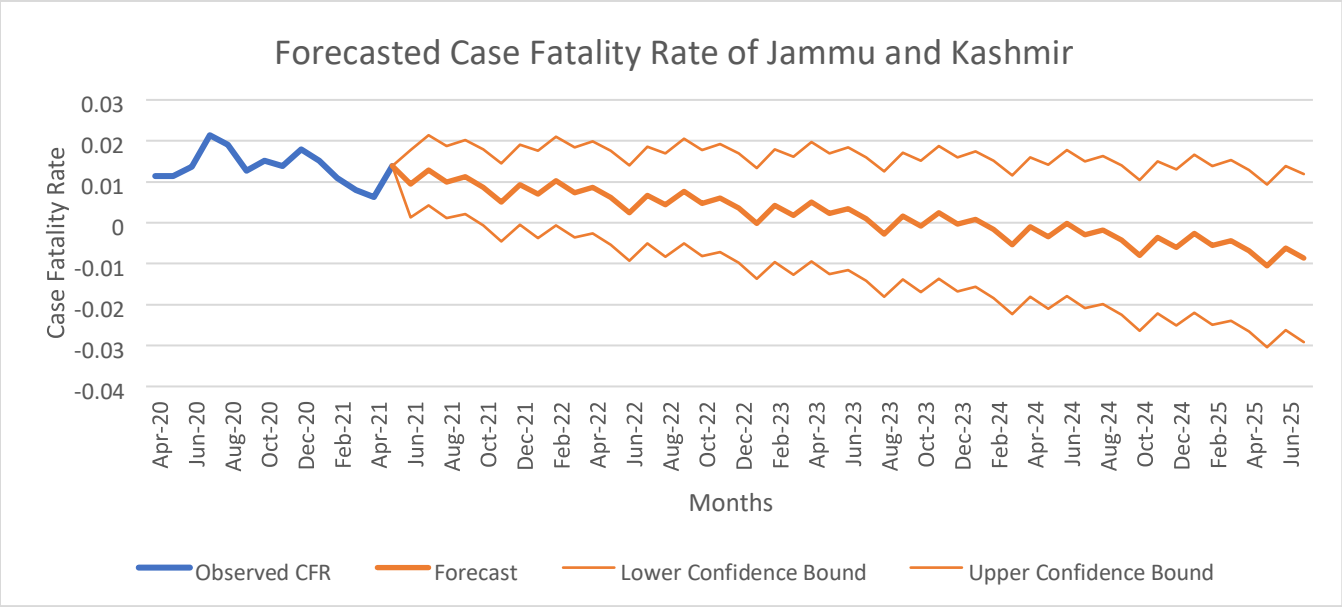
Forecasted CFR of Jammu and Kashmir

Months	Forecasted CFR	Lower Confidence Bound	Upper Confidence Bound
May-21	0.013893065	0.01	0.01
Jun-21	0.009504998	0.00	0.02
Jul-21	0.01283441	0.00	0.02

Aug-21	0.009960543	0.00	0.02
Sep-21	0.011178996	0.00	0.02
Oct-21	0.008689402	0.00	0.02
Nov-21	0.004968801	0.00	0.01
Dec-21	0.009324676	0.00	0.02
Jan-22	0.006919809	0.00	0.02
Feb-22	0.010249221	0.00	0.02
Mar-22	0.007375354	0.00	0.02
Apr-22	0.008593806	0.00	0.02
May-22	0.006104212	-0.01	0.02
Jun-22	0.002383611	-0.01	0.01
Jul-22	0.006739486	-0.01	0.02
Aug-22	0.00433462	-0.01	0.02
Sep-22	0.007664032	-0.01	0.02
Oct-22	0.004790165	-0.01	0.02
Nov-22	0.006008617	-0.01	0.02
Dec-22	0.003519023	-0.01	0.02
Jan-23	-0.000201578	-0.01	0.01
Feb-23	0.004154297	-0.01	0.02
Mar-23	0.00174943	-0.01	0.02
Apr-23	0.005078843	-0.01	0.02
May-23	0.002204976	-0.01	0.02
Jun-23	0.003423428	-0.01	0.02
Jul-23	0.000933834	-0.01	0.02
Aug-23	-0.002786767	-0.02	0.01
Sep-23	0.001569108	-0.01	0.02
Oct-23	-0.000835759	-0.02	0.02
Nov-23	0.002493653	-0.01	0.02
Dec-23	-0.000380214	-0.02	0.02
Jan-24	0.000838239	-0.02	0.02
Feb-24	-0.001651355	-0.02	0.02
Mar-24	-0.005371956	-0.02	0.01
Apr-24	-0.001016081	-0.02	0.02
May-24	-0.003420948	-0.02	0.01
Jun-24	-9.15357E-05	-0.02	0.02
Jul-24	-0.002965403	-0.02	0.01
Aug-24	-0.00174695	-0.02	0.02
Sep-24	-0.004236544	-0.02	0.01
Oct-24	-0.007957145	-0.03	0.01
Nov-24	-0.00360127	-0.02	0.01

Dec-24	-0.006006137	-0.03	0.01
Jan-25	-0.002676725	-0.02	0.02
Feb-25	-0.005550592	-0.02	0.01
Mar-25	-0.004332139	-0.02	0.02
Apr-25	-0.006821733	-0.03	0.01
May-25	-0.010542334	-0.03	0.01
Jun-25	-0.006186459	-0.03	0.01
Jul-25	-0.008591326	-0.03	0.01

Figure:10



We have plotted the months in X-Axis and the observed or forecasted case fatality rates(without multiplier) in Y-Axis. **Table:4** and **Figure:9** represent observed CFRs, **Table:5** and **Figure:10** represent the forecasted CFRs for **Jammu and Kashmir**. From **Figure:9** we see that the graph line is fluctuated over the time. At July'20 the CFR is highest with case fatality around 21 per 1000 infected people. Then it has gradually decreased upto September'20, where the case fatality was around 13 per 1000 infected people. Then It has increased and reached December'20 with case fatality 18 per 1000 infected people. Then, it has decreased again upto April'21. In the month of May'21 we have noticed the case fatality rate is again higher. Overall, the graph has a downward trend. As per forecast we can state that the case fatality rate is being decreased over the time with some fluctuations. It is

being noticed that the outbreak of COVID-19 will be existing through out next two years. After January'24 the forecasted case fatality rate is reduced to negative values, which we assume to be zero. Thus, we can state that from our forecast, in the very beginning of 2024 this state will be free from the deaths due to COVID-19.

Ladakh

Table:6

The COVID-19 figures of Ladakh

Months	Confirmed Cases	Deaths	Case Fatality Rate(without multiplier)
Apr-20	9	0	0
May-20	52	0	0
Jun-20	890	1	0.001123596
Jul-20	414	6	0.014492754
Aug-20	1260	27	0.021428571
Sep-20	1557	24	0.015414258
Oct-20	1999	16	0.008004002
Nov-20	2209	42	0.019013128
Dec-20	1044	11	0.010536398
Jan-21	272	3	0.011029412
Feb-21	97	0	0
Mar-21	303	0	0
Apr-21	3747	10	0.002668802
May-21	4631	48	0.010364932

Figure:10

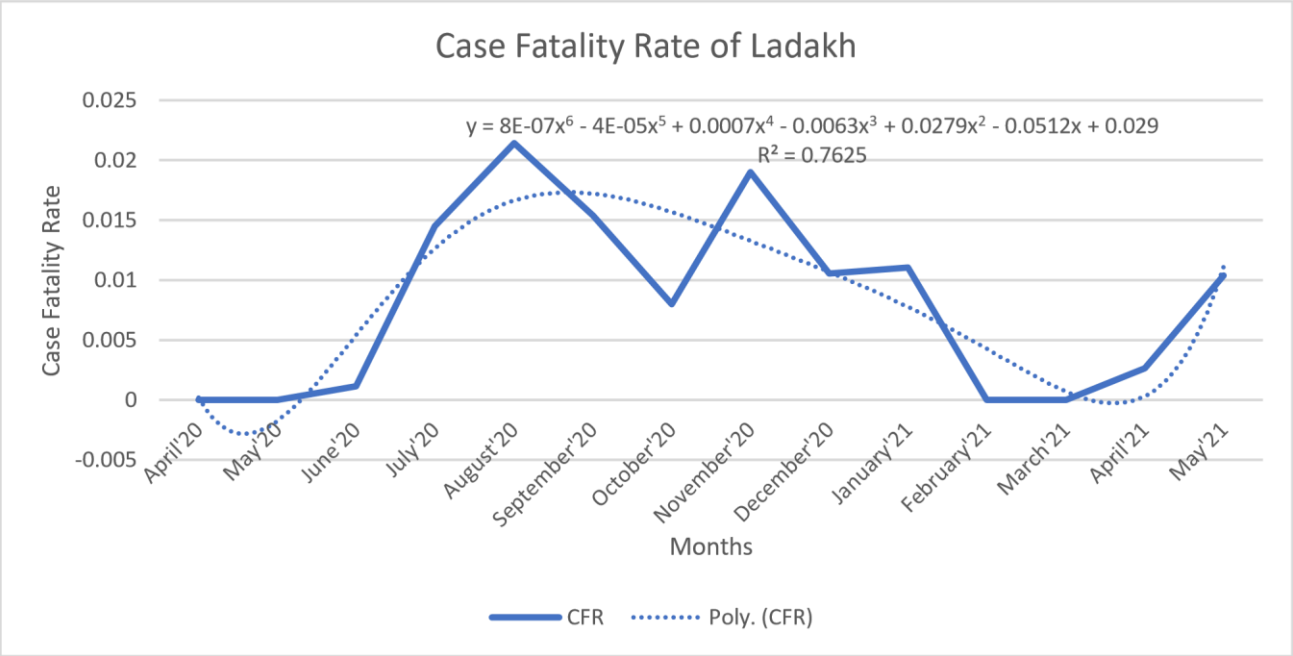


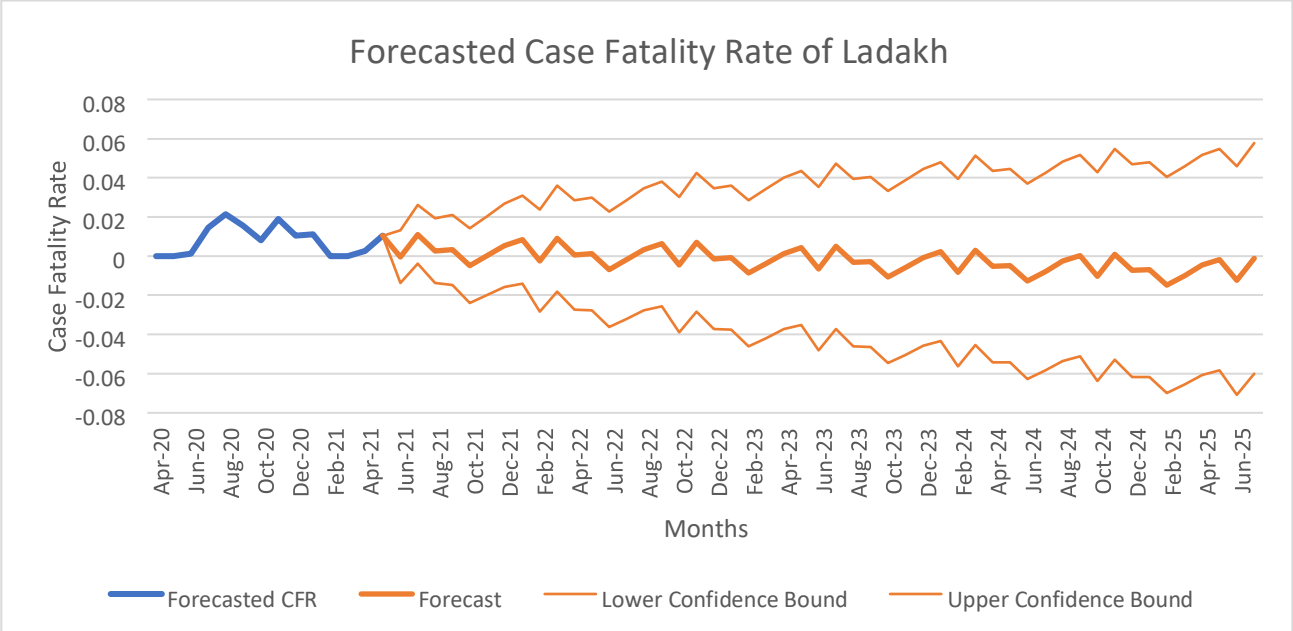
Table:7

Forecasted CFR of Ladakh

Months	Forecasted CFR	Lower Confidence Bound	Upper Confidence Bound
May-21	0.010364932	0.01	0.01
Jun-21	-0.00032622	-0.01	0.01
Jul-21	0.011031895	0.00	0.03
Aug-21	0.002744154	-0.01	0.02
Sep-21	0.003218717	-0.01	0.02
Oct-21	-0.004707988	-0.02	0.01
Nov-21	0.000242506	-0.02	0.02
Dec-21	0.005446266	-0.02	0.03
Jan-22	0.008335388	-0.01	0.03
Feb-22	-0.00234616	-0.03	0.02
Mar-22	0.009011956	-0.02	0.04
Apr-22	0.000724214	-0.03	0.03
May-22	0.001198777	-0.03	0.03
Jun-22	-0.006727928	-0.04	0.02
Jul-22	-0.001777434	-0.03	0.03
Aug-22	0.003426326	-0.03	0.03
Sep-22	0.006315449	-0.03	0.04
Oct-22	-0.0043661	-0.04	0.03

Nov-22	0.006992016	-0.03	0.04
Dec-22	-0.001295726	-0.04	0.03
Jan-23	-0.000821163	-0.04	0.04
Feb-23	-0.008747868	-0.05	0.03
Mar-23	-0.003797374	-0.04	0.03
Apr-23	0.001406387	-0.04	0.04
May-23	0.004295509	-0.03	0.04
Jun-23	-0.006386039	-0.05	0.04
Jul-23	0.004972076	-0.04	0.05
Aug-23	-0.003315666	-0.05	0.04
Sep-23	-0.002841103	-0.05	0.04
Oct-23	-0.010767807	-0.05	0.03
Nov-23	-0.005817313	-0.05	0.04
Dec-23	-0.000613553	-0.05	0.04
Jan-24	0.002275569	-0.04	0.05
Feb-24	-0.008405979	-0.06	0.04
Mar-24	0.002952136	-0.05	0.05
Apr-24	-0.005335605	-0.05	0.04
May-24	-0.004861043	-0.05	0.04
Jun-24	-0.012787747	-0.06	0.04
Jul-24	-0.007837253	-0.06	0.04
Aug-24	-0.002633493	-0.05	0.05
Sep-24	0.000255629	-0.05	0.05
Oct-24	-0.010425919	-0.06	0.04
Nov-24	0.000932197	-0.05	0.05
Dec-24	-0.007355545	-0.06	0.05
Jan-25	-0.006880982	-0.06	0.05
Feb-25	-0.014807687	-0.07	0.04
Mar-25	-0.009857193	-0.07	0.05
Apr-25	-0.004653433	-0.06	0.05
May-25	-0.001764311	-0.06	0.05
Jun-25	-0.012445859	-0.07	0.05
Jul-25	-0.001087743	-0.06	0.06

Figure:12



We have plotted the months in X-Axis and the observed or forecasted case fatality rates(without multiplier) in Y-Axis. The observed CFRs are represented by **Table:6** and **Figure:11** and the forecasted CFRs are represented by **Table:7** and **Figure:12** for **Ladakh**. From **Table:6** we can see in the months of April'20, May'20, February'21 and March'21 there is no death cases. In the month of August'20 the case fatality rate is highest for Ladakh with case fatality 21 per 1000 infected people. In September'20 case fatality has reduced to 8 per 1000 infected people. Again, in November'20 it has become 19 per 1000 people which has been reduced to zero in February'21 and March'21. After that it has started increasing again. Overall, the graph has neither upward nor downward trend. As per forecast sheet, it has the most fluctuations. The figures are being fluctuated all around zero over the years 2021,2022 and mid of 2023. Some mild peaks have been noticed at the beginning of 2024 and it's been continued fluctuating upto November'24. From the end of 2024 the forecasted CFR has turned into negative values,which we assume as zero. Thus, we can state as per forecast that the impact of COVID-19 will be reduced from 2025.

Sikkim

Table:8

The COVID-19 figures of Sikkim

Month	Confirmed Cases	Deaths	Case Fatality Rate(without multiplier)
Apr-20	0	0	0
May-20	1	0	0
Jun-20	87	0	0
Jul-20	522	1	0.001915709
Aug-20	1017	2	0.001966568
Sep-20	1310	32	0.024427481
Oct-20	976	33	0.033811475
Nov-20	1072	40	0.037313433
Dec-20	892	19	0.021300448
Jan-21	211	6	0.028436019
Feb-21	47	2	0.042553191
Mar-21	98	0	0
Apr-21	1514	11	0.007265522
May-21	7424	104	0.014008621

Figure:13

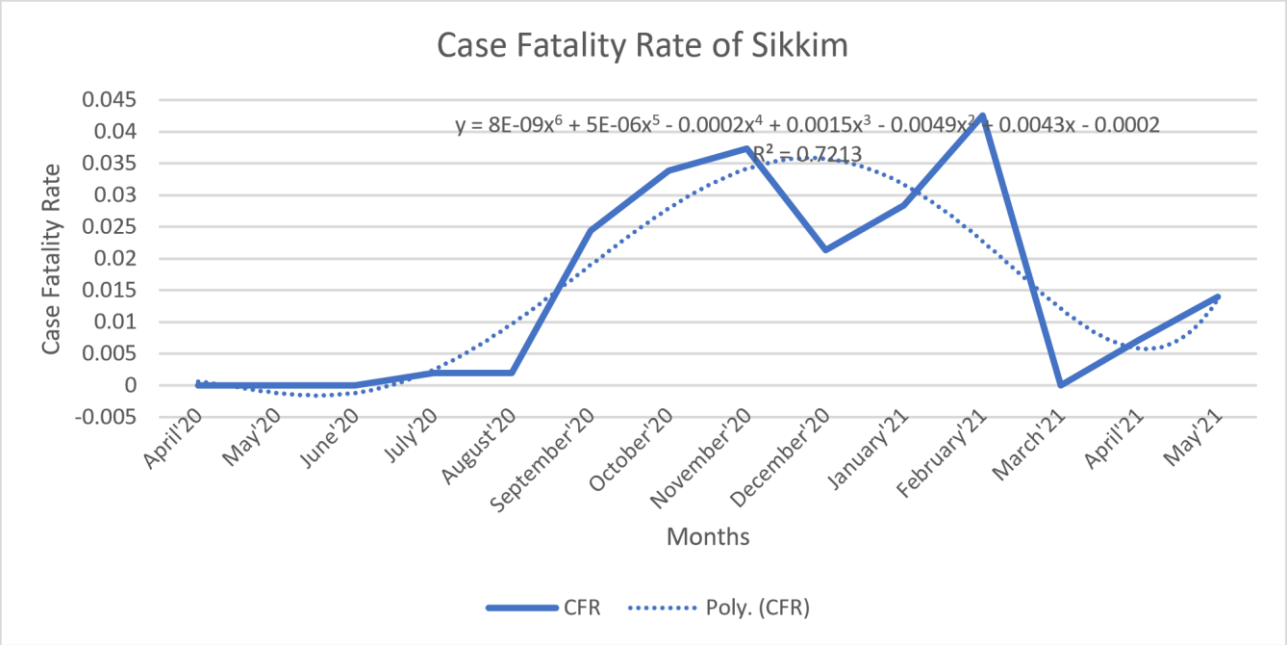


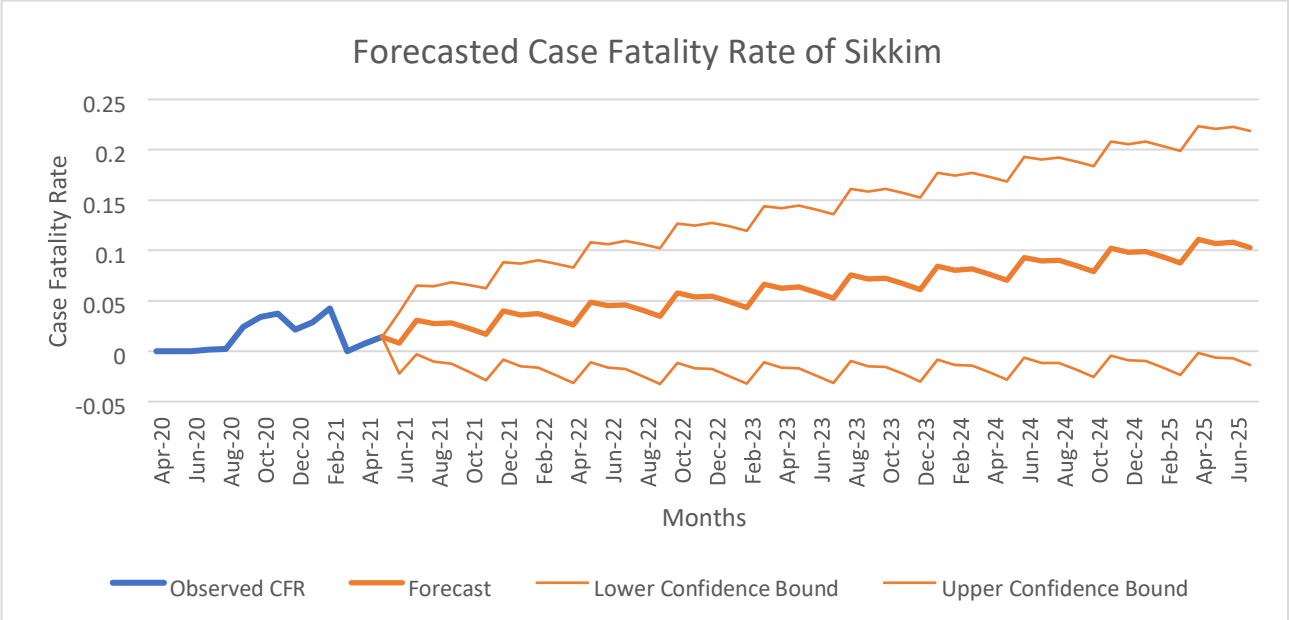
Table:9

Forecasted CFR of Sikkim

Months	Forecasted CFR	Lower Confidence Bound	Upper Confidence Bound
May-21	0.014008621	0.01	0.01
Jun-21	0.00805558	-0.02	0.04
Jul-21	0.031060629	0.00	0.07
Aug-21	0.027243777	-0.01	0.06
Sep-21	0.028176804	-0.01	0.07
Oct-21	0.02288649	-0.02	0.07
Nov-21	0.016933449	-0.03	0.06
Dec-21	0.039938498	-0.01	0.09
Jan-22	0.036121646	-0.01	0.09
Feb-22	0.037054673	-0.02	0.09
Mar-22	0.031764359	-0.02	0.09
Apr-22	0.025811318	-0.03	0.08
May-22	0.048816367	-0.01	0.11
Jun-22	0.044999515	-0.02	0.11
Jul-22	0.045932542	-0.02	0.11
Aug-22	0.040642228	-0.02	0.11
Sep-22	0.034689187	-0.03	0.10
Oct-22	0.057694236	-0.01	0.13
Nov-22	0.053877384	-0.02	0.12

Dec-22	0.054810411	-0.02	0.13
Jan-23	0.049520097	-0.02	0.12
Feb-23	0.043567056	-0.03	0.12
Mar-23	0.066572105	-0.01	0.14
Apr-23	0.062755253	-0.02	0.14
May-23	0.063688281	-0.02	0.14
Jun-23	0.058397966	-0.02	0.14
Jul-23	0.052444925	-0.03	0.14
Aug-23	0.075449974	-0.01	0.16
Sep-23	0.071633122	-0.02	0.16
Oct-23	0.07256615	-0.02	0.16
Nov-23	0.067275835	-0.02	0.16
Dec-23	0.061322794	-0.03	0.15
Jan-24	0.084327843	-0.01	0.18
Feb-24	0.080510991	-0.01	0.17
Mar-24	0.081444019	-0.01	0.18
Apr-24	0.076153704	-0.02	0.17
May-24	0.070200664	-0.03	0.17
Jun-24	0.093205712	-0.01	0.19
Jul-24	0.08938886	-0.01	0.19
Aug-24	0.090321888	-0.01	0.19
Sep-24	0.085031573	-0.02	0.19
Oct-24	0.079078533	-0.03	0.18
Nov-24	0.102083581	0.00	0.21
Dec-24	0.098266729	-0.01	0.21
Jan-25	0.099199757	-0.01	0.21
Feb-25	0.093909442	-0.02	0.20
Mar-25	0.087956402	-0.02	0.20
Apr-25	0.11096145	0.00	0.22
May-25	0.107144598	-0.01	0.22
Jun-25	0.108077626	-0.01	0.22
Jul-25	0.102787311	-0.01	0.22

Figure:14



We have plotted the months in X-Axis and the observed or forecasted case fatality rates(without multiplier) in Y-Axis. The observed and forecasted CFRs of Sikkim are given in Table:8 and Table:9 respectively and the graphical representations are in Figure:13 and Figure:14.The CFRs have been zero at the initial stage and in month of March'21. After June'20 the CFRs have been gradually increased. At the Month of November'20 it has case fatality 37 per 1000 infected people. Then the rate has dropped in December'20 with 21 per 1000 infected people. Again, the graph has been increased and in February'21 it has the highest case fatality with 42 per 1000 infected people. Again, from April'21 the line graph has increased. Overall the graph has an upward trend. Thus, in **Figure:14** the forecasted CFRs are increasing over time with some fluctuations.But, the lower confidence bound of CFRs is steadily showing negative values(which we assume to be zero) from August'21. Thus, we can state as per forecast that the death due to COVID-19 won't come to an end till December'22 and so on but there is a mild chance that there may not exist any death cases from August'21 due to COVID-19.

Uttar Pradesh

Table:10

The COVID-19 figures of Uttar Pradesh

Months	Confirmed Cases	Deaths	Case Fatality Rate (Without Multiplier)
Apr-20	2033	39	0.019183473
May-20	5311	162	0.03050273
Jun-20	15383	471	0.030618215
Jul-20	58211	915	0.015718679
Aug-20	144593	1836	0.01269771
Sep-20	169224	2292	0.013544178
Oct-20	85226	1292	0.015159693
Nov-20	61791	735	0.011894936
Dec-20	43093	610	0.014155431
Jan-21	15113	298	0.019718123
Feb-21	3271	75	0.022928768
Mar-21	12646	75	0.005930729
Apr-21	601956	3438	0.005711381
May-21	472064	8108	0.017175637

Figure:15

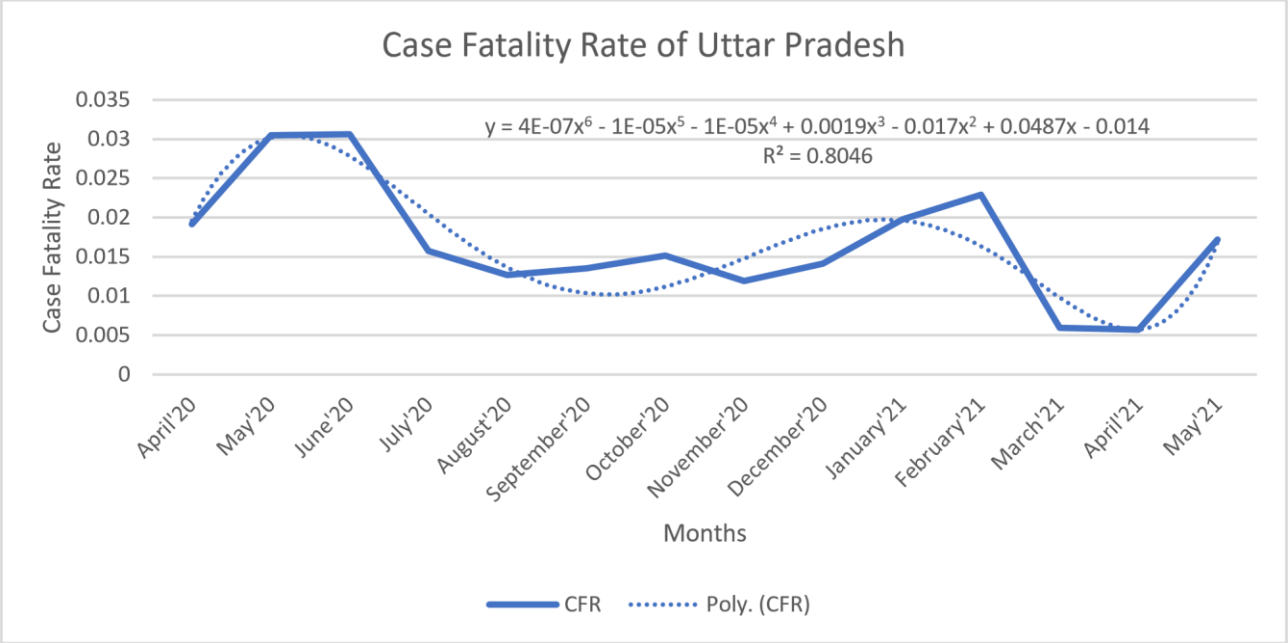


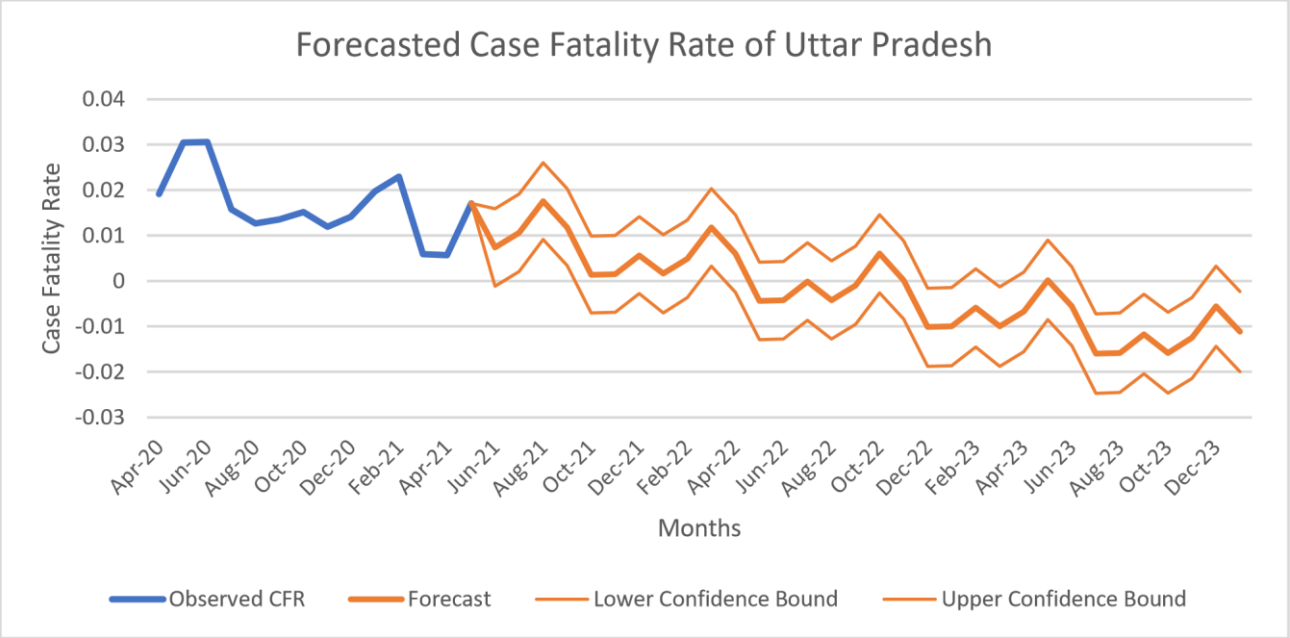
Table:11

Forecasted CFR of Uttar Pradesh

Months	Forecasted CFR	Lower Confidence Bound	Upper Confidence Bound
May-21	0.017175637	0.02	0.02
Jun-21	0.007401716	0.00	0.02

Jul-21	0.010644066	0.00	0.02
Aug-21	0.017589785	0.01	0.03
Sep-21	0.01183468	0.00	0.02
Oct-21	0.001415651	-0.01	0.01
Nov-21	0.001570013	-0.01	0.01
Dec-21	0.005700649	0.00	0.01
Jan-22	0.001611314	-0.01	0.01
Feb-22	0.004853664	0.00	0.01
Mar-22	0.011799383	0.00	0.02
Apr-22	0.006044278	0.00	0.01
May-22	-0.004374752	-0.01	0.00
Jun-22	-0.004220389	-0.01	0.00
Jul-22	-8.97535E-05	-0.01	0.01
Aug-22	-0.004179088	-0.01	0.00
Sep-22	-0.000936739	-0.01	0.01
Oct-22	0.00600898	0.00	0.01
Nov-22	0.000253875	-0.01	0.01
Dec-22	-0.010165154	-0.02	0.00
Jan-23	-0.010010791	-0.02	0.00
Feb-23	-0.005880156	-0.01	0.00
Mar-23	-0.009969491	-0.02	0.00
Apr-23	-0.006727141	-0.02	0.00
May-23	0.000218578	-0.01	0.01
Jun-23	-0.005536527	-0.01	0.00
Jul-23	-0.015955556	-0.02	-0.01
Aug-23	-0.015801194	-0.02	-0.01
Sep-23	-0.011670558	-0.02	0.00
Oct-23	-0.015759893	-0.02	-0.01
Nov-23	-0.012517543	-0.02	0.00
Dec-23	-0.005571824	-0.01	0.00

Figure:16



We have plotted the months in X-Axis and the observed or forecasted case fatality rates(without multiplier) in Y-Axis. **Figure:15** represents the observed case fatality rate of **Uttar Pradesh**, data given in **Table:10**.The graphical representation of forecasted CDRs given in **Table:11** is in **Figure:16.** From the very beginning of COVID-19 period, the case fatality rate graph of Uttar Pradesh has been very high. In May'20-June'20 the case fatality has been 30 per 1000 infected people on average. Then the graph has decreased. In October'20 the rate has slightly increased, then started decreasing again. After reaching second peak in February'21 with case fatality 22 per 1000 infected people the rate has dropped again. In May'21 the case fatality is raised to 17 per 1000 infected people. Overall, the graph has downward trend. From forecast sheet we have seen the impact of COVID-19 is existed throughout the year 2021 and the mid of 2022. Then the rate has turned into negative values which we assume to be zero. It has been observed that the case fatality rate has raised to very small positive values in the end of 2022 and in the middle of 2024.After May'24 there is no peak observed. So, we can state there won't be any death due to COVID19 from mid 2024 and so on.

Uttarakhand

Table:12

The COVID-19 figures of Uttarakhand

Months	Confirmed Cases	Deaths	Case Fatality Rate(Without multiplier)
Apr-20	48	0	0
May-20	694	5	0.007204611
Jun-20	2082	34	0.016330451
Jul-20	4234	37	0.008738781
Aug-20	12170	181	0.014872638
Sep-20	28760	334	0.011613352
Oct-20	13920	420	0.030172414
Nov-20	12425	211	0.016981891
Dec-20	16276	282	0.017326124
Jan-21	5452	139	0.025495231
Feb-21	963	48	0.049844237
Mar-21	3087	22	0.00712666
Apr-21	74749	789	0.010555325
May-21	153471	3899	0.025405451

Figure:17

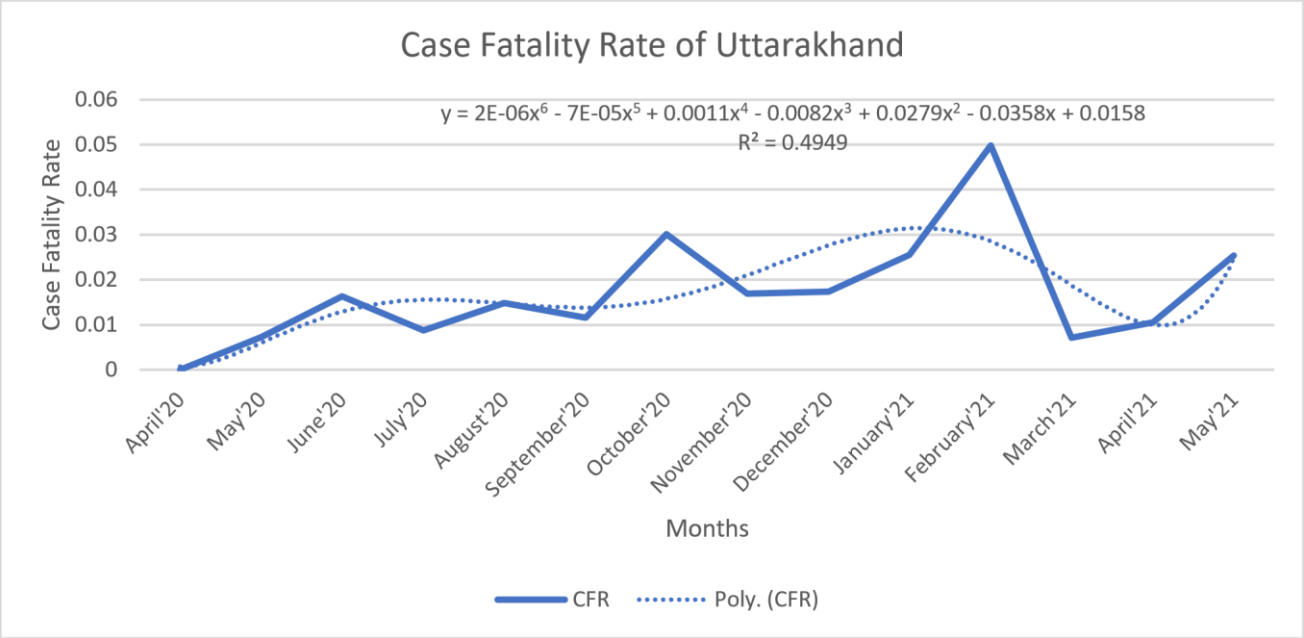


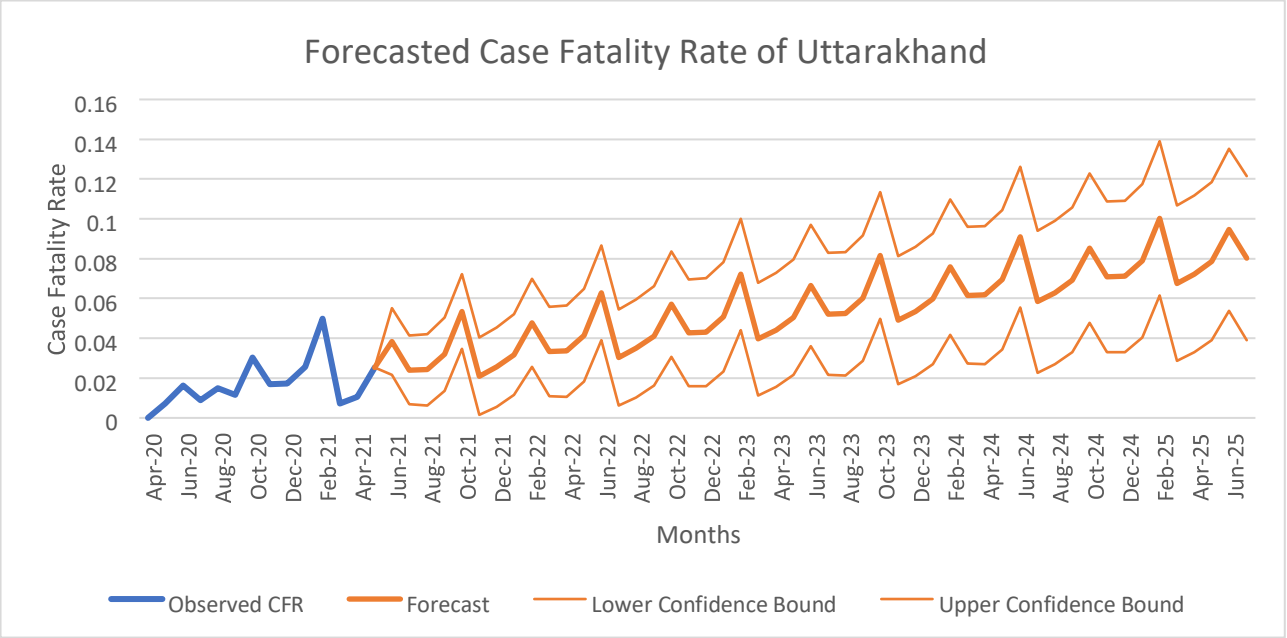
Table:13

Forecasted CFR of Uttarakhand

Months	Forecasted CFR	Lower Confidence Bound	Upper Confidence Bound
May-21	0.025405451	0.03	0.03
Jun-21	0.03844172	0.02	0.06
Jul-21	0.024125533	0.01	0.04
Aug-21	0.024245324	0.01	0.04
Sep-21	0.032066519	0.01	0.05
Oct-21	0.053458495	0.03	0.07
Nov-21	0.020885722	0.00	0.04
Dec-21	0.025497433	0.01	0.05
Jan-22	0.031833285	0.01	0.05
Feb-22	0.047801295	0.03	0.07
Mar-22	0.033485108	0.01	0.06
Apr-22	0.033604899	0.01	0.06
May-22	0.041426094	0.02	0.06
Jun-22	0.06281807	0.04	0.09
Jul-22	0.030245297	0.01	0.05
Aug-22	0.034857007	0.01	0.06
Sep-22	0.04119286	0.02	0.07
Oct-22	0.057160869	0.03	0.08
Nov-22	0.042844682	0.02	0.07

Dec-22	0.042964473	0.02	0.07
Jan-23	0.050785668	0.02	0.08
Feb-23	0.072177644	0.04	0.10
Mar-23	0.039604871	0.01	0.07
Apr-23	0.044216582	0.02	0.07
May-23	0.050552434	0.02	0.08
Jun-23	0.066520444	0.04	0.10
Jul-23	0.052204256	0.02	0.08
Aug-23	0.052324048	0.02	0.08
Sep-23	0.060145243	0.03	0.09
Oct-23	0.081537219	0.05	0.11
Nov-23	0.048964446	0.02	0.08
Dec-23	0.053576156	0.02	0.09
Jan-24	0.059912009	0.03	0.09
Feb-24	0.075880018	0.04	0.11
Mar-24	0.061563831	0.03	0.10
Apr-24	0.061683622	0.03	0.10
May-24	0.069504817	0.03	0.10
Jun-24	0.090896793	0.06	0.13
Jul-24	0.05832402	0.02	0.09
Aug-24	0.062935731	0.03	0.10
Sep-24	0.069271583	0.03	0.11
Oct-24	0.085239593	0.05	0.12
Nov-24	0.070923405	0.03	0.11
Dec-24	0.071043197	0.03	0.11
Jan-25	0.078864392	0.04	0.12
Feb-25	0.100256368	0.06	0.14
Mar-25	0.067683595	0.03	0.11
Apr-25	0.072295305	0.03	0.11
May-25	0.078631158	0.04	0.12
Jun-25	0.094599167	0.05	0.14
Jul-25	0.08028298	0.04	0.12

Figure:18



We have plotted the months in X-Axis and the observed or forecasted case fatality rates(without multiplier) in Y-Axis. The figures of observed and forecasted CFRs of Uttarakhand are given in Table:12 and Table:13 respectively and the graphs are represented in Figure:17and figure:18.From the initial stage the graph is tending upward. The case fatality has increased 16 per 1000 infected people in June'20 to 30 per 1000 infected people in October'20 and then increased upto 49 per 1000 people in February'21.The line graph has decreased after February'21 and again tended upward after April'21. Overall the graph has upward trend. Thus, in Figure:18 the forecasted CFRs are increasing over time with some fluctuations. In fact, the lower confidence bound of CFRs are also positive. Thus we can state as per forecast that the death due to COVID-19 won't come to an end till December'22 and so on.

Case Fatality Rate of Northern Region and Forecasting

Northern India

Table:14

The COVID-19 figures of Northern India

Month	Confirmed Case	Death	Case Fatality Rate(Without multiplier)
April'20	2654	45	0.016955539
May'20	8091	191	0.023606476
June'20	23967	577	0.024074769
July'20	77577	1234	0.015906776
August'20	179773	2396	0.013327919
September'20	246585	3300	0.013382809
October'20	129407	2197	0.016977443
November'20	111226	1565	0.014070451
December'20	87306	1413	0.016184455
January'21	27133	547	0.020159953
February'21	7264	164	0.022577093
March'21	25220	181	0.007176844
April'21	757531	4932	0.006510625
May'21	846515	15437	0.018235944

Figure:19

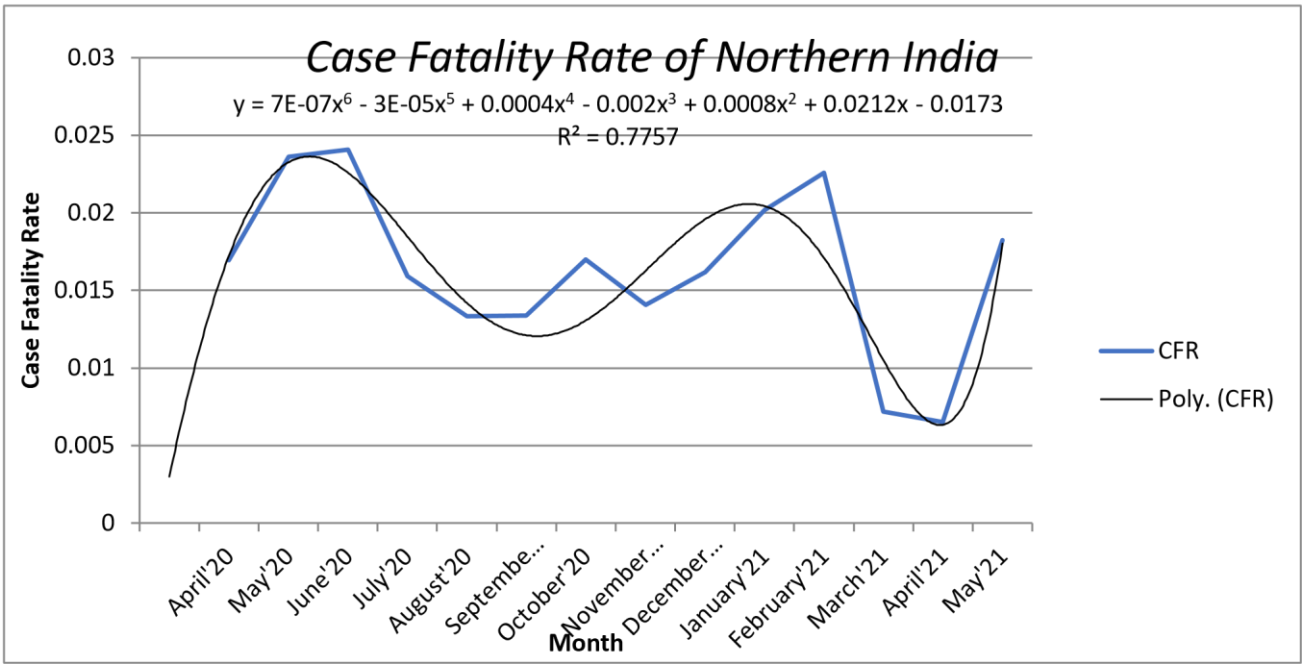


Table:15

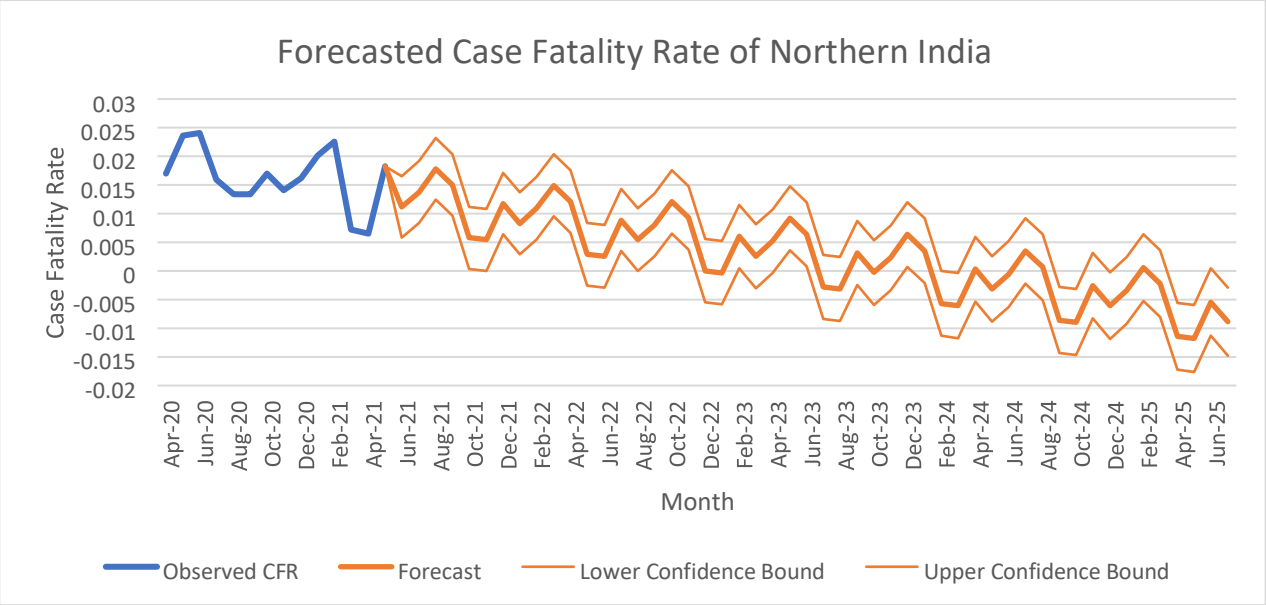
Forecasted CFR of Northern India

Months	Forecasted CFR	Lower Confidence Bound	Upper Confidence Bound
May-21	0.018235944	0.02	0.02

Jun-21	0.011179064	0.01	0.02
Jul-21	0.013779282	0.01	0.02
Aug-21	0.01780215	0.01	0.02
Sep-21	0.014995603	0.01	0.02
Oct-21	0.005767515	0.00	0.01
Nov-21	0.005414079	0.00	0.01
Dec-21	0.011751416	0.01	0.02
Jan-22	0.008313577	0.00	0.01
Feb-22	0.010913795	0.01	0.02
Mar-22	0.014936663	0.01	0.02
Apr-22	0.012130115	0.01	0.02
May-22	0.002902028	0.00	0.01
Jun-22	0.002548592	0.00	0.01
Jul-22	0.008885928	0.00	0.01
Aug-22	0.00544809	0.00	0.01
Sep-22	0.008048307	0.00	0.01
Oct-22	0.012071176	0.01	0.02
Nov-22	0.009264628	0.00	0.01
Dec-22	3.65405E-05	-0.01	0.01
Jan-23	-0.000316896	-0.01	0.01
Feb-23	0.006020441	0.00	0.01
Mar-23	0.002582602	0.00	0.01
Apr-23	0.00518282	0.00	0.01
May-23	0.009205689	0.00	0.01
Jun-23	0.006399141	0.00	0.01
Jul-23	-0.002828947	-0.01	0.00
Aug-23	-0.003182383	-0.01	0.00
Sep-23	0.003154954	0.00	0.01
Oct-23	-0.000282885	-0.01	0.01
Nov-23	0.002317333	0.00	0.01
Dec-23	0.006340201	0.00	0.01
Jan-24	0.003533653	0.00	0.01
Feb-24	-0.005694434	-0.01	0.00
Mar-24	-0.00604787	-0.01	0.00
Apr-24	0.000289466	-0.01	0.01
May-24	-0.003148372	-0.01	0.00
Jun-24	-0.000548155	-0.01	0.01
Jul-24	0.003474714	0.00	0.01
Aug-24	0.000668166	-0.01	0.01
Sep-24	-0.008559921	-0.01	0.00

Oct-24	-0.008913358	-0.01	0.00
Nov-24	-0.002576021	-0.01	0.00
Dec-24	-0.006013859	-0.01	0.00
Jan-25	-0.003413642	-0.01	0.00
Feb-25	0.000609227	-0.01	0.01
Mar-25	-0.002197321	-0.01	0.00
Apr-25	-0.011425409	-0.02	-0.01
May-25	-0.011778845	-0.02	-0.01
Jun-25	-0.005441508	-0.01	0.00
Jul-25	-0.008879347	-0.01	0.00

Figure:20



We have plotted the months in X-Axis and the observed or forecasted case fatality rates(without multiplier) in Y-Axis. We represent the figures of observed case fatality rate by **Table:14** and **Figure:19** ; the figures of forecasted case fatality rate by **Table:15** and **Figure:20** for **Northern Region.** Its case fatality rates include all the states discussed above and it has helped to depict the overall condition of the states also. At the initial stage the case fatality rate has increased gradually. In June'20 it has reached its peak with case fatality 24 per 1000 infected people the started decreasing. In October there has been a mild peak with case fatality 16 per 1000 infected people. In the month of February'21 the case fatality rate is 0.022577093 i.e. 22 per

1000 infected people. The graph has decreased after that until April'21. Overall, the graph has downward trend. In **Figure:20** the case fatality rate has been seen to be decreased with massive fluctuations. The impact of COVID-19 on death cases is observed throughout the year 2021,2022 and most of 2023.From the middle of 2024 the death records are seemed to be zero(negative, which we assume to be zero). After a mild peak in February'25 the Case Fatality rate is completely zero(negative, which we assume to be zero). Thus, we can state that the impact of COVID-19 will be reduced from beginning of 2025.

- **Important Notes:** In the graphical and tabular representation we can see the modified data, arranged and presented accordingly in Tables and Graphs. Here, some clarifications and descriptions of the Tables and graphs are given below-
  1. **Table:2, Table:4, Table:6, Table:8, Table:10, Table:12** represents the modified figures of confirmed cases and deaths extracted from the original data. Figures per month of confirmed cases and deaths in **Table:14** are the sum of the **Table:2, Table:4, Table:6, Table:8, Table:10, Table:12.** The data is there, from April'20 to May'21.
  2. The CFRS(observed and forecasted) in all of the above tables are calculated without multiplier and graphs are shown the figures according to it.
  3. In the graphs, Months are represented in X-Axis and the Case Fatality Rates(without multiplier) are represented in Y-Axis.
  4. In **Figure:2, Figure:3, Figure:4, Figure:5, Figure:6** we have fitted the 2^{nd}, 3^{rd}, 4^{th}, 5^{th} and 6^{th} degree polynomial curves on the figures of northern region of India and comparing with the line diagrams we can state, 6^{th} degree polynomial curve is the best fit. Thus, we have only represented the 6^{th} degree polynomial curves during rest of the projects.

5. The case fatality rate(without multiplier) figures of May'21 in **Table:3, Table:5, Table:7, Table:9, Table:11, Table:13** and **Table:15** are not exactly forecasted figures. We have included this month as the forecasting lines are started from the points of CFR figures of May'21.
6. **Case fatality rate can not be negative.Thus, we will assume the negative figures as zero.**

✞ *Interpretation:*

The COVID-19 crisis not only challenges disease control and crisis management but may also have long-term and far-reaching impacts on states, societies and international co-operation. A densely populated country like India, has faced more than 4 lakhs deaths due to this severe outbreak of COVID-19. Here, we are interested to get an idea about the near future condition of northern region of India as a whole, including the states Himachal Pradesh, Jammu and Kashmir, Ladakh, Sikkim, Uttar Pradesh and Uttarakhand.

In the forecasting process the real life factors like co-morbidity, vaccination, number of asymptomatic persons etc., which are actually effecting the original scenario haven't been included here. As a result, we can say that the forecasted figures won't be considered as the ultimate figures or the exact outcome of near future. But, it will surely provide a conjecture about the ongoing crisis.

From the forecasted data of **Northern Region** as a whole, we see that the case fatality rate is massively fluctuating over the years of 2021,2022,2023 upto mid of 2024. It is being suspected that the several waves of COVID-19 will effect the northern part of India in long-term. Although, it is a great relief to observe a steady decrement of case fatality rate after February'25, which indicates the northern region of India will be completely COVID-free around March'25.

For **Himachal Pradesh,** the forecasted data is showing an upward trend all over the time period, which is very unfortunate. But, as the whole northern

region of India is forecasted to be COVID-free within very beginning of 2025,it is absurd for a state, included in that particular region, to show a an upward trending line graph with very high case fatality rate all over the time period. Thus, we will consider the lower interval bounds of the forecasted values as another one of the possible forecasted outcomes. The lower confidence bound of the forecasted figures shows a steady decrement of case fatality rate after June'22. Thus, we conclude one of the possible cases that Himachal Pradesh can be considered as COVID-free state from July'22.

From the forecasted data of **Jammu and Kashmir**, the severe impact of COVID-19 has been observed throughout the years of 2021,2022 and even in the beginning of 2023. The death figure is started fluctuating from mid of 2023.It has been seen from February'24 that the outbreak of COVID-19 is not effecting further.

For the state **Ladakh,** the forecasted data has shown an amazing fluctuation of case fatality rate from the very beginning of forecasting period. We can state that the death figure of this particular state is been in control for a long time since June'22 except some sporadic death figures have been observed during 2023-2024.From the end of 2024,i.e. December'24 Ladakh seems to be absolutely free of COVID-19.

The forecasted figures of case fatality rate is showing a continuous increment for **Sikkim** which is very absurd and impossible for a state with such a small population figure. Therefore, we will consider the figures of lower confidence bound of forecasting as one of the likely possible cases. From the figures we get to see that there is a possibility that the death figures due to COVID-19 may not exist since August'21. Although, we can't conclude that the state will be completely COVID-free after that. As, we have forecasted that the northern region of India will be free of COVID-19 around March's, we expect the COVID-19 situation of Sikkim won't be an exceptional.

As per the forecast, the case fatality rate of **Uttar Pradesh** has turned into zero in May'22. But, it is very unfortunate to notice some sporadic spikes of

positive values with case fatality 6 per 1000 affected people in October'22 and with case fatality 2 per 10000 affected people (case fatality rate is 0.000253875), which is very mild. We consider the raise in death figure is due to some other causes like lack of awareness or importation of disease from other states or countries. Overall, from December'22 Uttar Pradesh won't suffer any death due to COVID-19.

The forecasted case fatality rate of **Uttarakhand** has been seen being increased over the time, which is very unlikely. In fact, the lower confidence bounds of the forecasted figures are showing an upward trend on graph. In November'21 the lower confidence bound reaches zero and it has started increasing since then. Though, the forecasted figures for the state is a bit absurd, we expect this state will also be freed from COVID-19 within 2025.

Some of the forecasted figures are not satisfactory at all due to some limitations. Although, it can be concluded that the whole northern region is expected to be virus-free within mid 2025 and we would like to expect the same thing for India as well.

✞ ***Conclusion:***

We conclude that the Case Fatality Rate is a very effective measure to state the actual condition of COVID-19 Disease as it depends on figures of Confirmed Cases and Deaths. The growth curves of CDR well fits to 6^{th} degree polynomial for some of the region and for some states ,not for all due to some limitations. But, we manage to work with that. Forecasting depends on many real life variables, but here we only use the functional tools. That is why, forecasted figures can not be the ultimate figures for future. Upward and downward trending of graphs and figures have effected the forecasting. So, the forecasting process may not be completely satisfactory. Overall, we can conclude from this project work that the COVID-19 will be lasted around more than four years. Hope, this project will help in further research work.

✞ Future Scope for Work:

For further research, one can work on the case fatality rate over vaccinated population or on the efficiency of health sectors of individual states of North India. It can be observed whether there is any other factor(weather, awareness, various policies of state and central govt.) rather than comorbidity and immune system effecting the case fatality rate of particular states. The case fatality rate can be also projected taking into account age composition(For this, more detailed data is needed).

✞ Appendix:

Main Data: https://1drv.ms/x/s!Arpa6S8FcLwlgx7VdL8fhk_jVuzM
Modified Data: https://1drv.ms/x/s!Arpa6S8FcLwlgyAMJ1KW4rO7VzaJ
Work Sheet: https://1drv.ms/x/s!Arpa6S8FcLwlgyhd7eCa4ENHXmR9

✞ Acknowledgement:

The project has given me an ample scope to become self-confident and self-dependent. I am lucky to get the guidance from **Prof. Champa Chakraborty**, HOD, Department of Statistics and **Prof. Shilpak Mukherjee** , Associate professor, **Department of Statistics of Surendranath College**. They got a strong command on the subject and topics they covered during the entire semester, would help me a lot while implementing this knowledge in our practical life. I am grateful to all of them to complete to complete this project work. With the guidance of our respected teachers, I really enjoyed working on this project as it was a great learning process with a great effort.

Subhrojit Das

Signature of the Student

Date-

Roll no- 183115-21-0219

Regd no- 115-1111-0998-18

✞ *Certificate:*

It is certified that this project entitled as by the candidate of Roll no-183115-21-0219, Regd no-115-1111-0998-18, Year-2021, submitted in partial fulfillment to Discipline Specific Elective Coruse-B2 (DSE-B2) is a bonafide record of work carried out under my guidance and supervision.

Signature of the Project Guide

Date-

Subject- Statistics
Course- Discipline Specific Elective course-B2

✞ ***Bibliography:***

In order to complete this project I took help from numerous books and websites which are listed as follows:-

The Websites are:-

➢ https://prsindia.org/covid-19/cases

➢ https://en.wikipedia.org/wiki/COVID-19

➢ https://en.wikipedia.org/wiki/COVID-19_pandemic_in_India

➢ https://www.google.co.in/imghp?hl=en&tab=ri&ogbl

The Books are :-

Fundamentals Of Statistics by A.M. Goon, B.K. Gupta and B. Dasgupta

Fundamentals Of Mathematical Statistics by S.C Gupta and V.K. Kapoor