Cambridge Judge Business School
Cambridge Centre for Health Leadership & Enterprise

COVID-19 TRACKER: INDIA

4 July 2021

Centre for Health Leadership & Enterprise
UNIVERSITY OF CAMBRIDGE Judge Business School
HSTP Health Systems Transformation Platform
National Institute of Economic and Social Research

This tracker[1] has been developed by researchers at Cambridge Judge Business School and National Institute of Economic and Social Research, working with Health Systems Transformation Platform in India, as part of a pandemic monitoring series devoted to India and its states and union territories. It provides short term forecasts of the trajectory of the pandemic, identifying states and union territories that are at risk of increases in infection incidence. The forecasts are based on a structural time series model that uses historical data in estimation but adapts to the trend emerging in the most recent period. The model is described in Harvey and Kattuman (2021) "Time series models based on growth curves with applications to forecasting coronavirus". *Harvard Data Science Review*, Special issue 1 - COVID -19.

The reproduction number (Rt) for India edged up over the last week and now stands at 0.93. The trend value of the daily growth rate of cases continues to be negative, but has risen to -1.75%. Newly reported COVID-19 cases are likely to decline at a reduced rate in the coming days. By 18 July 2021, reported cases per day can be expected to be about 31,500.

Based on reproduction numbers, daily reported cases are likely to increase in Arunachal Pradesh, Kerala, Manipur, Meghalaya, Sikkim and Tripura. Of particular concern are Arunachal Pradesh, Kerala, Manipur, Sikkim and Tripura due to the likelihood that their positive daily growth rates of cases are accelerating. Daily reported cases are likely to remain stable in Maharashtra.

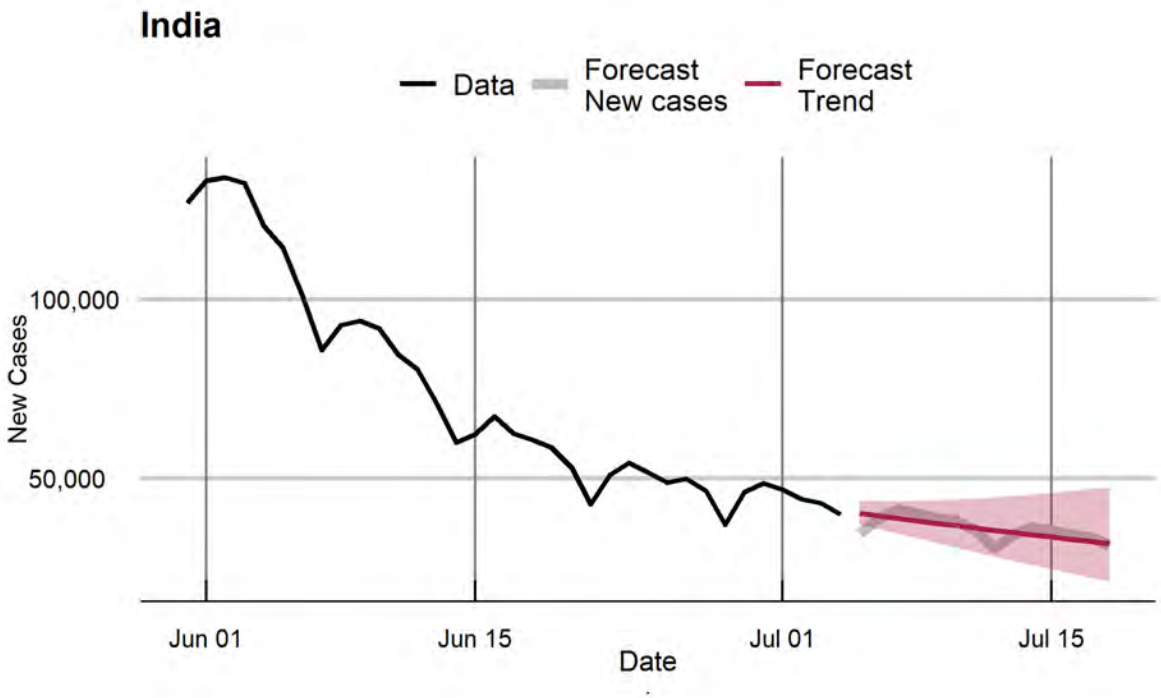
In all but a few of the remaining states and union territories the daily growth rates of new cases, though currently negative, are trended upwards, indicating the need for close monitoring and prompt policy corrections. The exceptions to this at present are Assam, Chandigarh, Delhi, Karnataka, Punjab and Telangana.

Mean absolute percentage error of the forecasts of daily cases in India given in the 27 June tracker, for the week beginning 28 June, was 7.1%. The accuracy of forecasts rely on the quality of the reported data. Changes in government pandemic policies and in transmission relevant social behaviour may cause realised numbers to depart from forecasts.

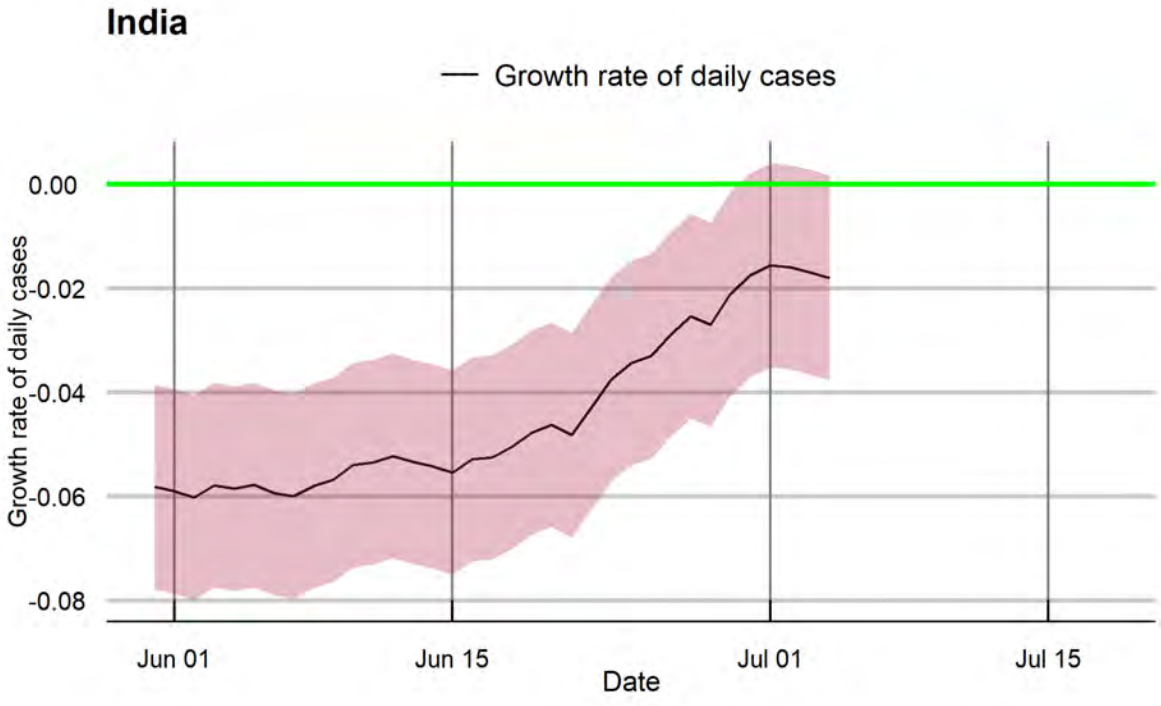
[1] CJBS COVID-19 Tracker for India can be accessed at: www.jbs.cam.ac.uk/covid-india
The companion spreadsheet contains all the estimates and forecasts.

Contact: Paul Kattuman <p.kattuman@jbs.cam.ac.uk>

Daily Covid-19 cases in India: Forecast

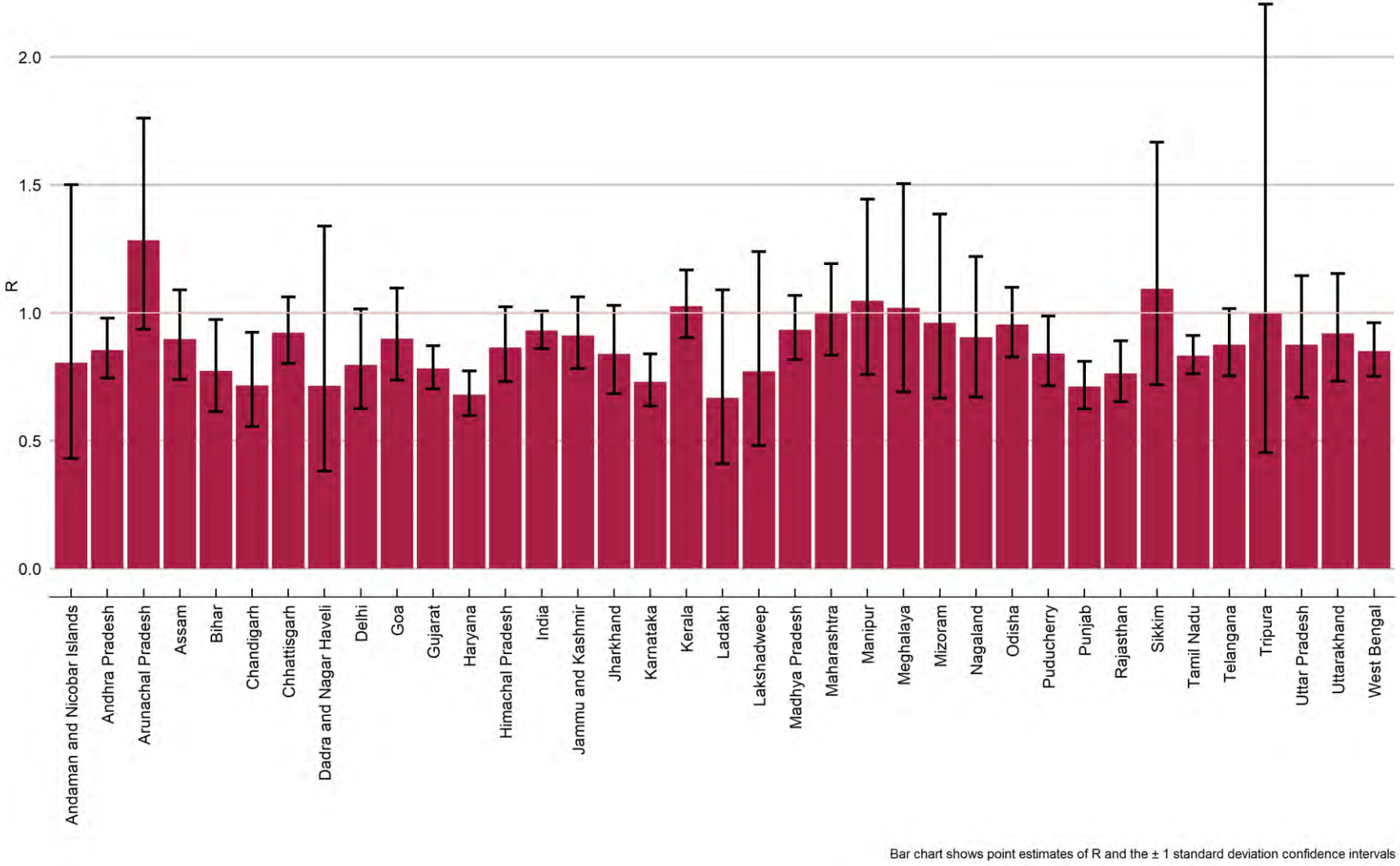


Forecasts of daily new cases for the period 5 July 2021 to 18 July 2021, based on data till 4 July 2021. New COVID-19 cases is likely to number about 31,500 per day by 18 July 2021.

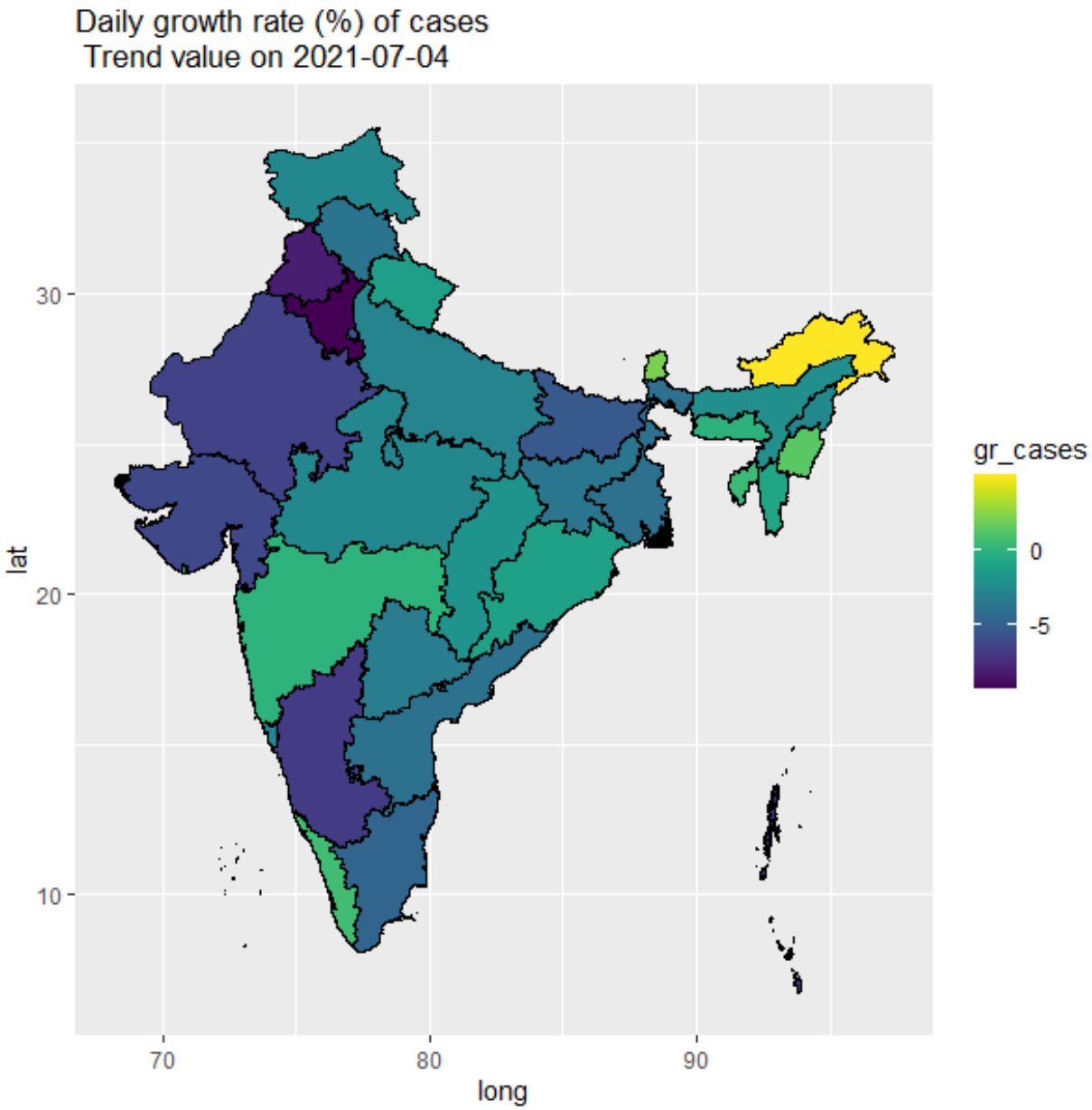


The filtered trend in the growth rate of daily new cases. Final date: 4 July 2021.

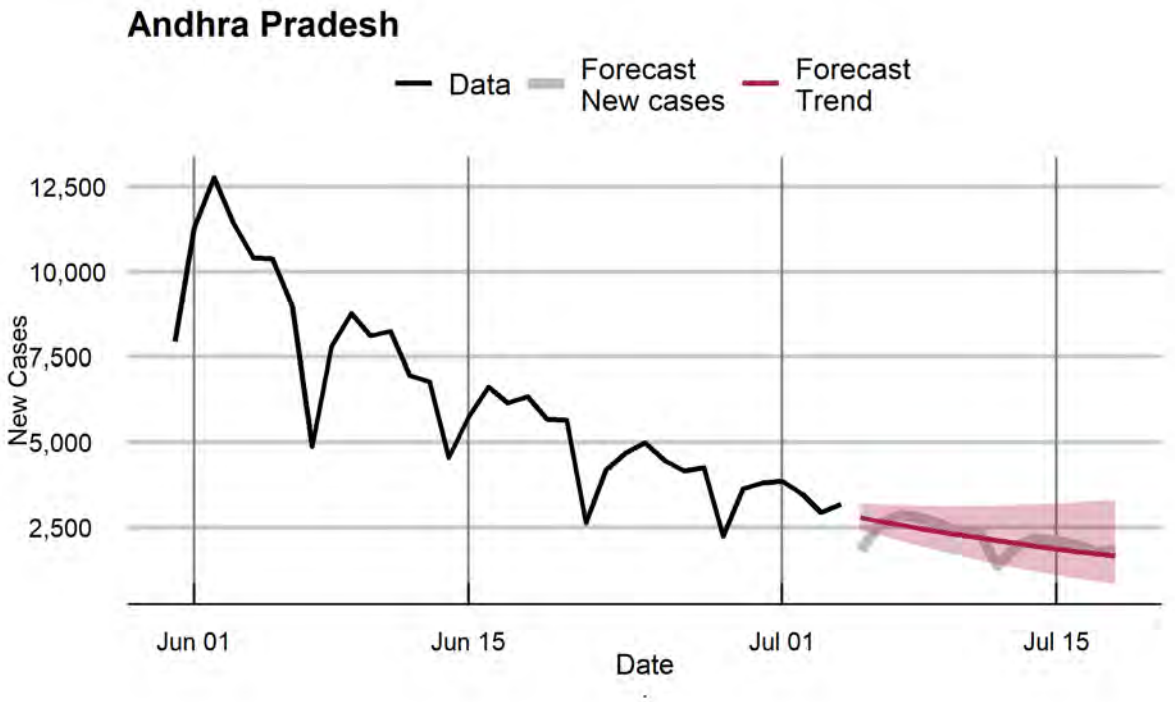
R_t: 4 July 2021

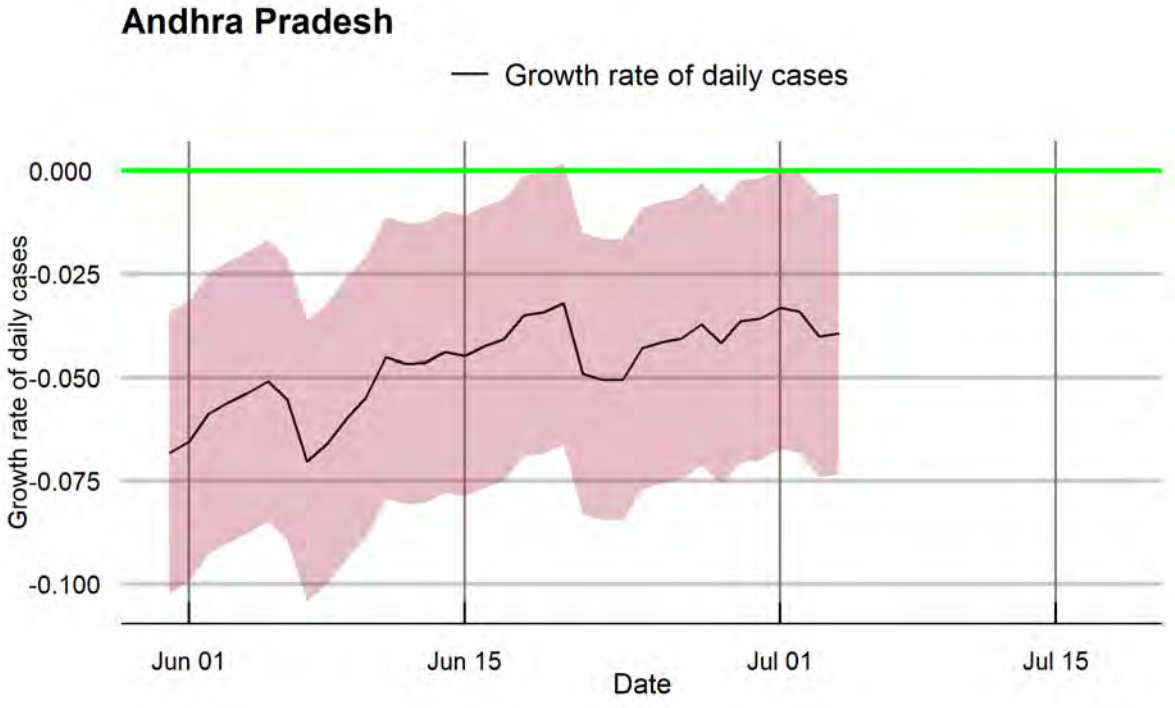


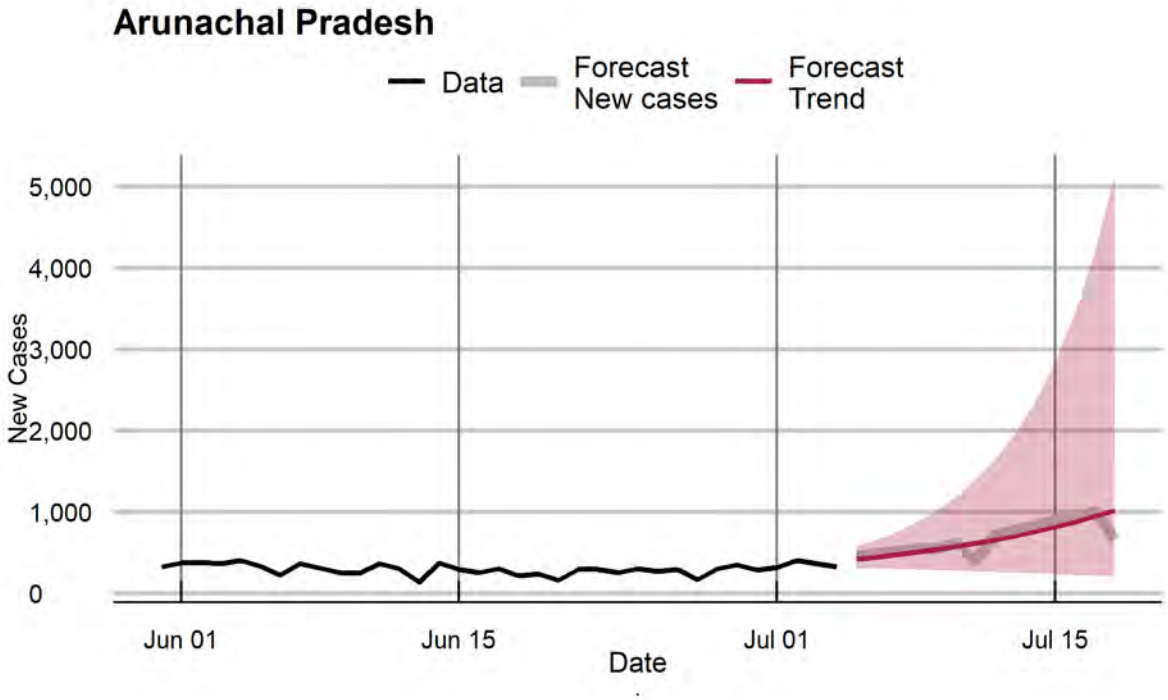
Bar chart shows point estimates of R and the ± 1 standard deviation confidence intervals

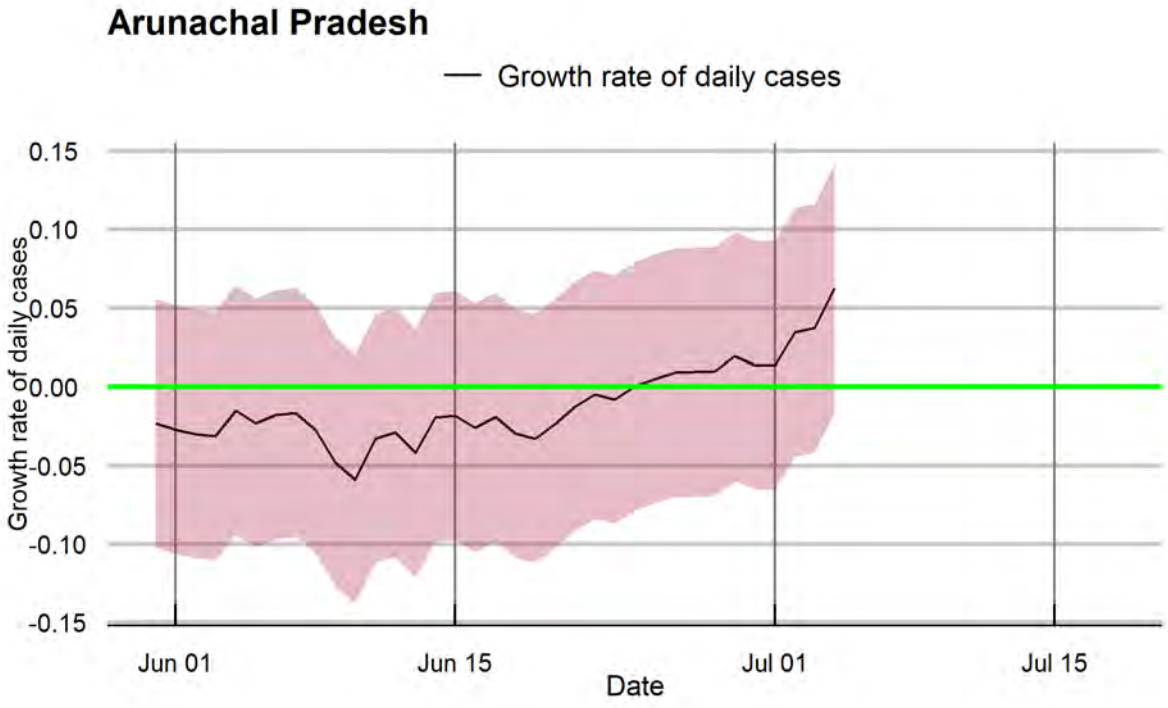

Daily growth rate (%) of cases
Trend value on 2021-07-04
30
20
10
lat
70
80
90
long
gr_cases
0
-5

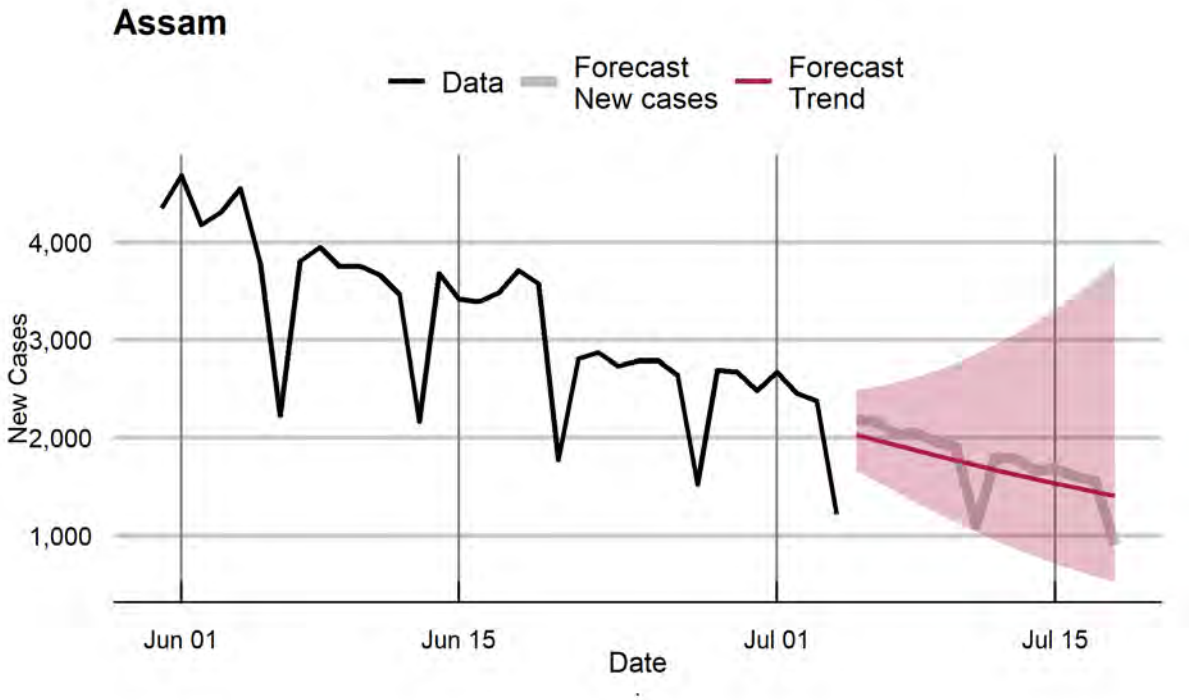
Case forecasts and growth rates: States and Union territories

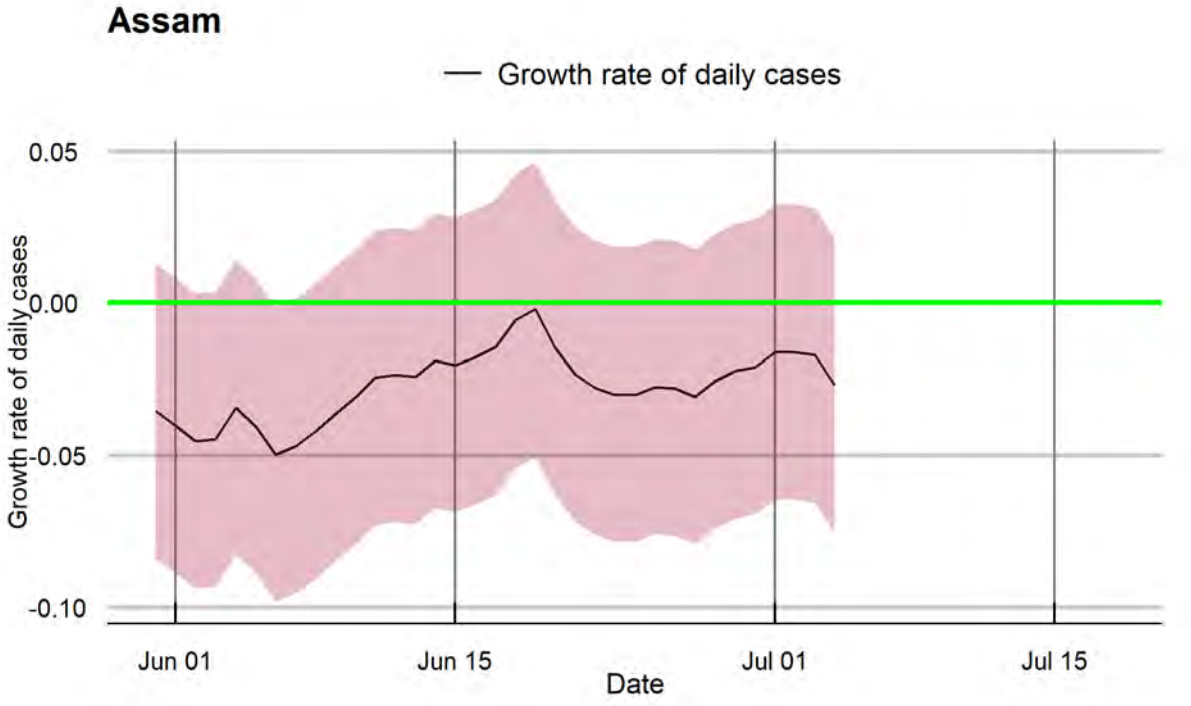


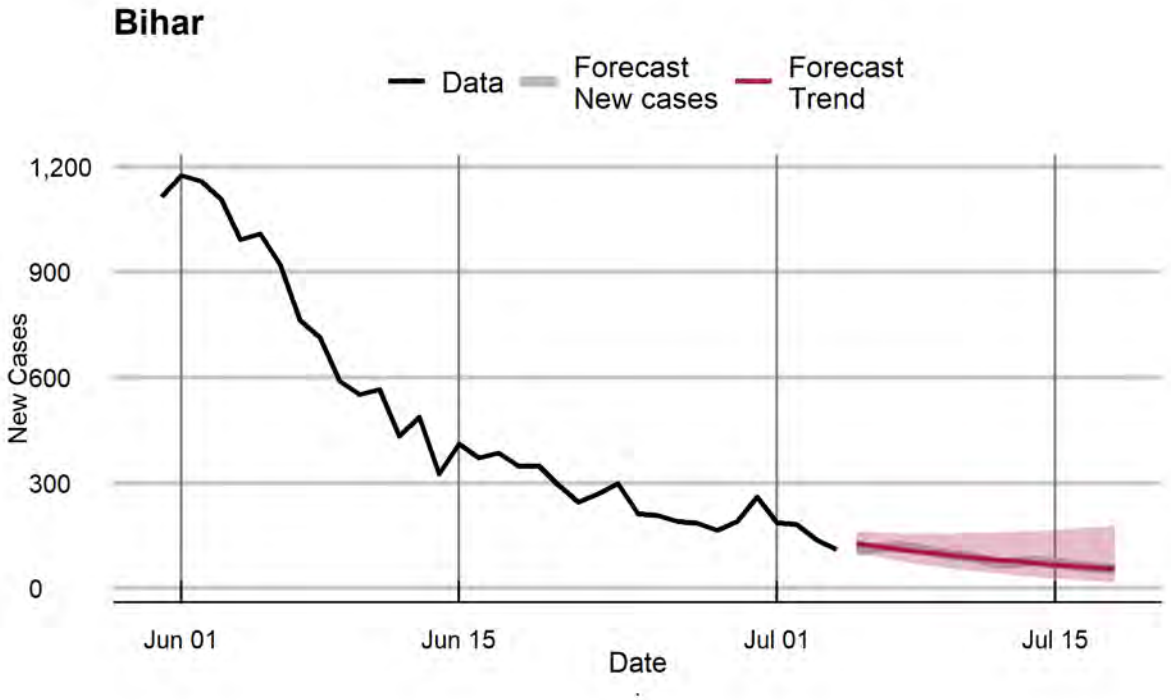


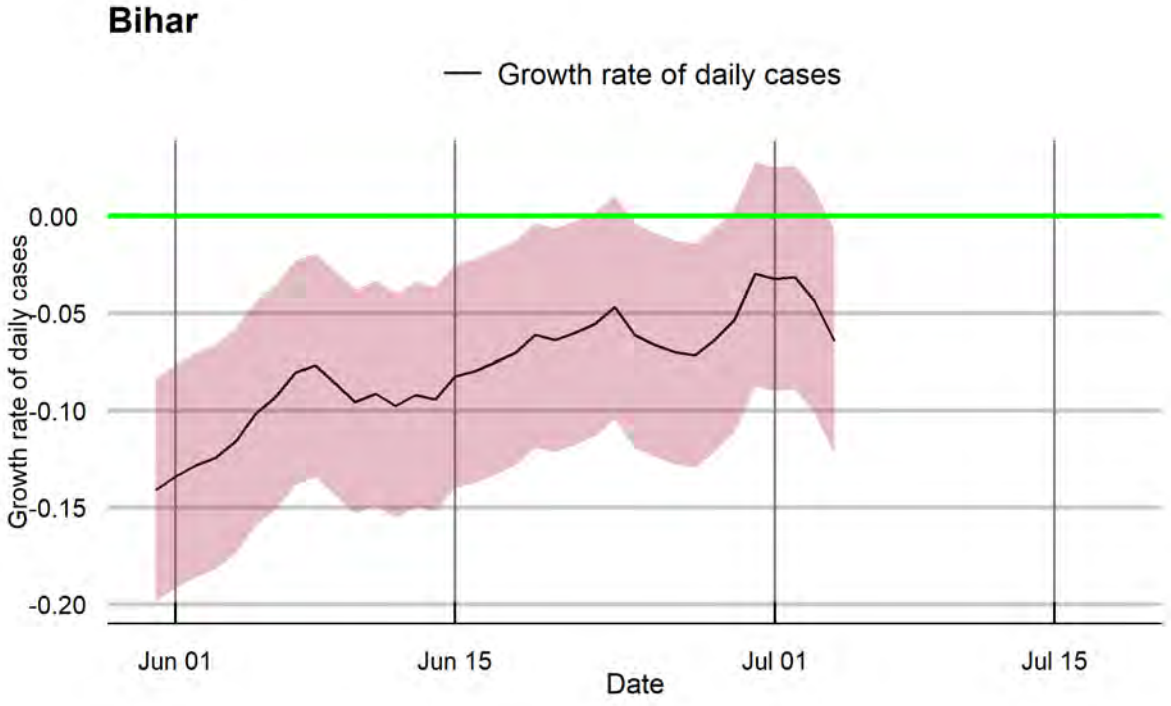

Arunachal Pradesh
Data
Forecast
New cases
Forecast
Trend
5,000
4,000
3,000
2,000
1,000
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

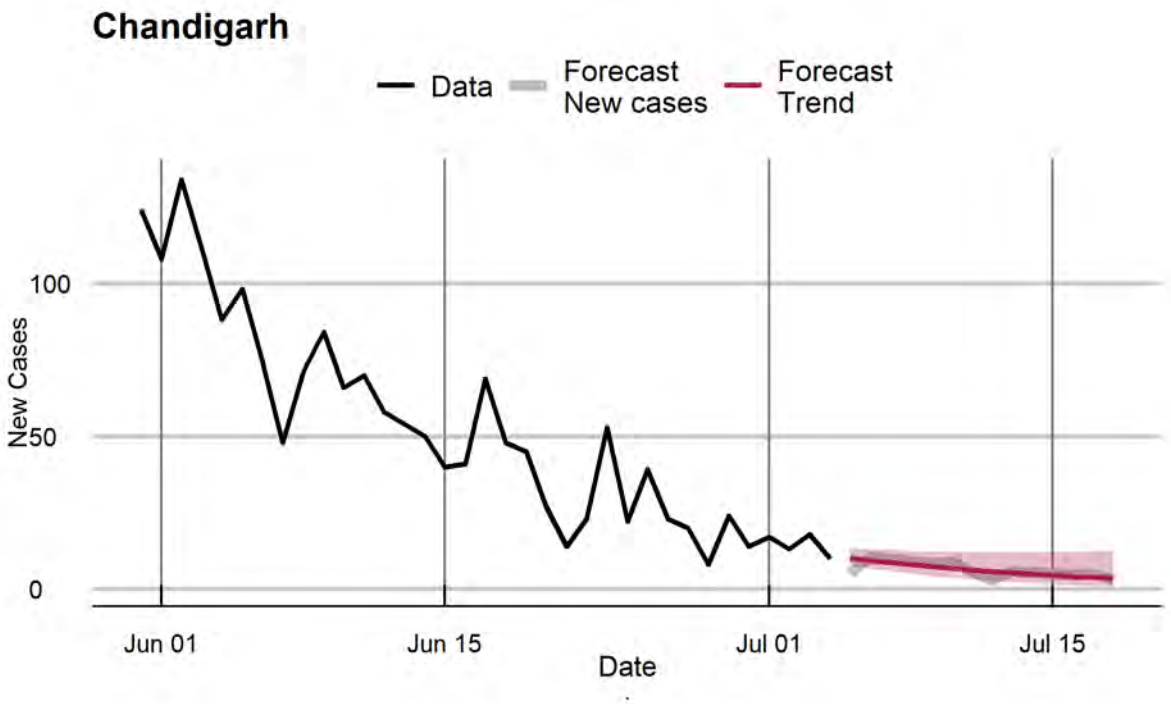

Arunachal Pradesh
Growth rate of daily cases
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

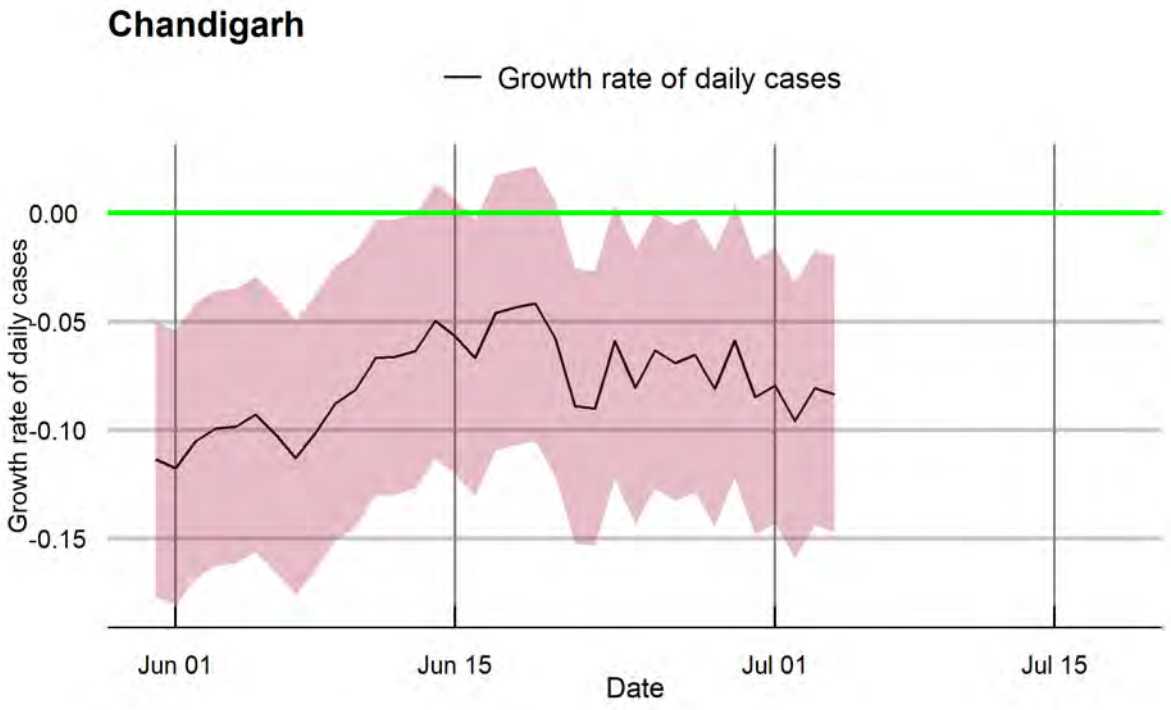

Assam
Data
Forecast
New cases
Forecast
Trend
4,000
3,000
2,000
1,000
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

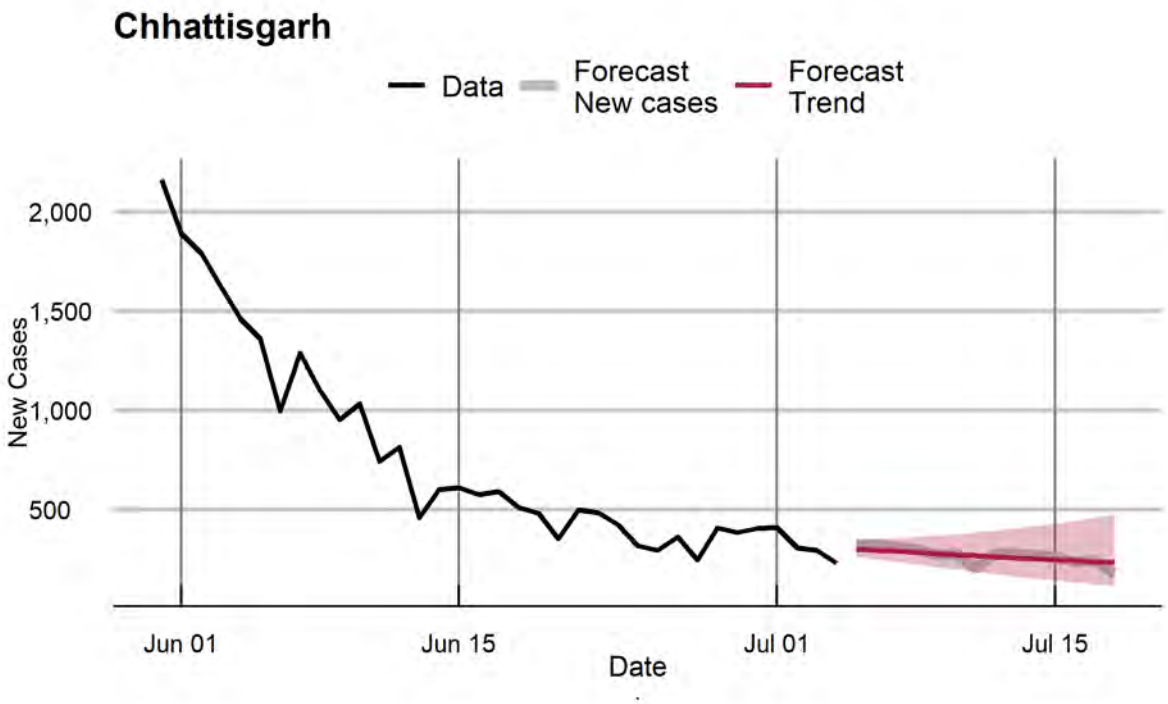

Assam
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

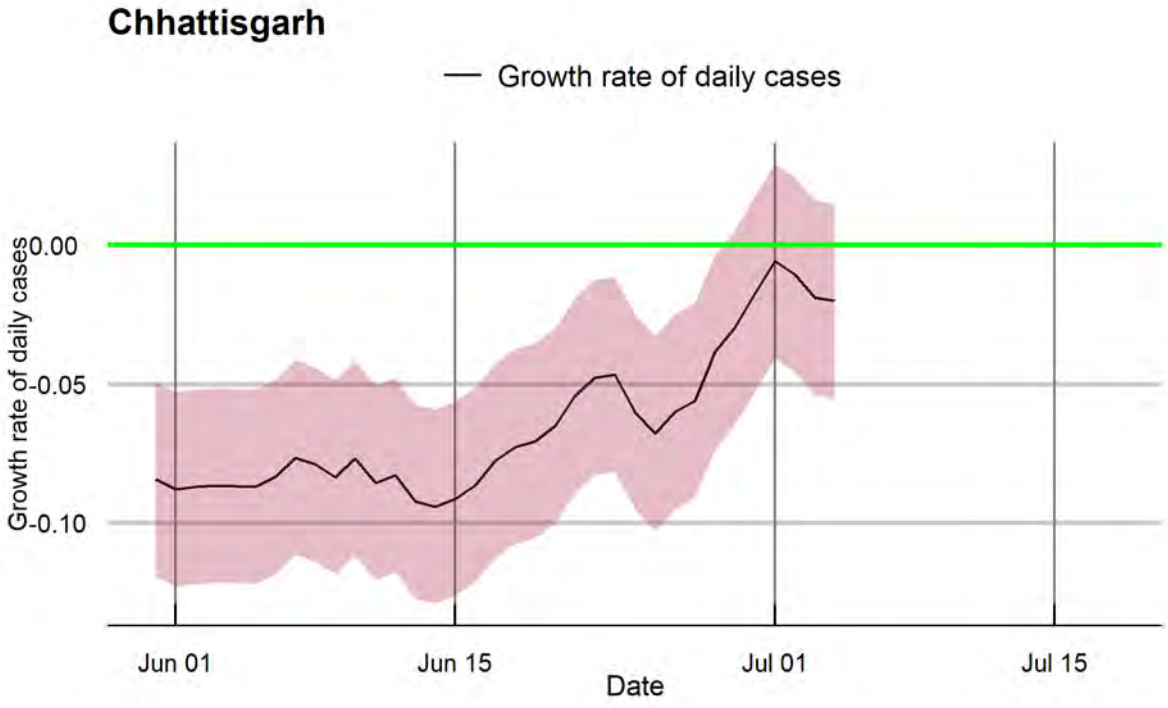

Bihar
Data
Forecast
New cases
Forecast
Trend
1,200
900
600
300
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

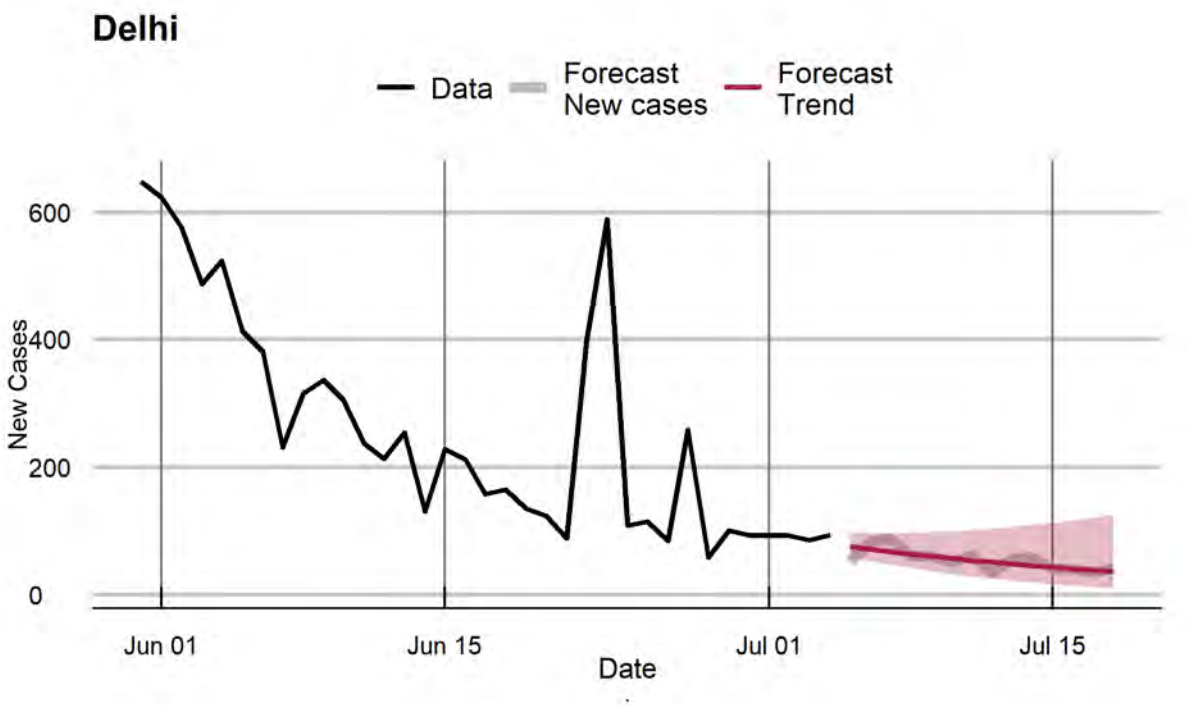

Bihar
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
-0.20
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

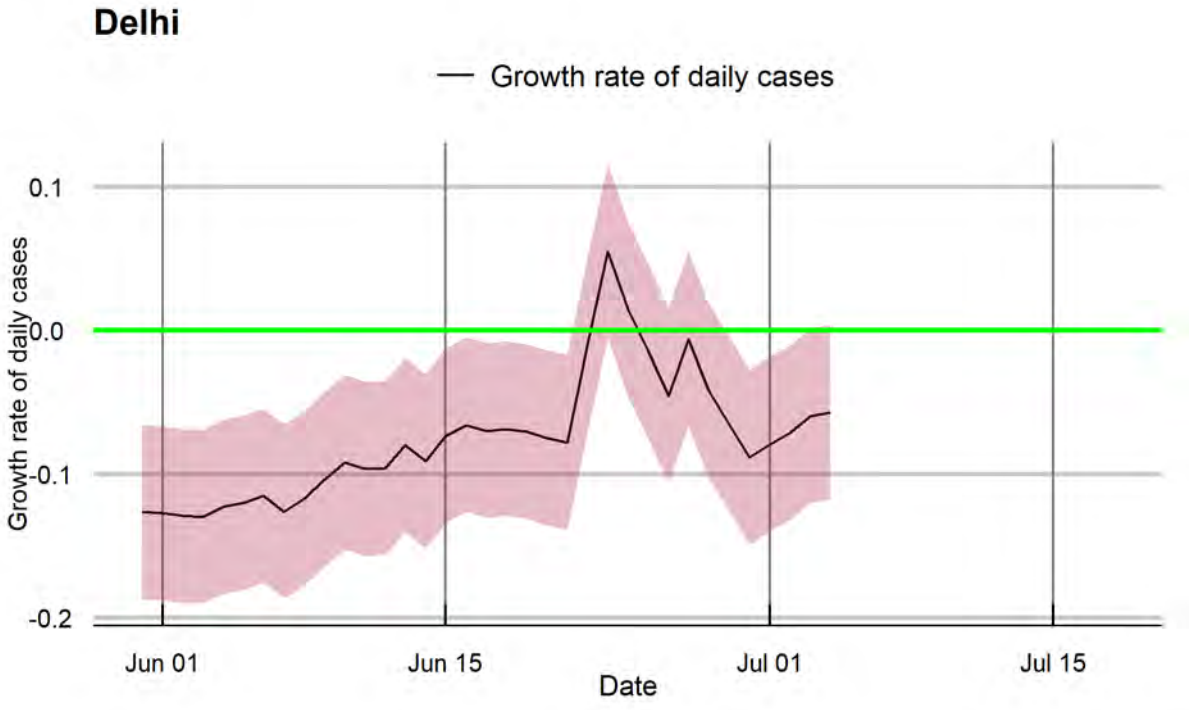

Chandigarh
Data
Forecast
New cases
Forecast
Trend
New Cases
100
50
0
Jun 01
Jun 15
Jul 01
Jul 15
Date

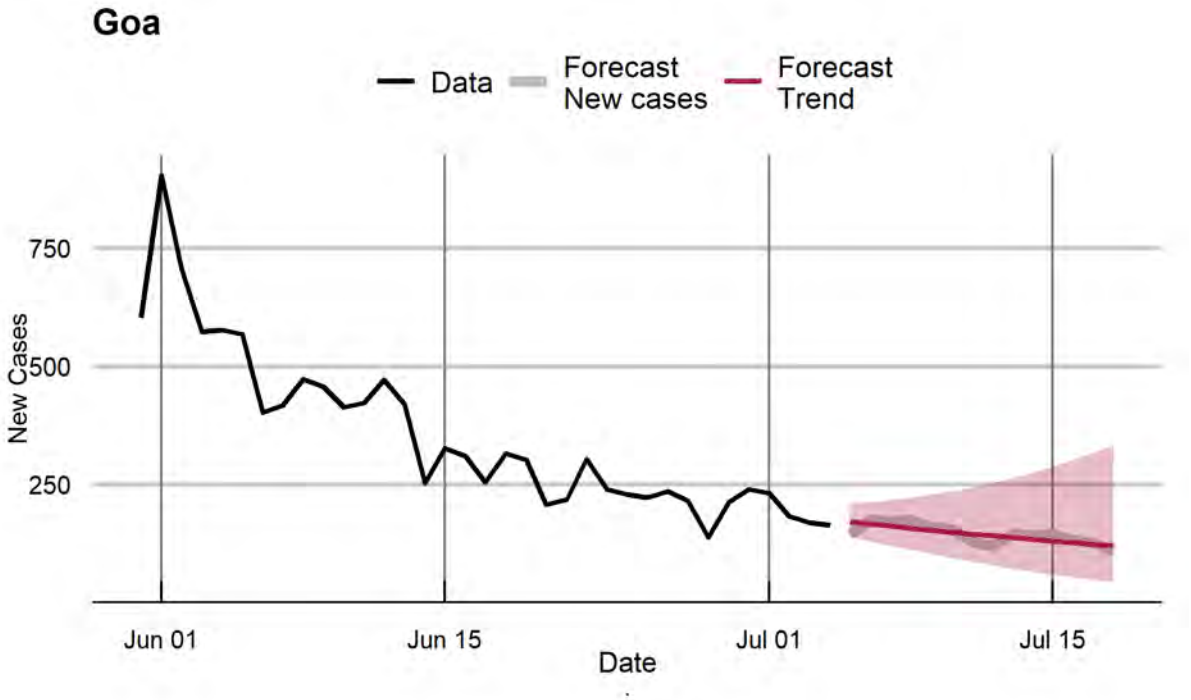

Chandigarh
Growth rate of daily cases
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Jun 01
Jun 15
Jul 01
Jul 15
Date

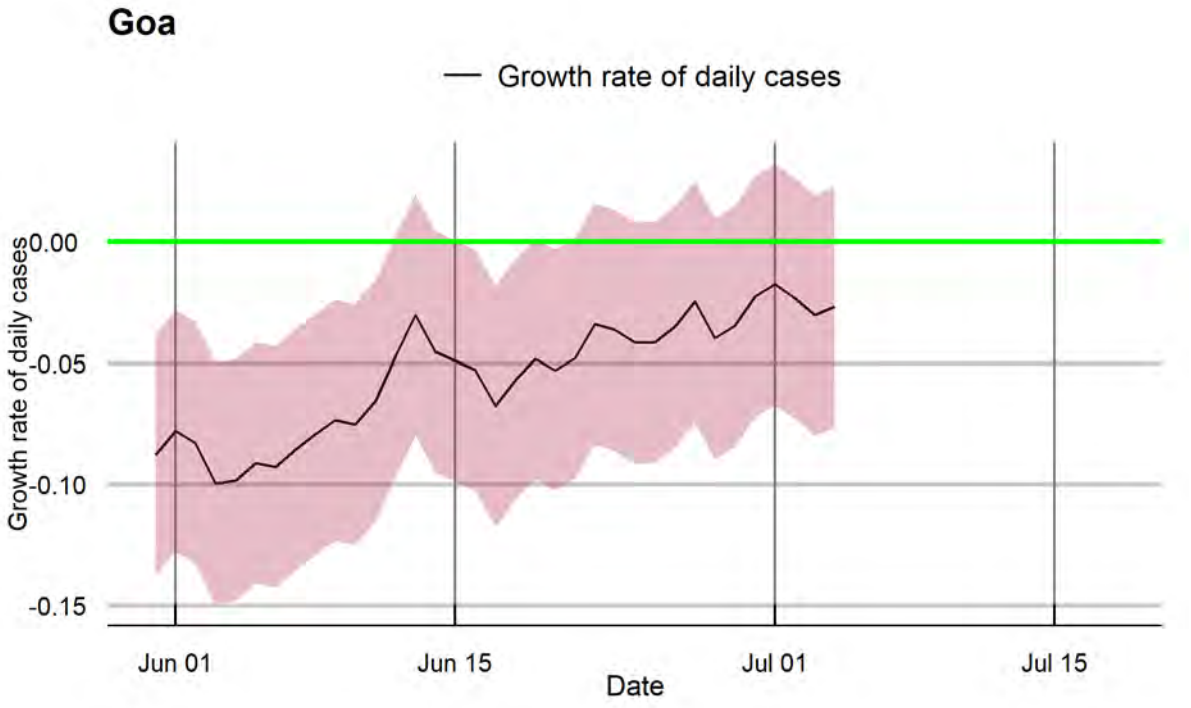

Chhattisgarh
Data
Forecast
New cases
Forecast
Trend
2,000
1,500
1,000
500
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

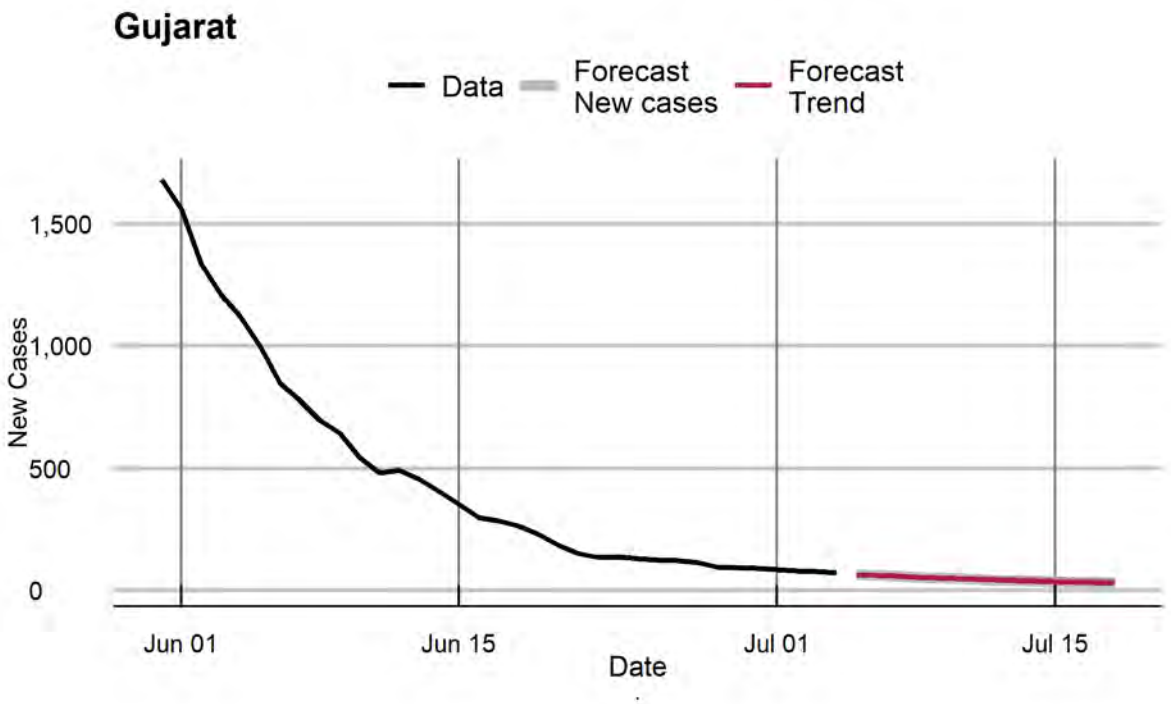

Chhattisgarh
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

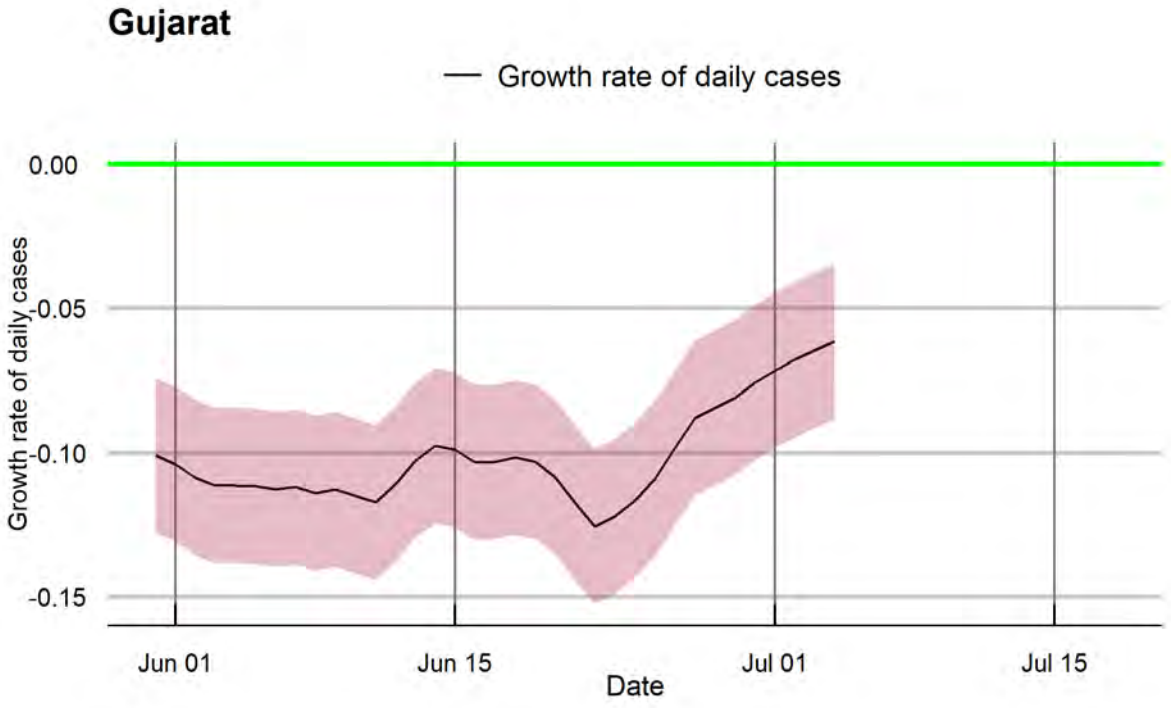

Delhi
Data
Forecast
New cases
Forecast
Trend
600
400
200
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

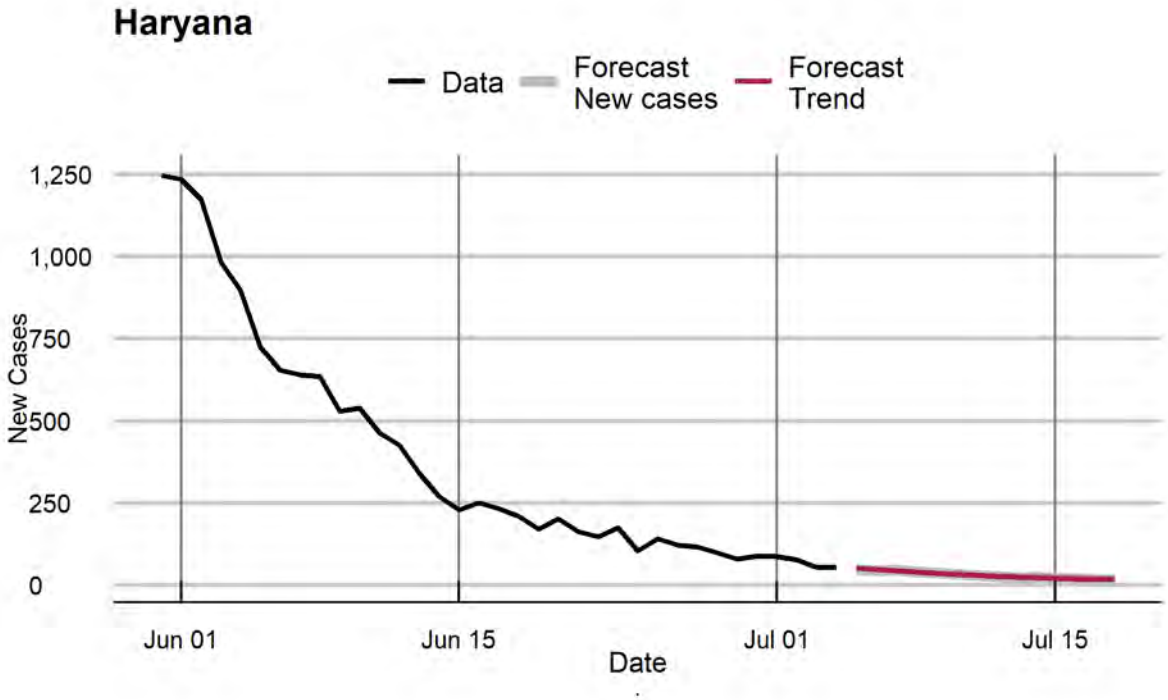

Delhi
Growth rate of daily cases
0.1
0.0
-0.1
-0.2
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

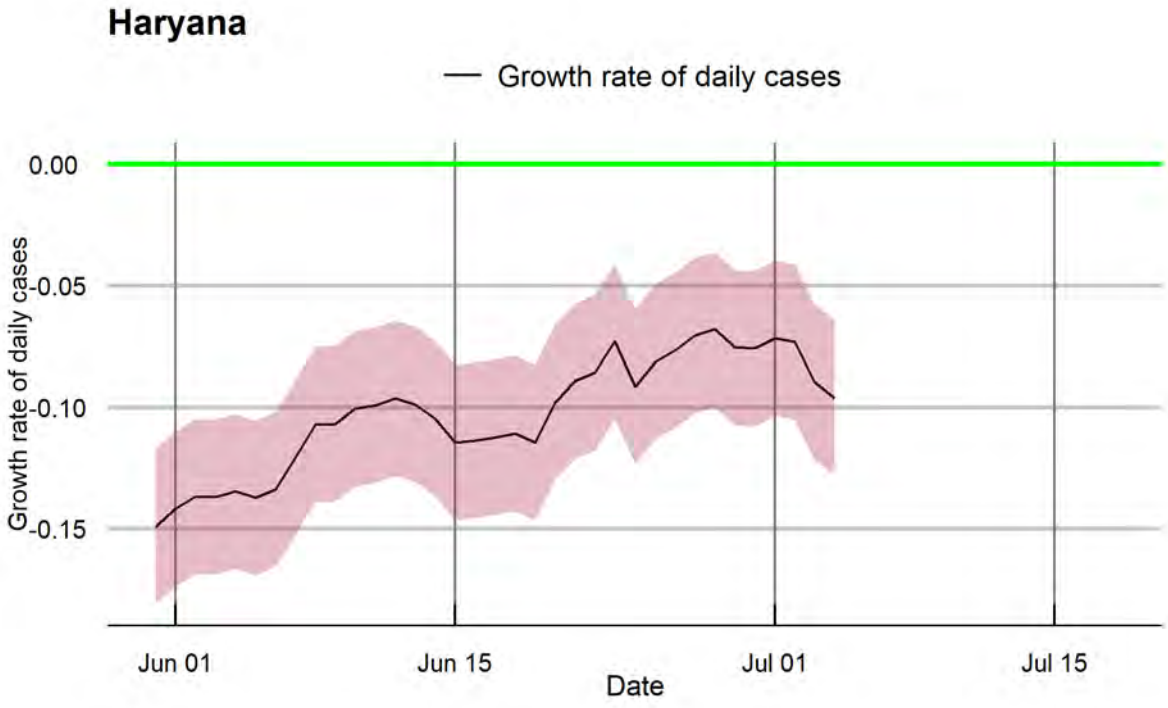

Goa
Data
Forecast
New cases
Forecast
Trend
750
500
250
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

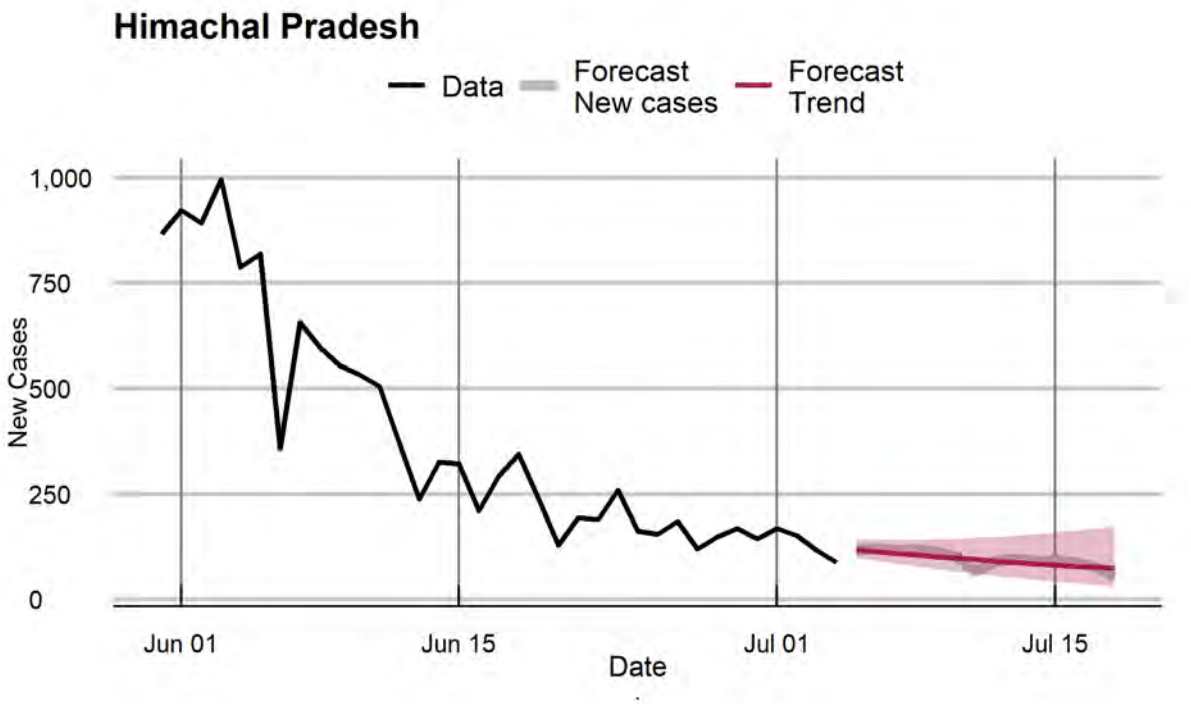

Goa
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

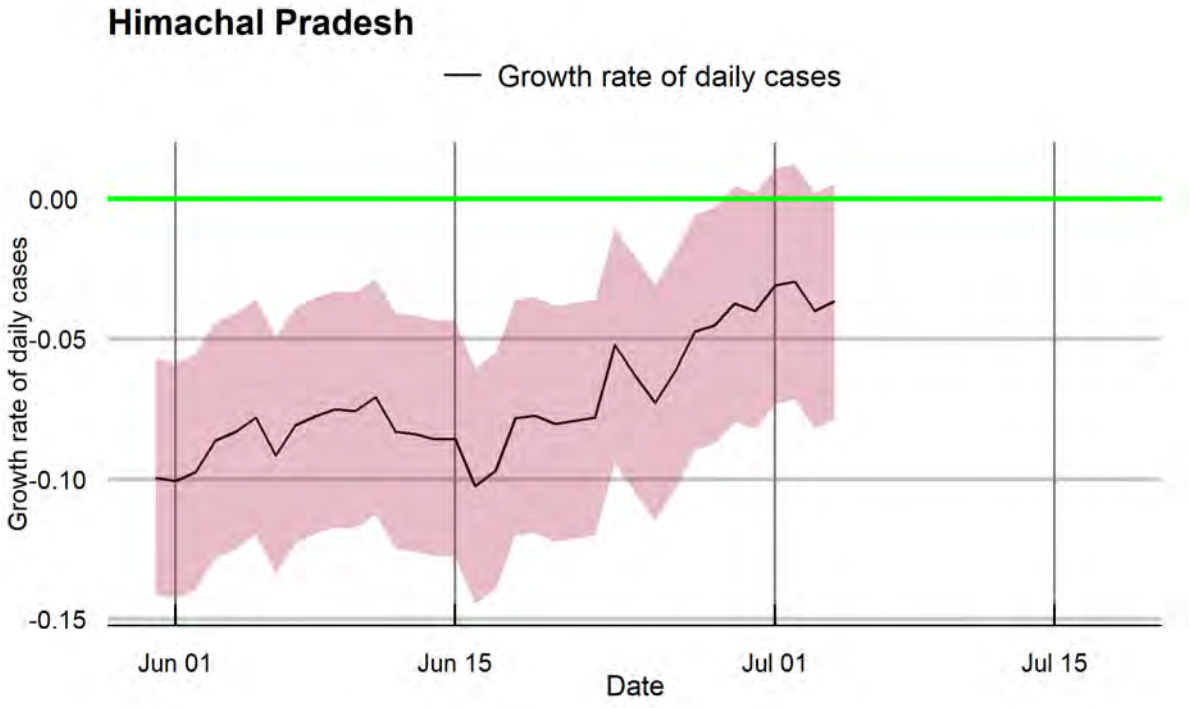

Gujarat
Data
Forecast
New cases
Forecast
Trend
1,500
1,000
500
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

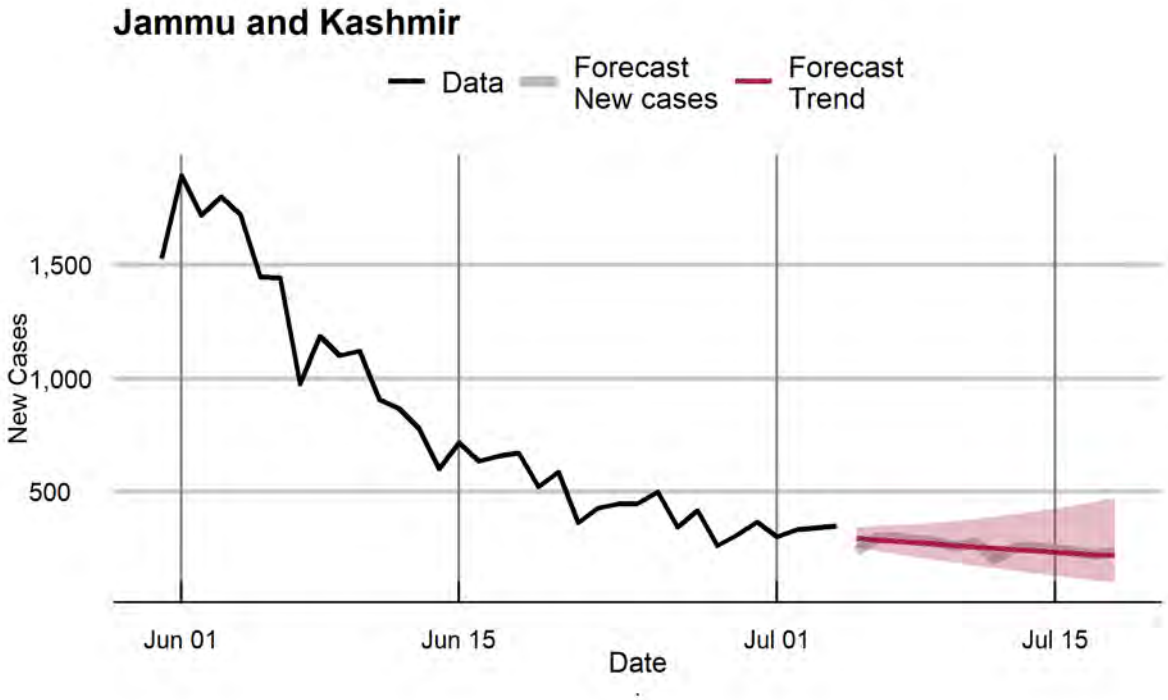

Gujarat
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

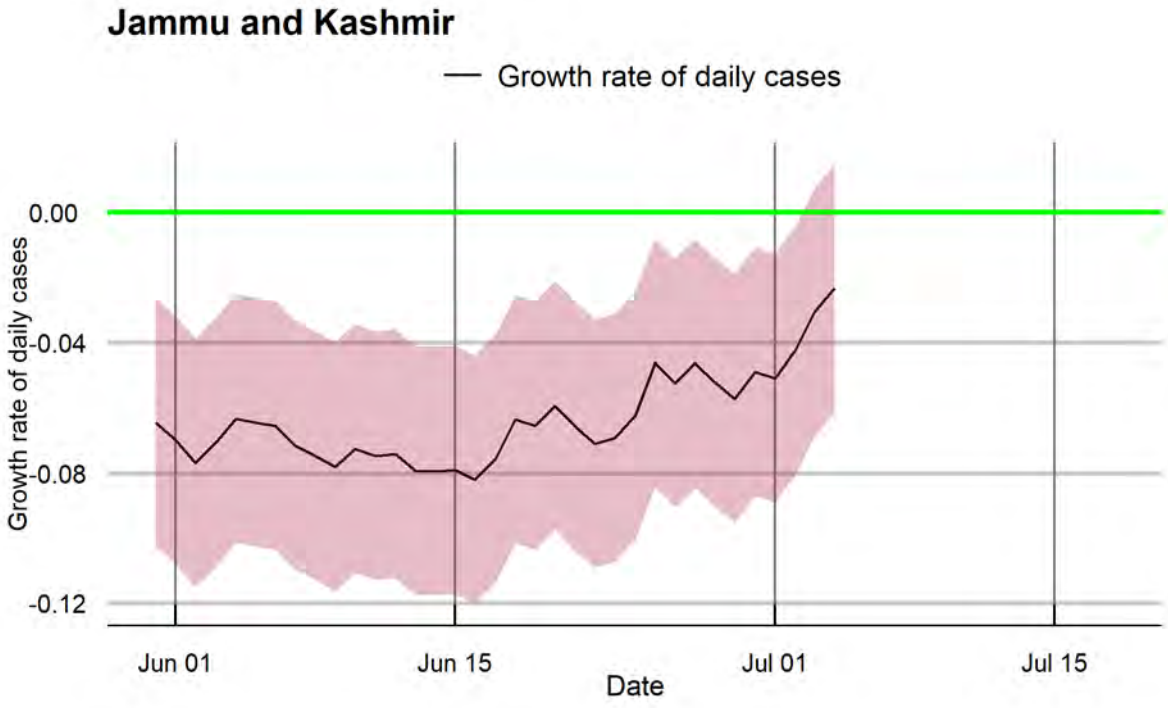

Haryana
Data
Forecast
New cases
Forecast
Trend
1,250
1,000
750
500
250
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

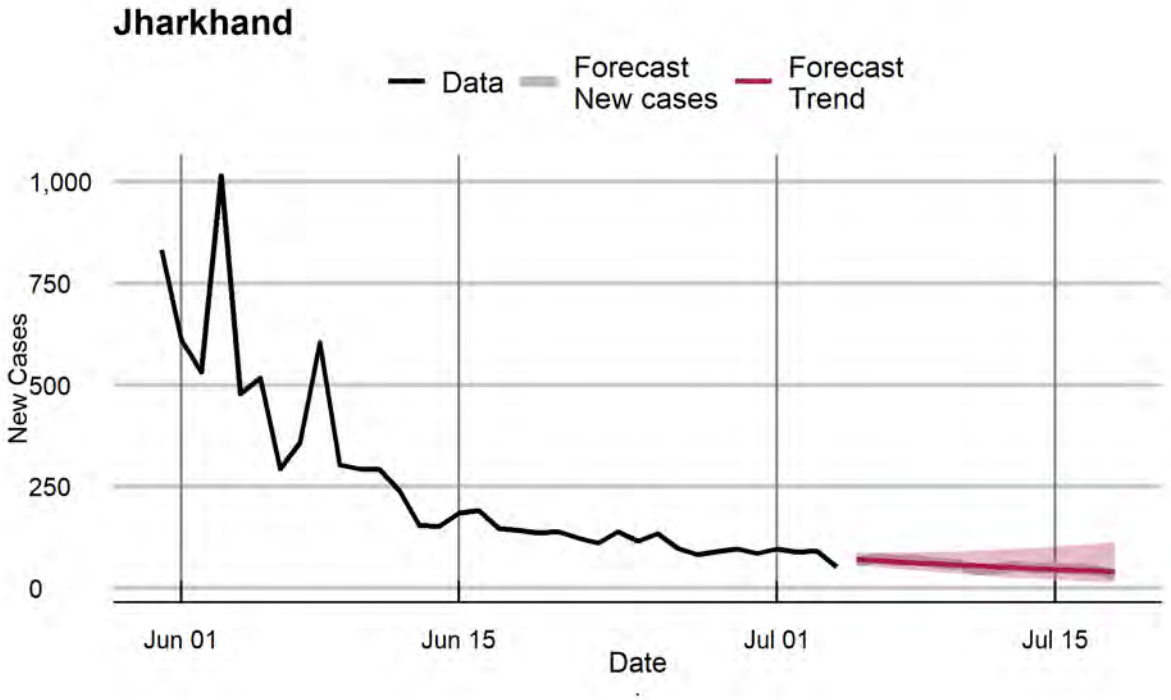

Haryana
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

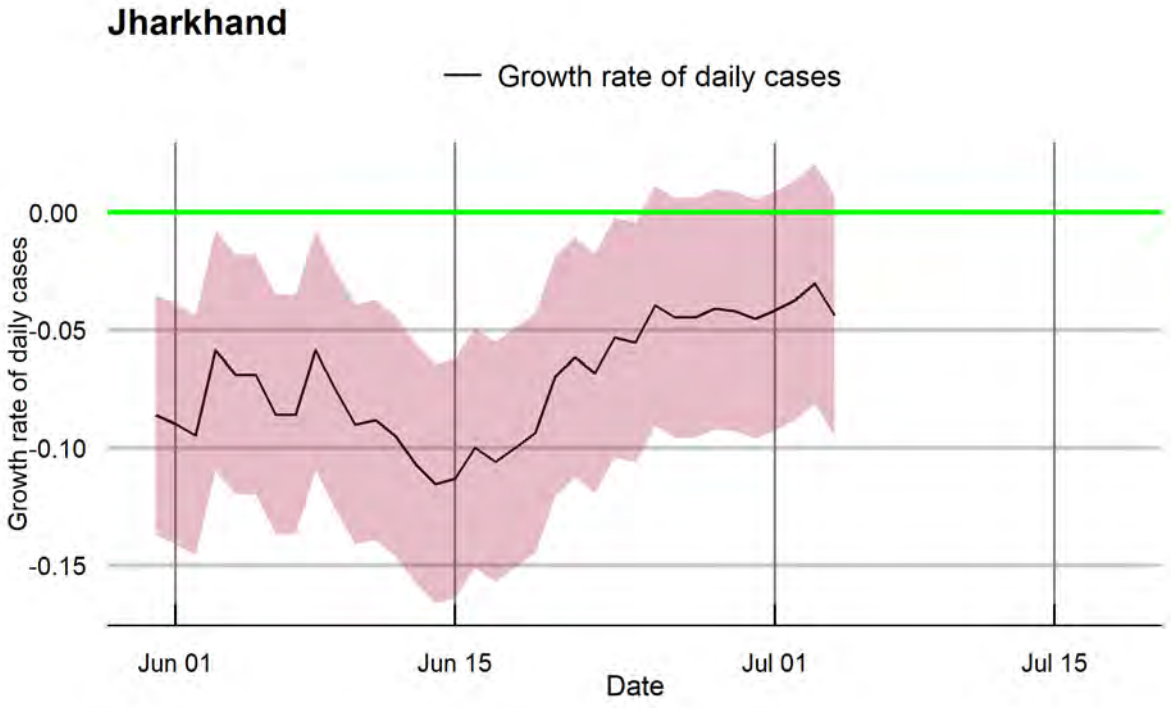

Himachal Pradesh
Data
Forecast
New cases
Forecast
Trend
1,000
750
500
250
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

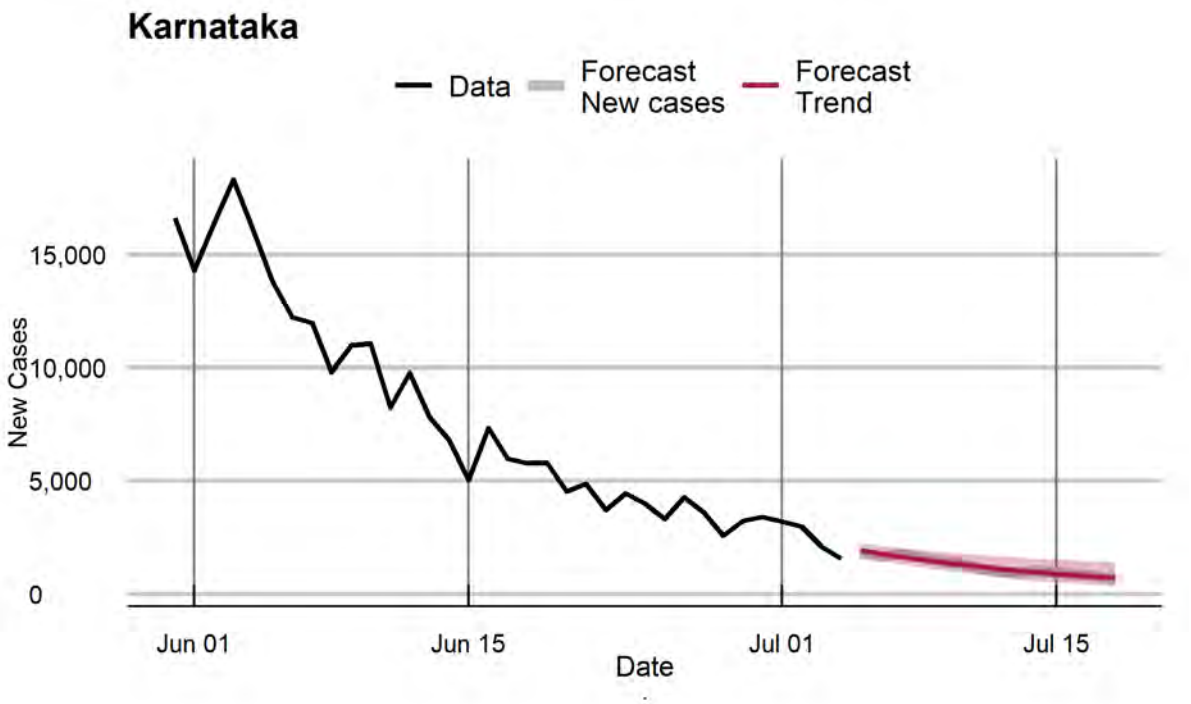

Himachal Pradesh
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

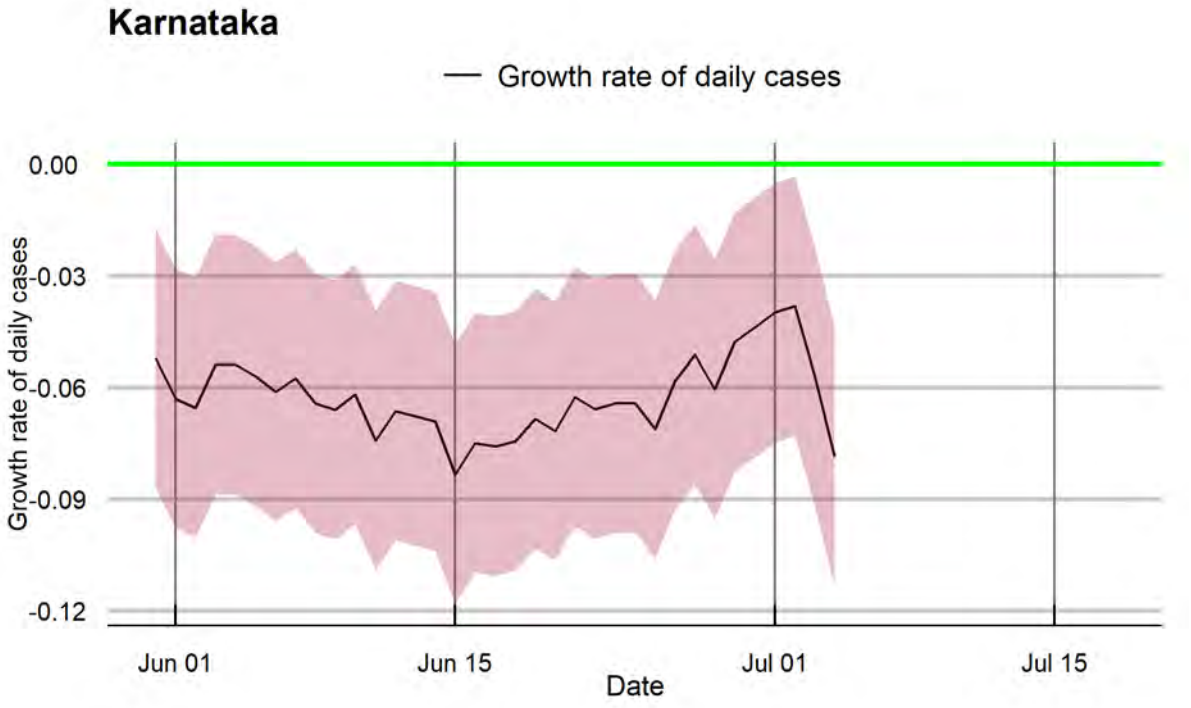

Jammu and Kashmir
Data
Forecast
New cases
Forecast
Trend
1,500
1,000
500
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

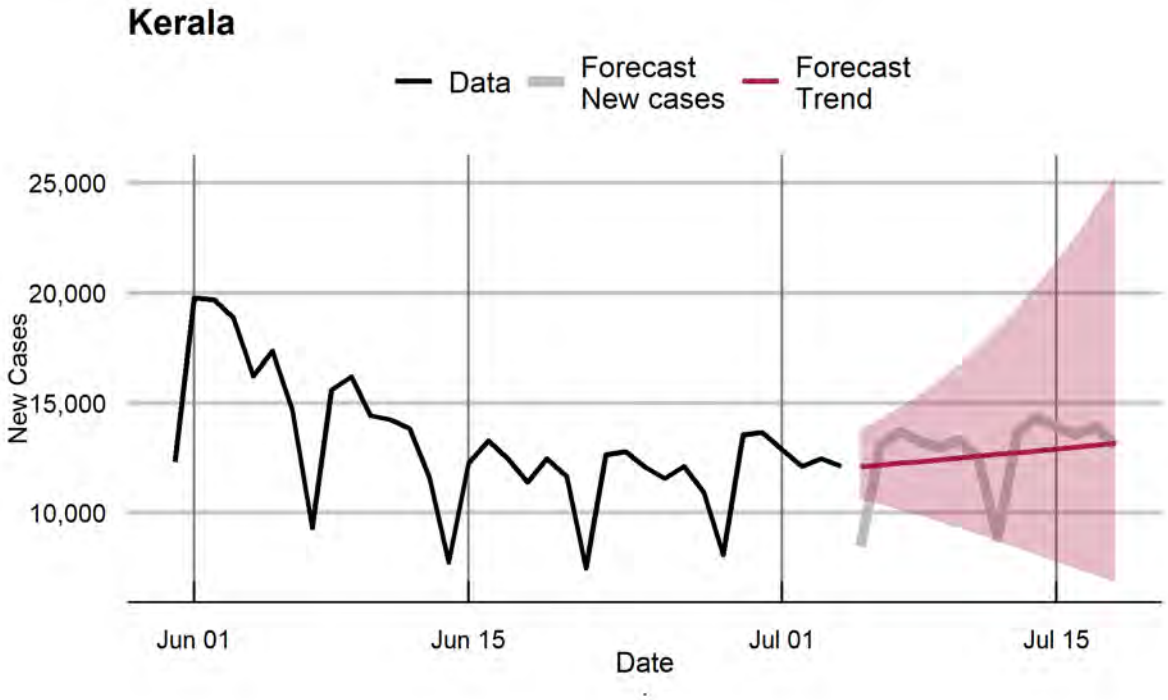

Jammu and Kashmir
Growth rate of daily cases
0.00
-0.04
-0.08
-0.12
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

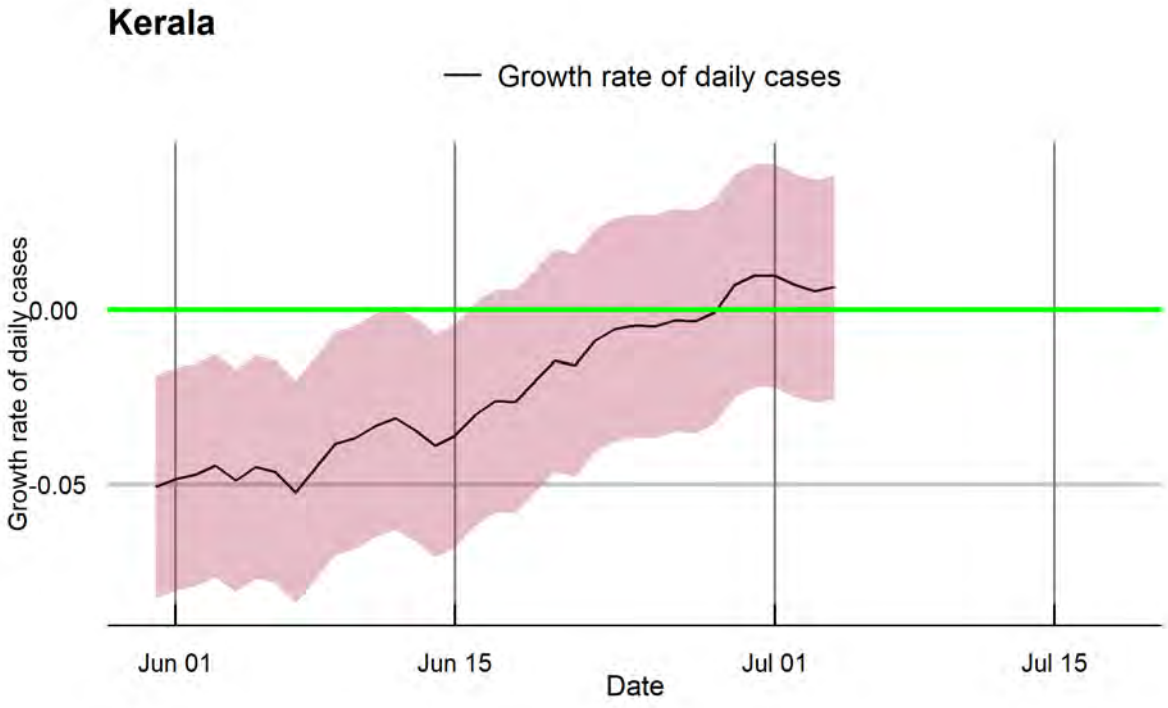

Jharkhand
Data
Forecast
New cases
Forecast
Trend
1,000
750
500
250
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

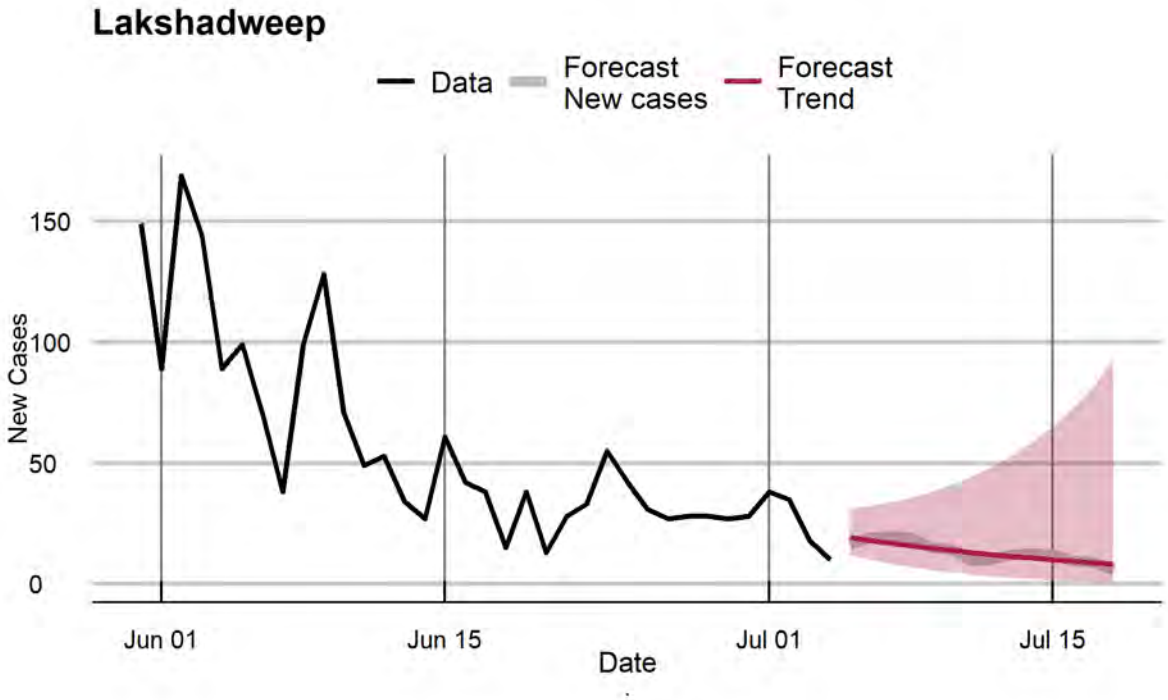

Jharkhand
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

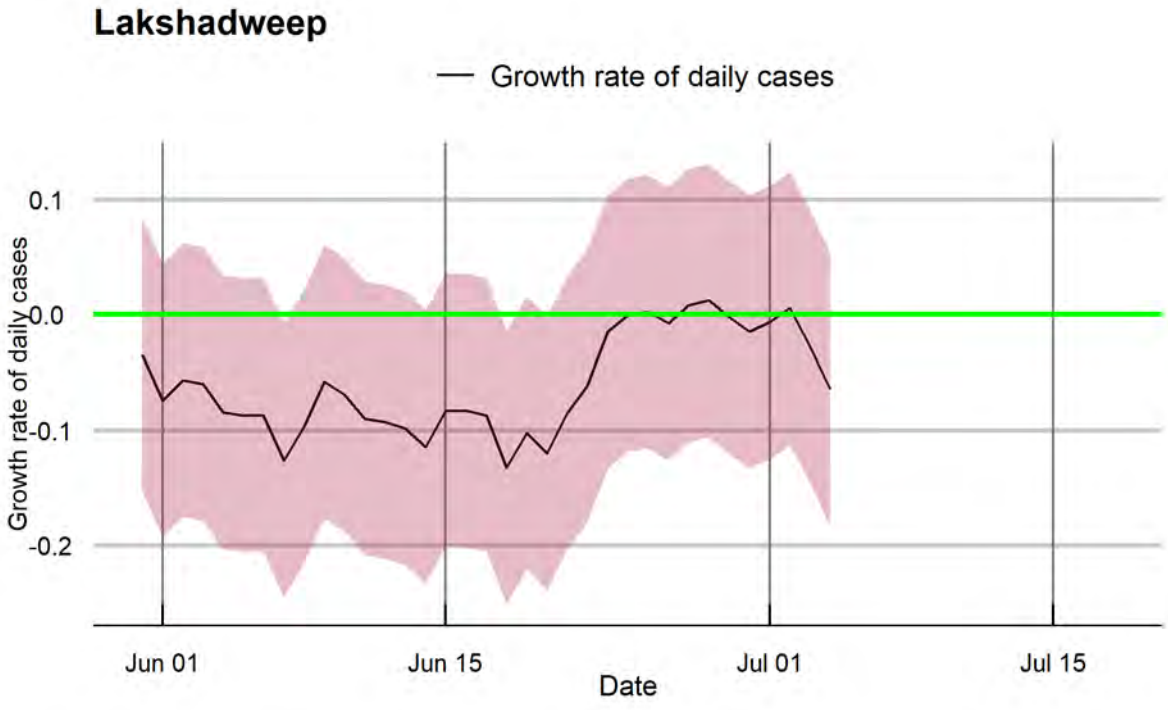

Karnataka
Data
Forecast
New cases
Forecast
Trend
15,000
10,000
5,000
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

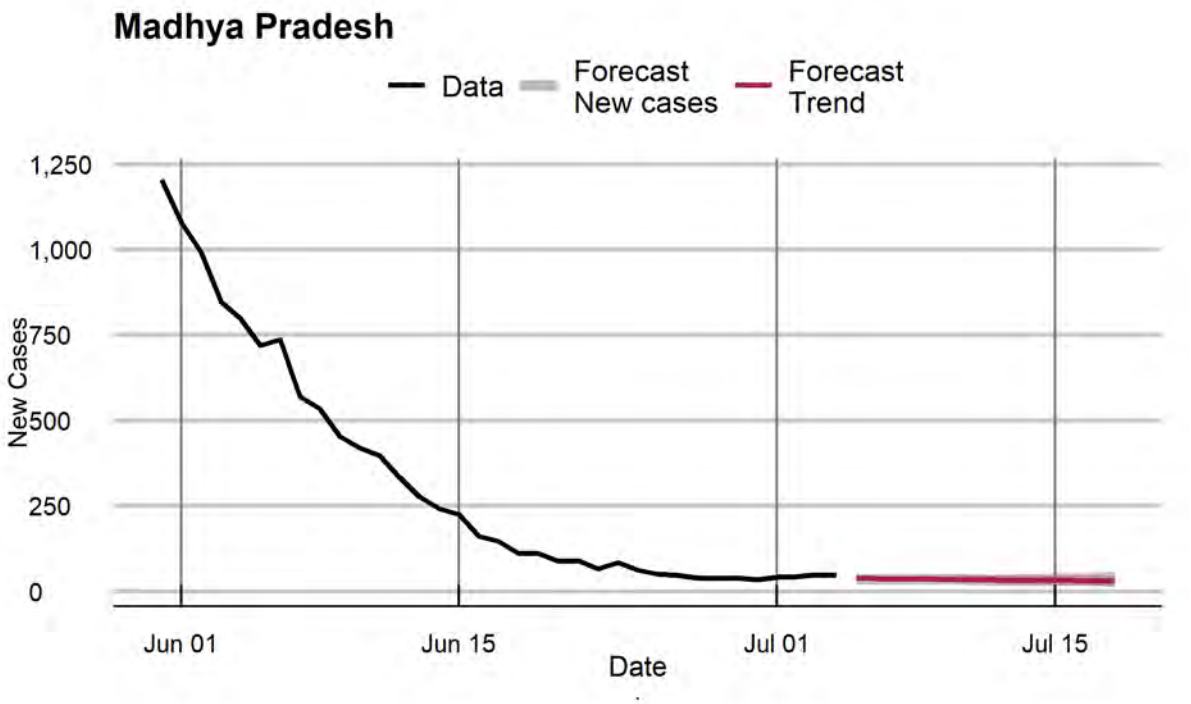

Karnataka
Growth rate of daily cases
0.00
-0.03
-0.06
-0.09
-0.12
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

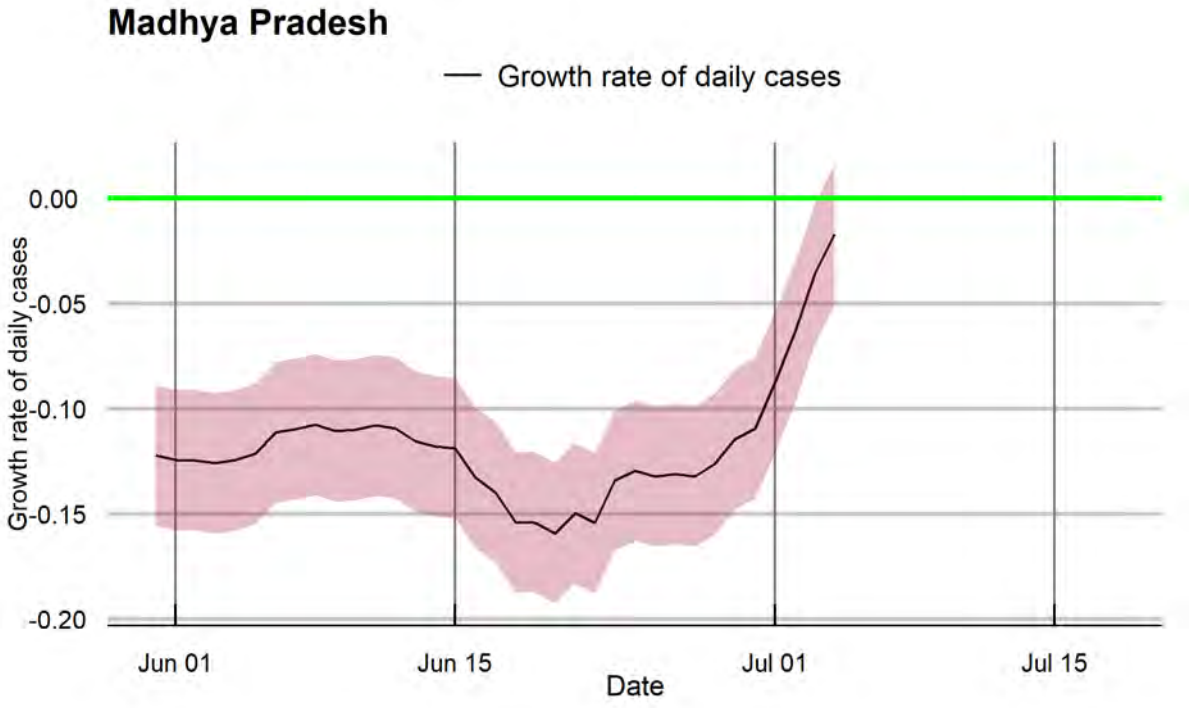

Kerala
Data
Forecast
New cases
Forecast
Trend
25,000
20,000
15,000
10,000
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

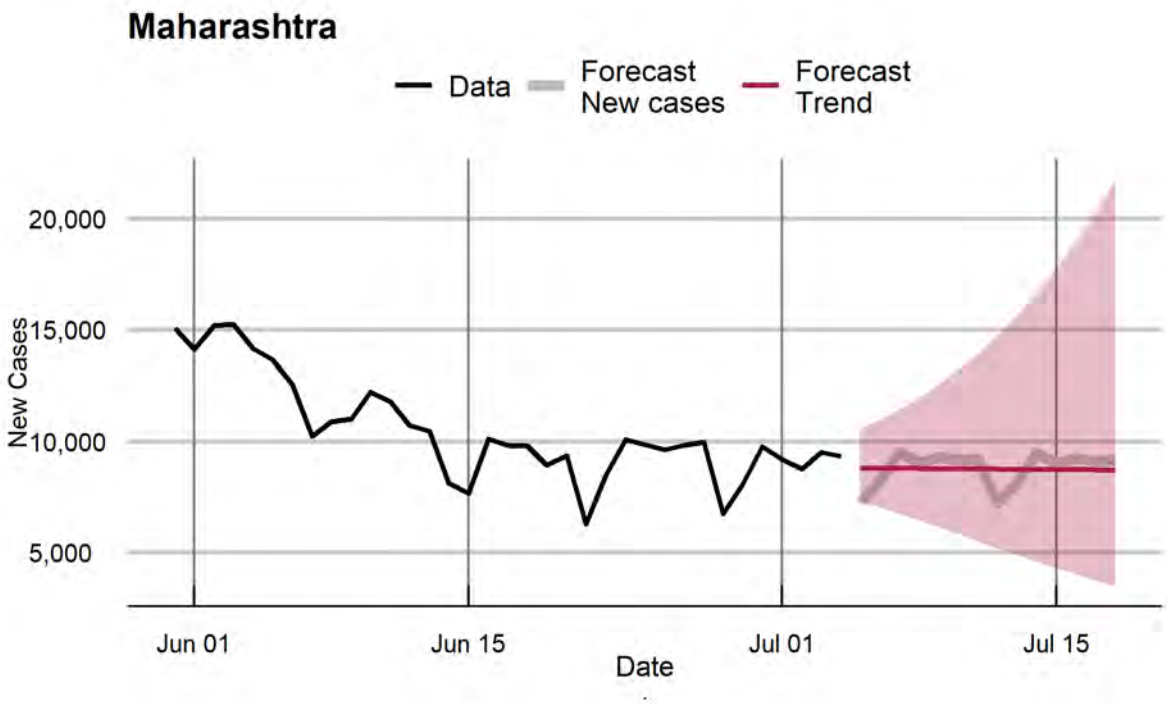

Kerala
Growth rate of daily cases
0.00
-0.05
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

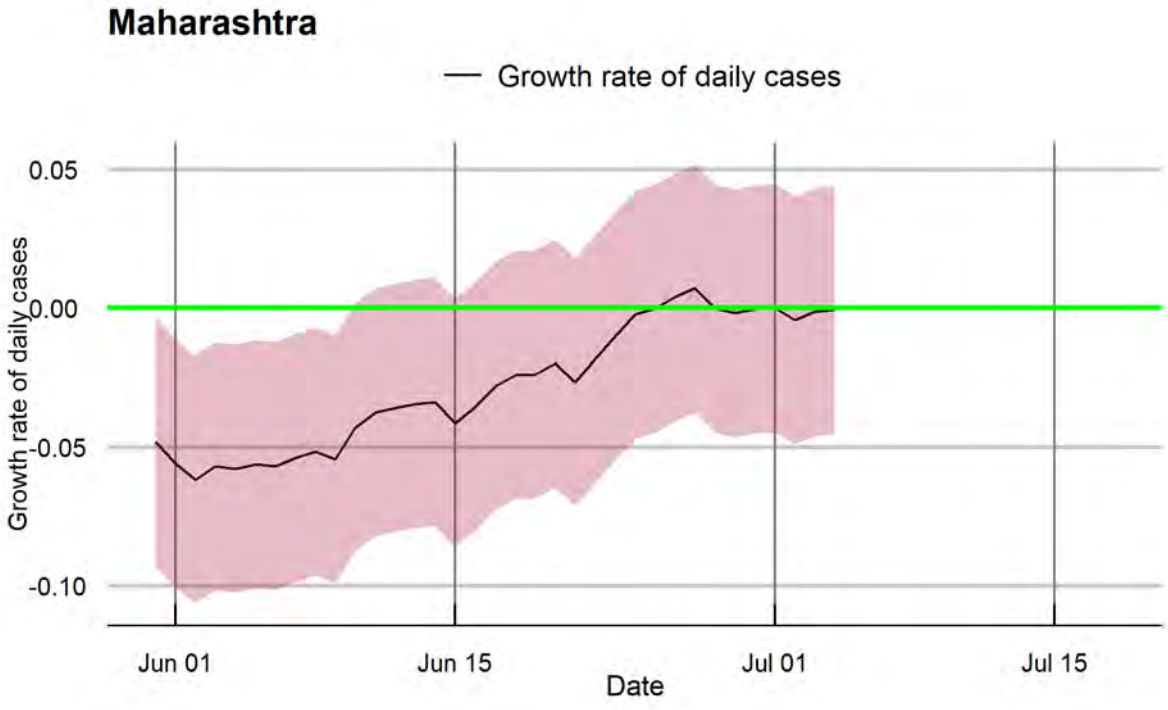

Lakshadweep
Data
Forecast
New cases
Forecast
Trend
150
100
50
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

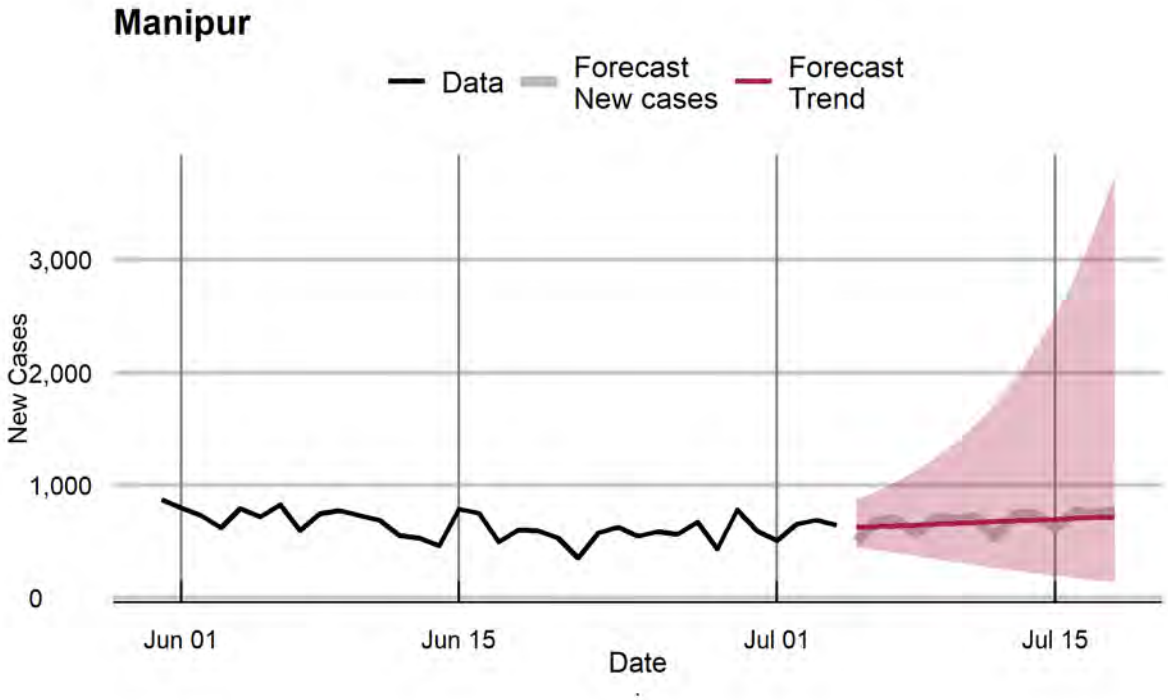

Lakshadweep
Growth rate of daily cases
0.1
0.0
-0.1
-0.2
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

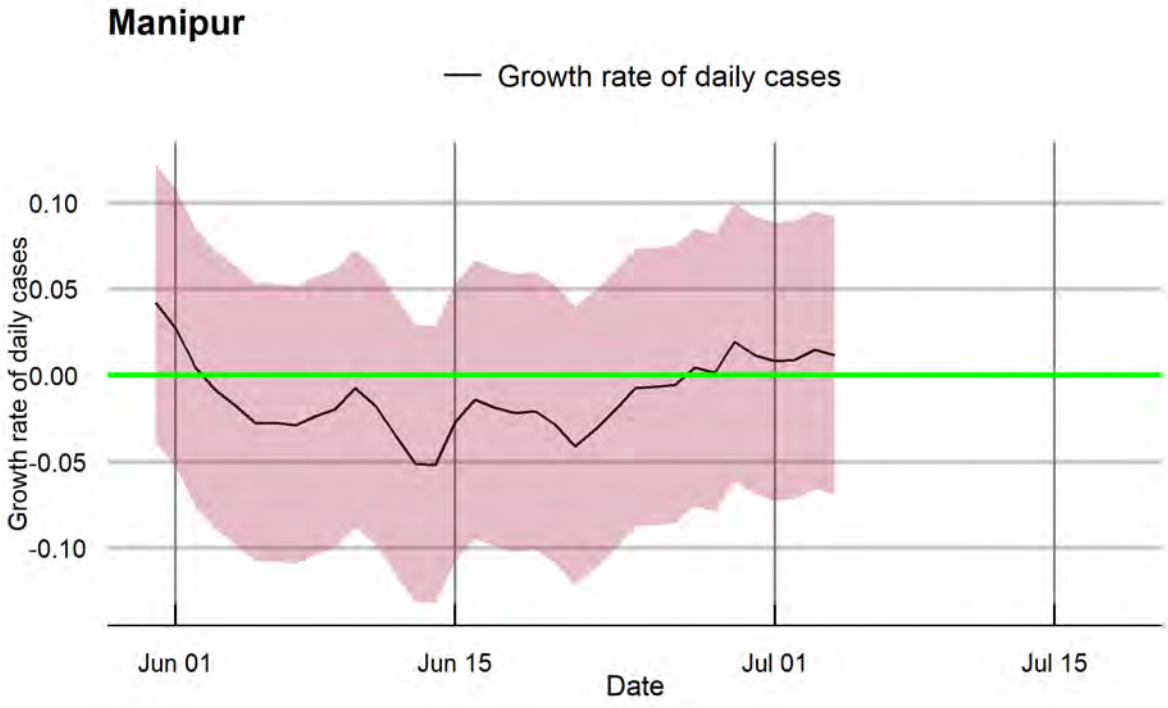

Madhya Pradesh
Data
Forecast
New cases
Forecast
Trend
1,250
1,000
750
500
250
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

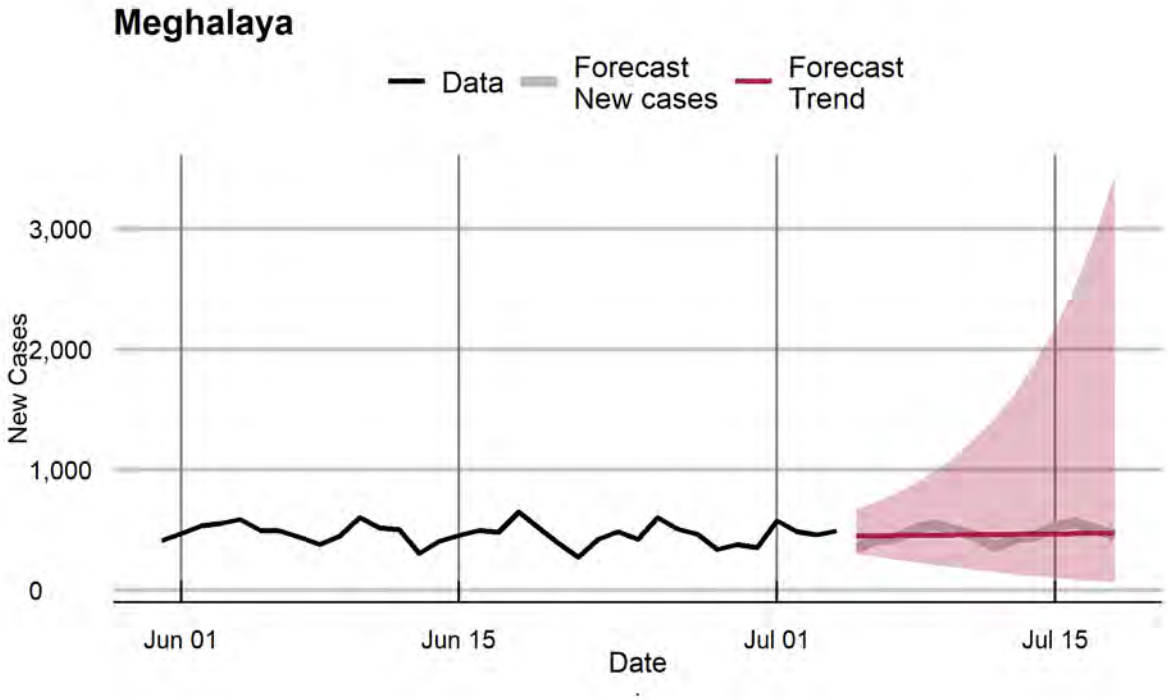

Madhya Pradesh
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
-0.20
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

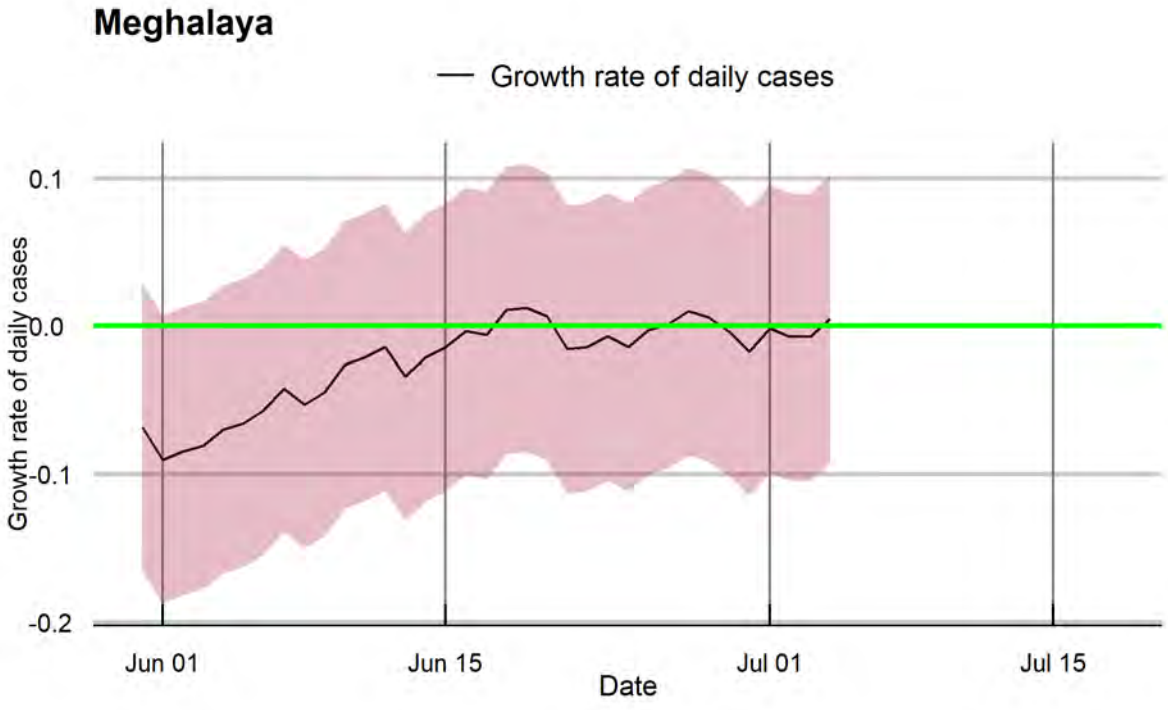

Maharashtra
Data
Forecast
New cases
Forecast
Trend
20,000
15,000
10,000
5,000
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

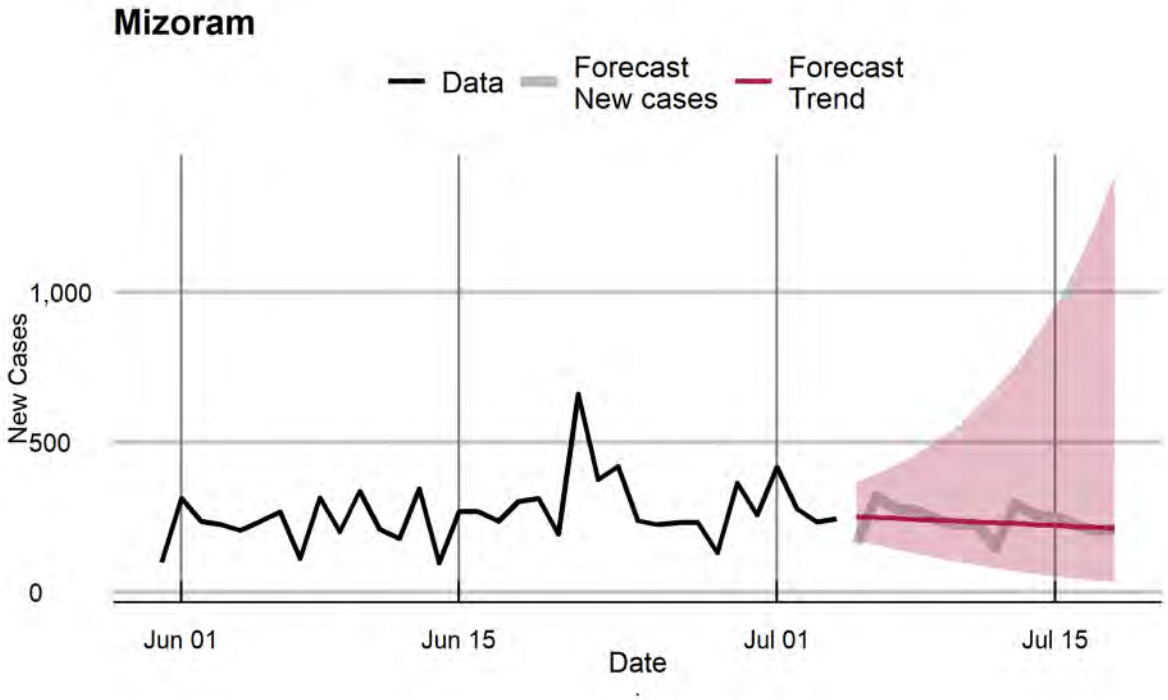

Maharashtra
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

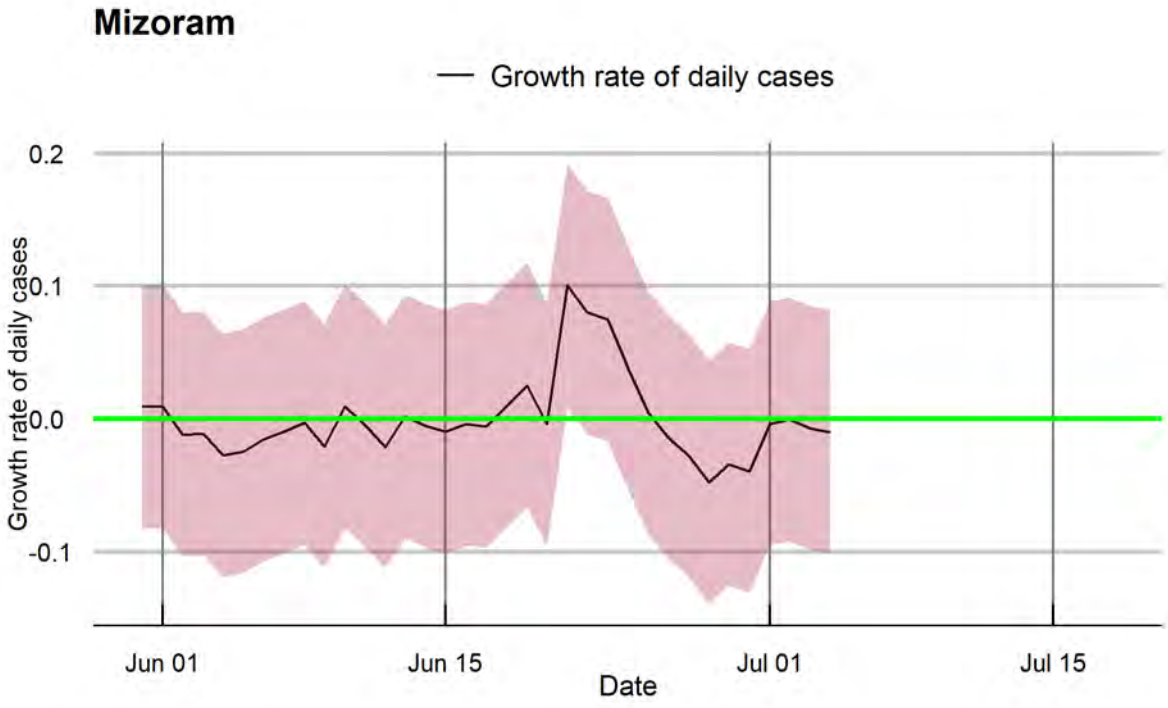

Manipur
Data
Forecast
New cases
Forecast
Trend
3,000
2,000
1,000
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

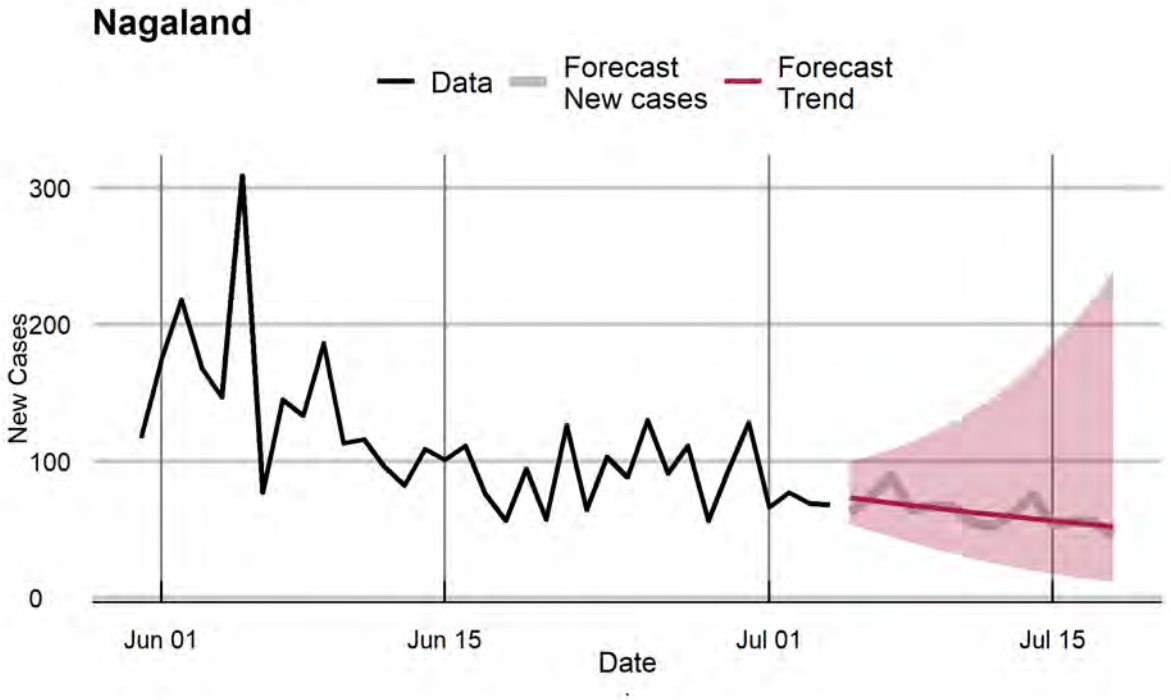

Manipur
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

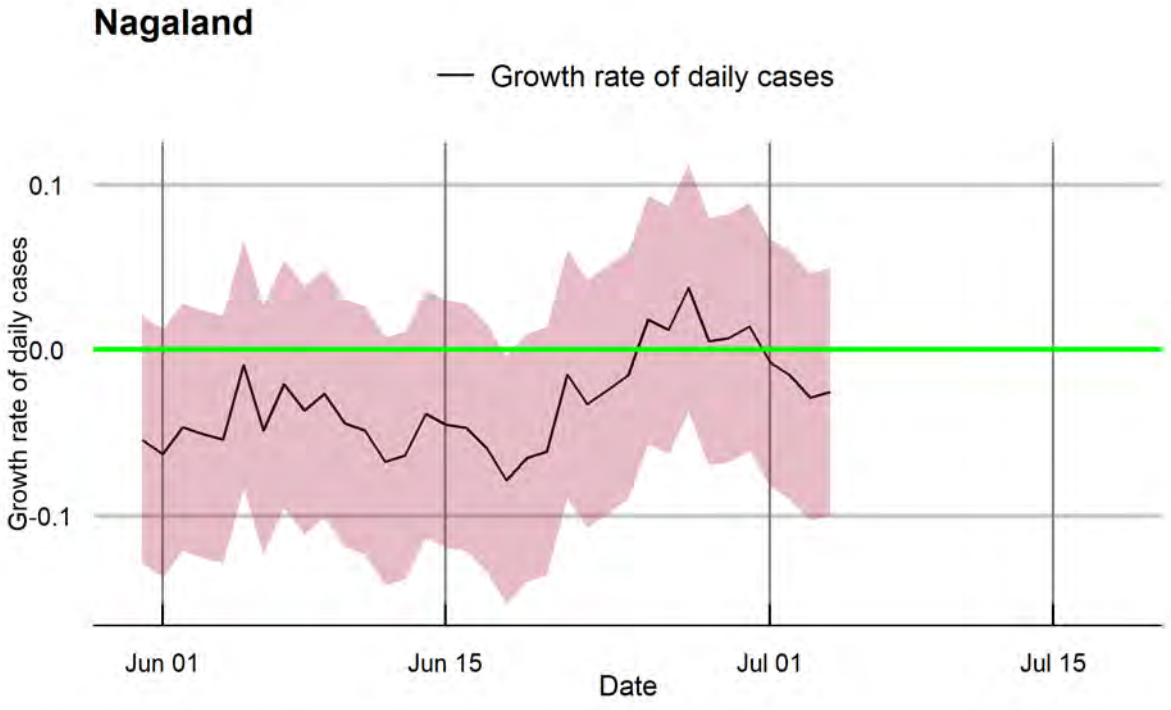

Meghalaya
Data
Forecast
New cases
Forecast
Trend
3,000
2,000
1,000
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

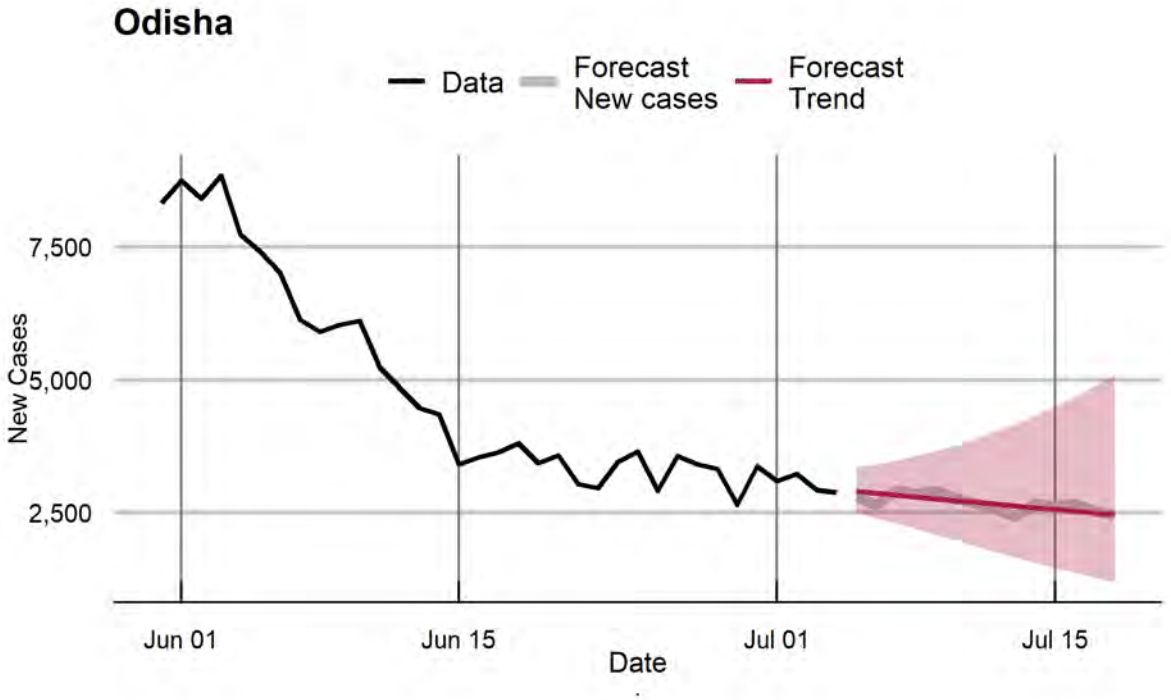

Meghalaya
Growth rate of daily cases
0.1
0.0
-0.1
-0.2
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

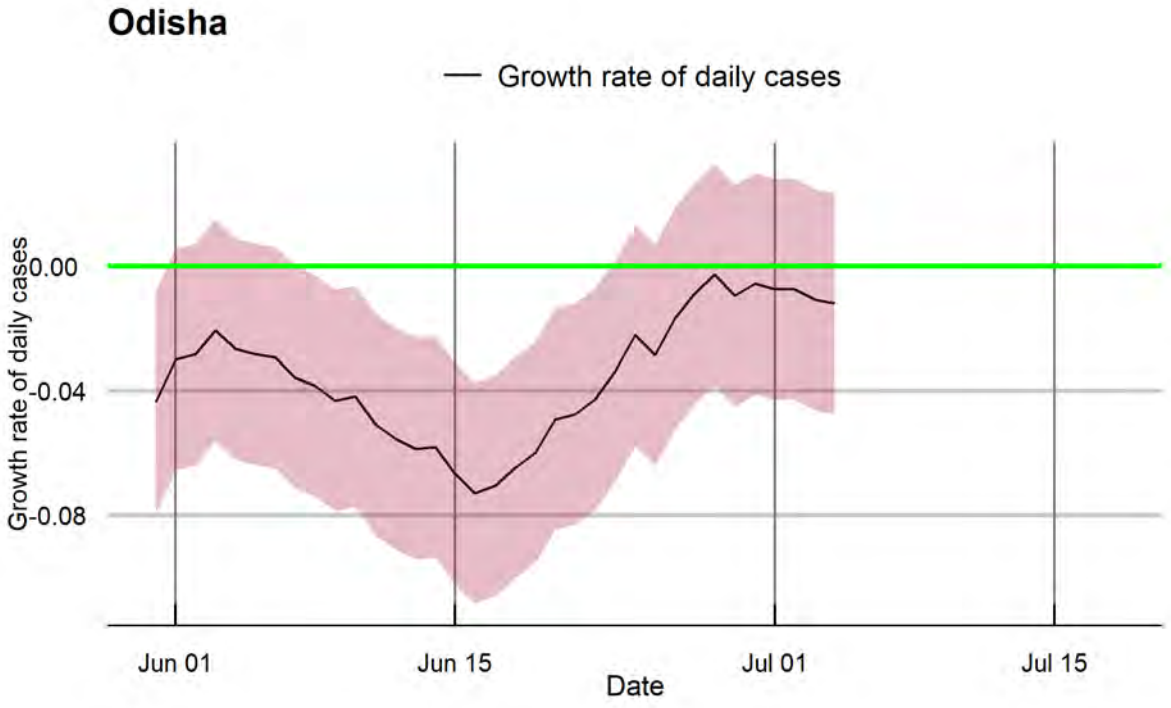

Mizoram
Data
Forecast
New cases
Forecast
Trend
1,000
500
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

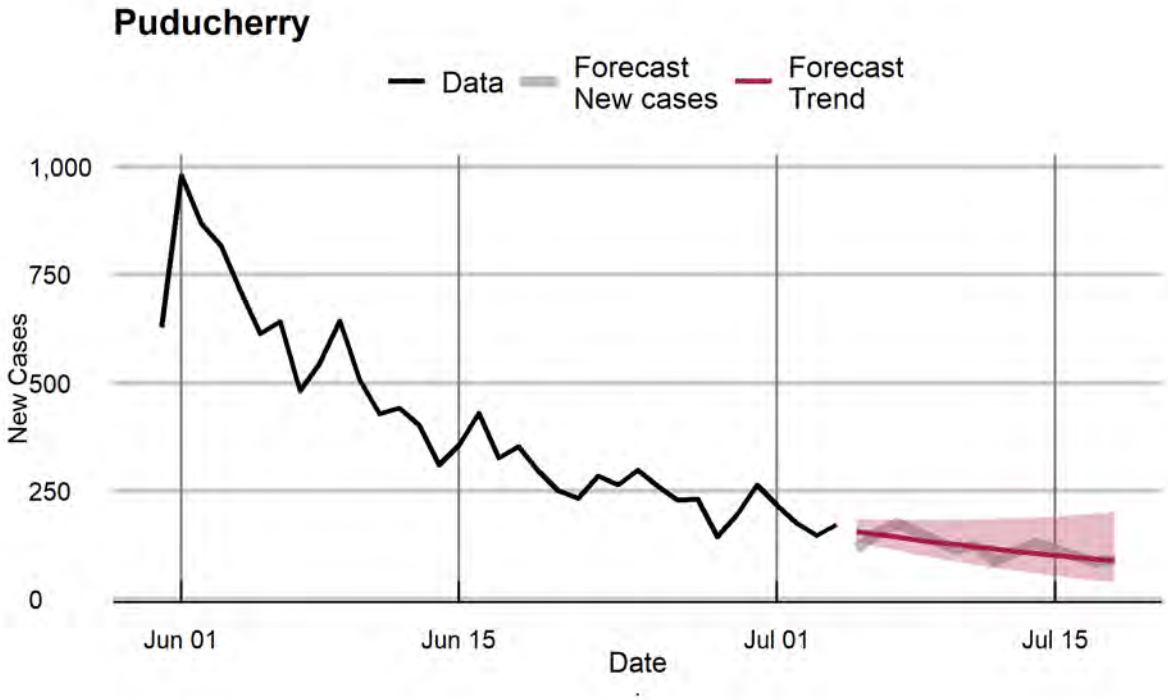

Mizoram
Growth rate of daily cases
0.2
0.1
0.0
-0.1
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

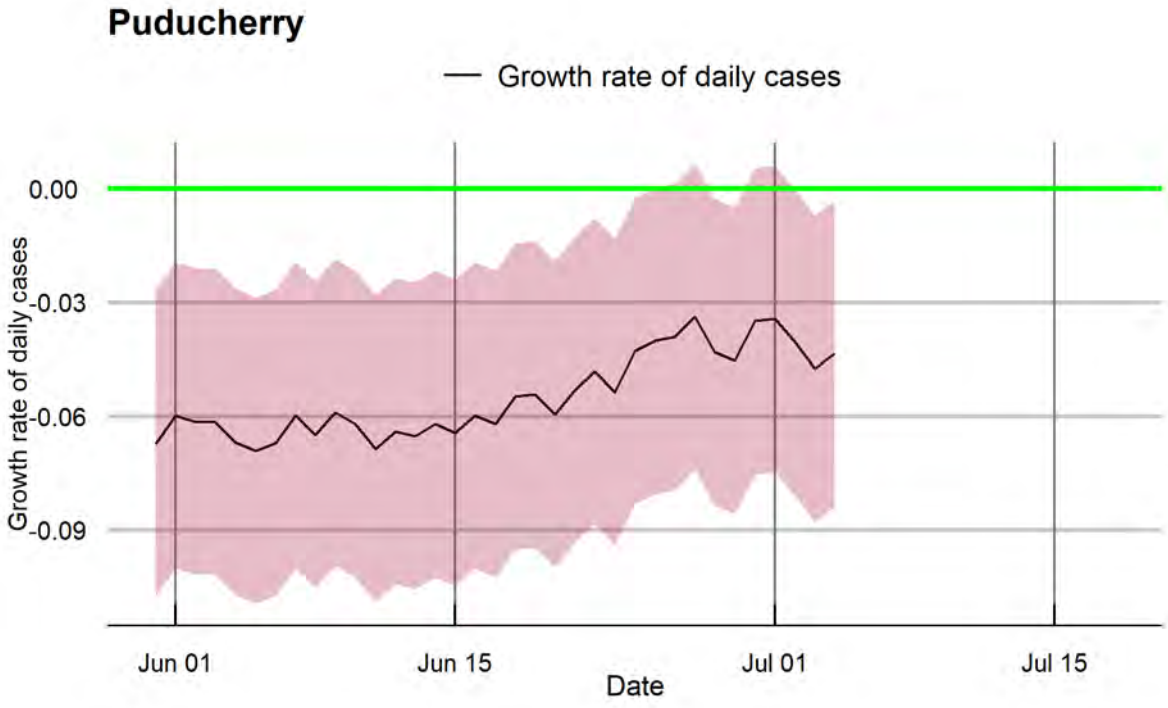

Nagaland
Data
Forecast
New cases
Forecast
Trend
300
200
100
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

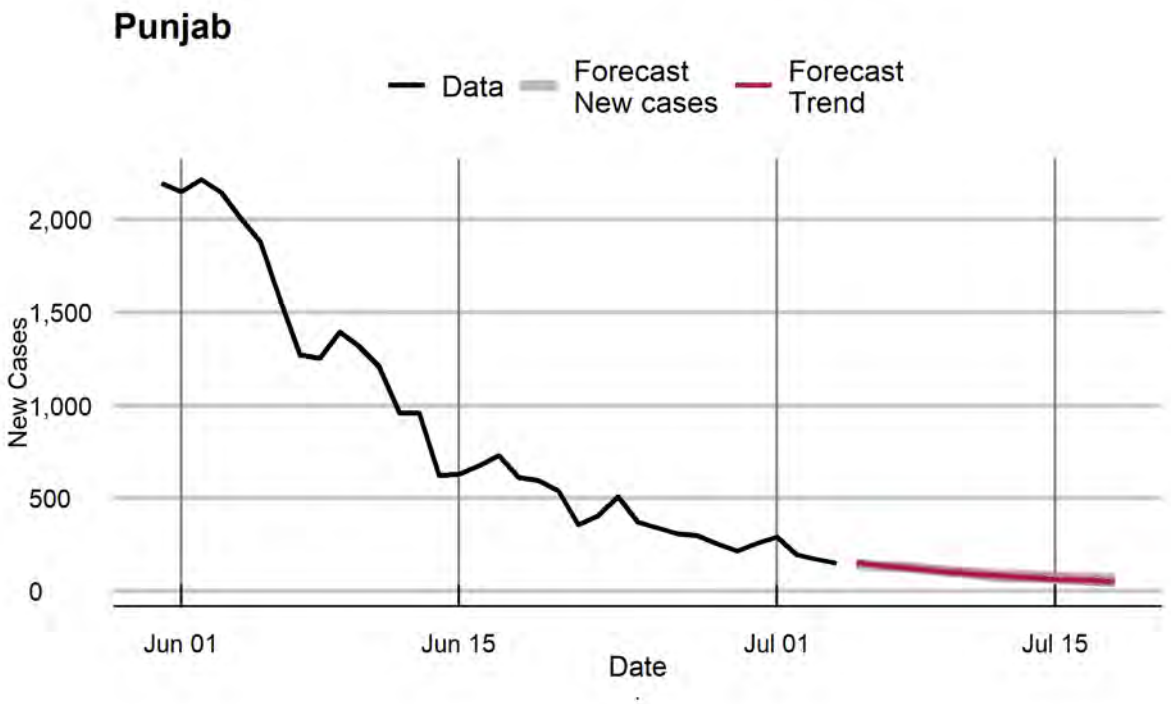

Nagaland
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

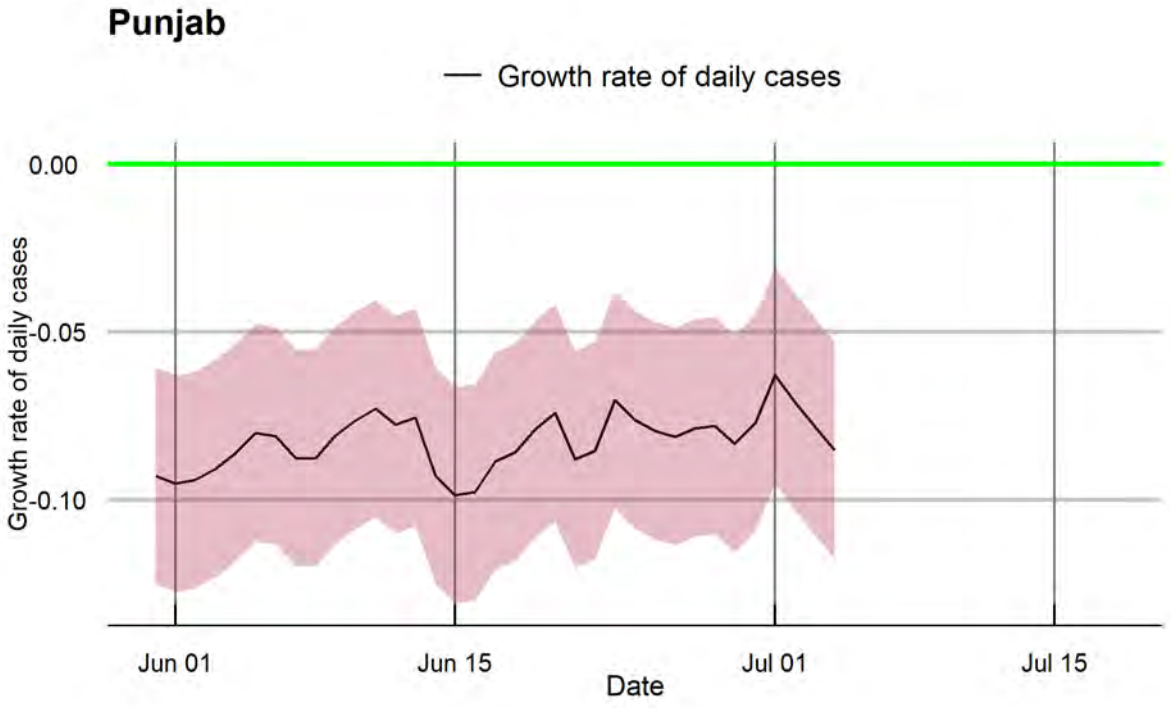

Odisha
Data
Forecast
New cases
Forecast
Trend
7,500
5,000
2,500
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

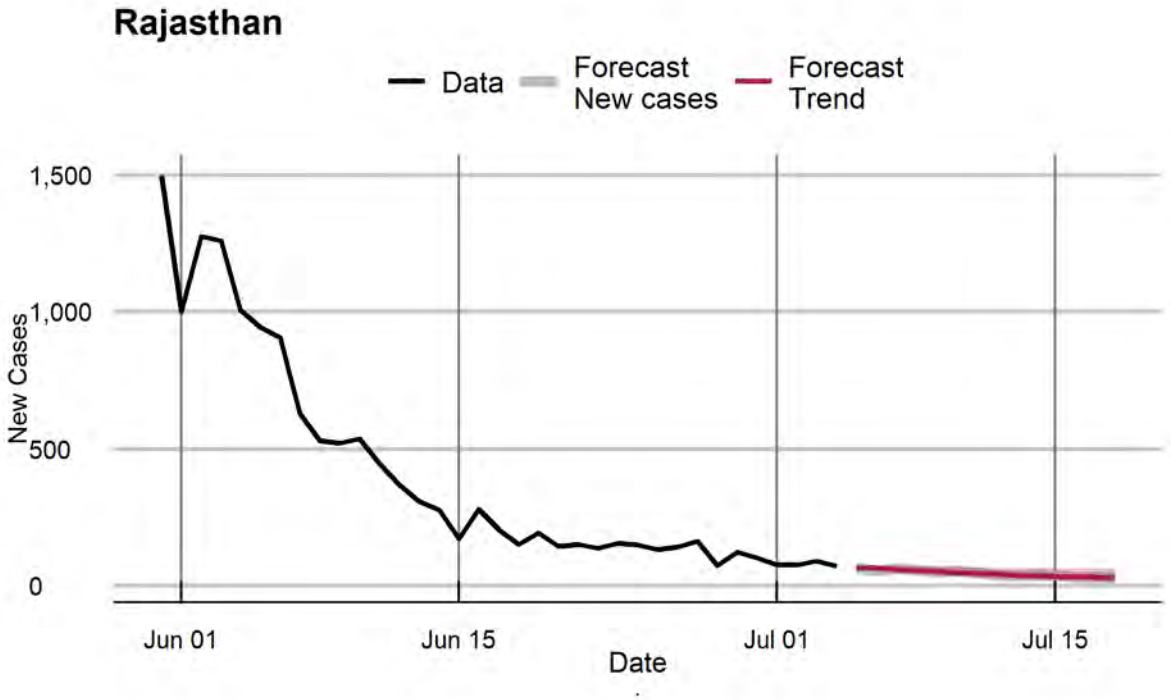

Odisha
Growth rate of daily cases
0.00
-0.04
-0.08
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

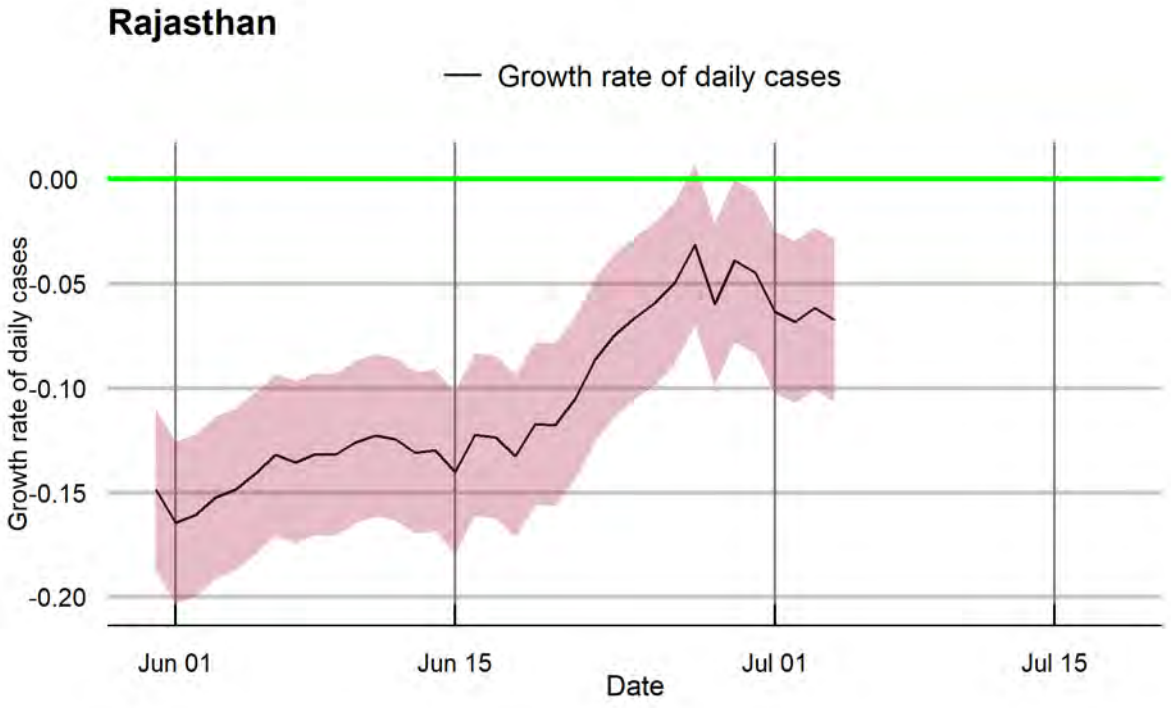

Puducherry
Data
Forecast
New cases
Forecast
Trend
1,000
750
500
250
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

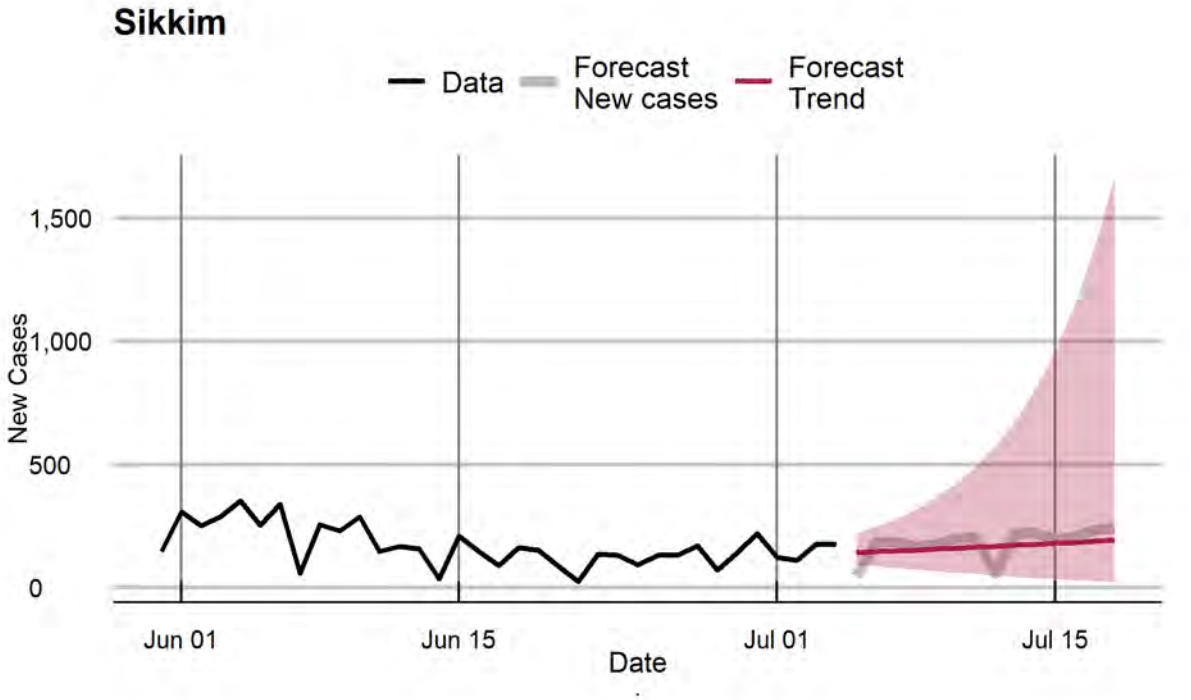

Puducherry
Growth rate of daily cases
0.00
-0.03
-0.06
-0.09
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

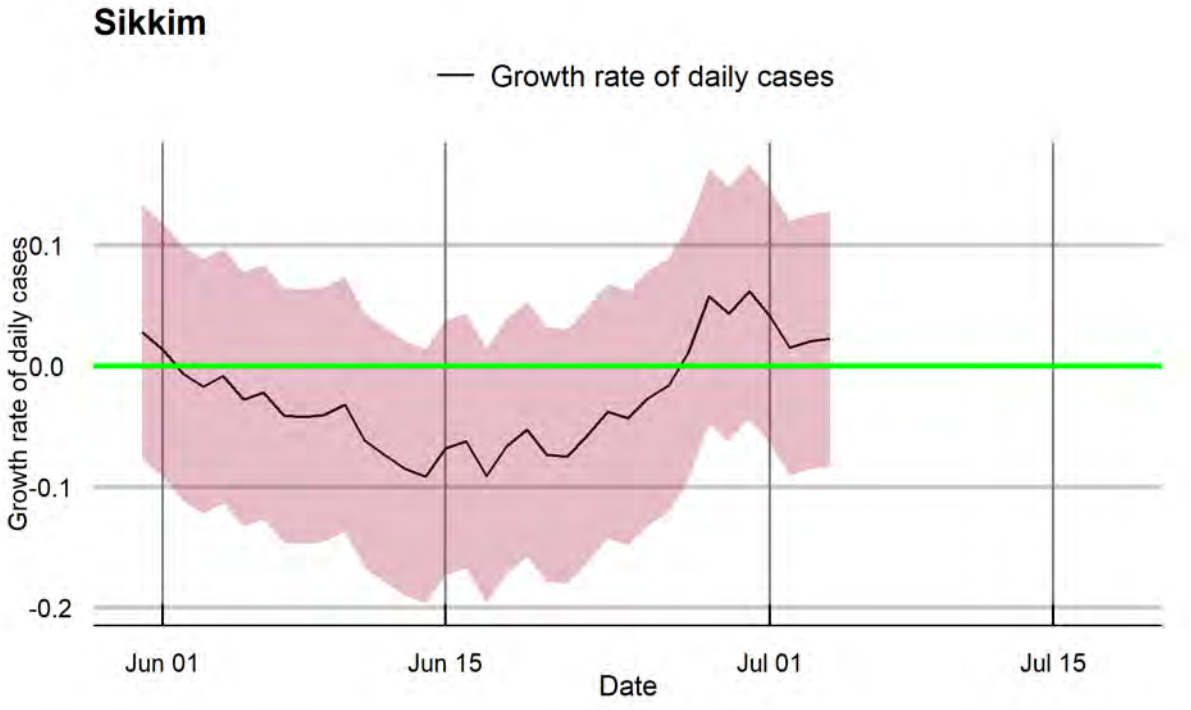

Punjab
Data
Forecast
New cases
Forecast
Trend
2,000
1,500
1,000
500
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

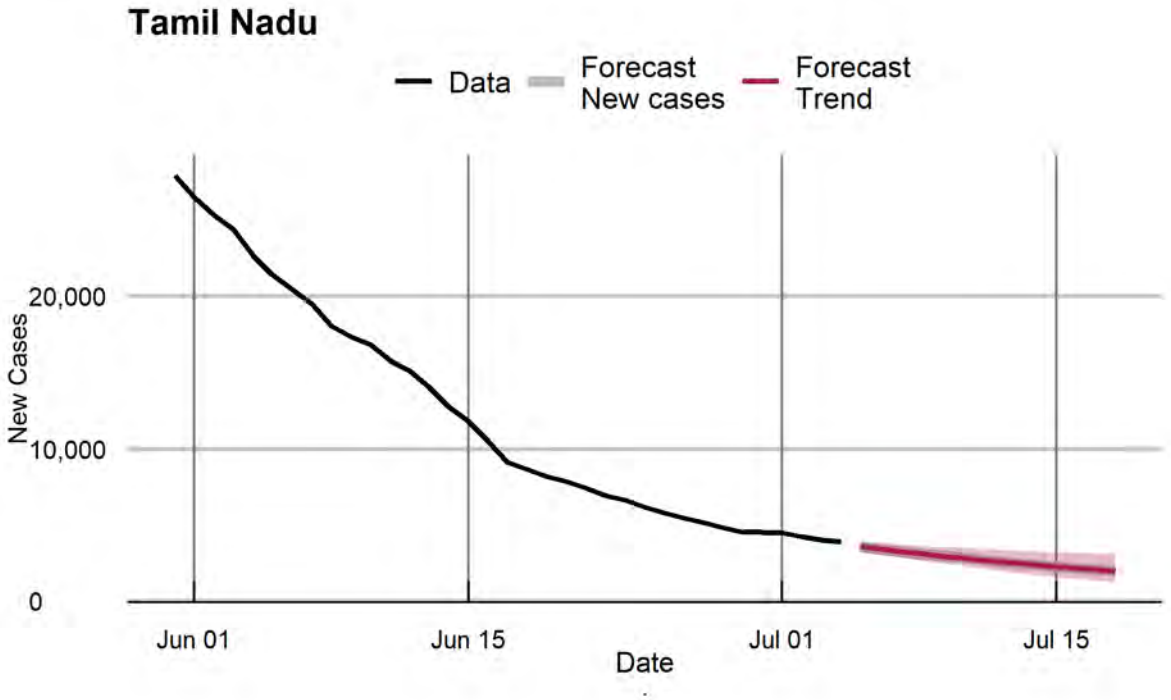

Punjab
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

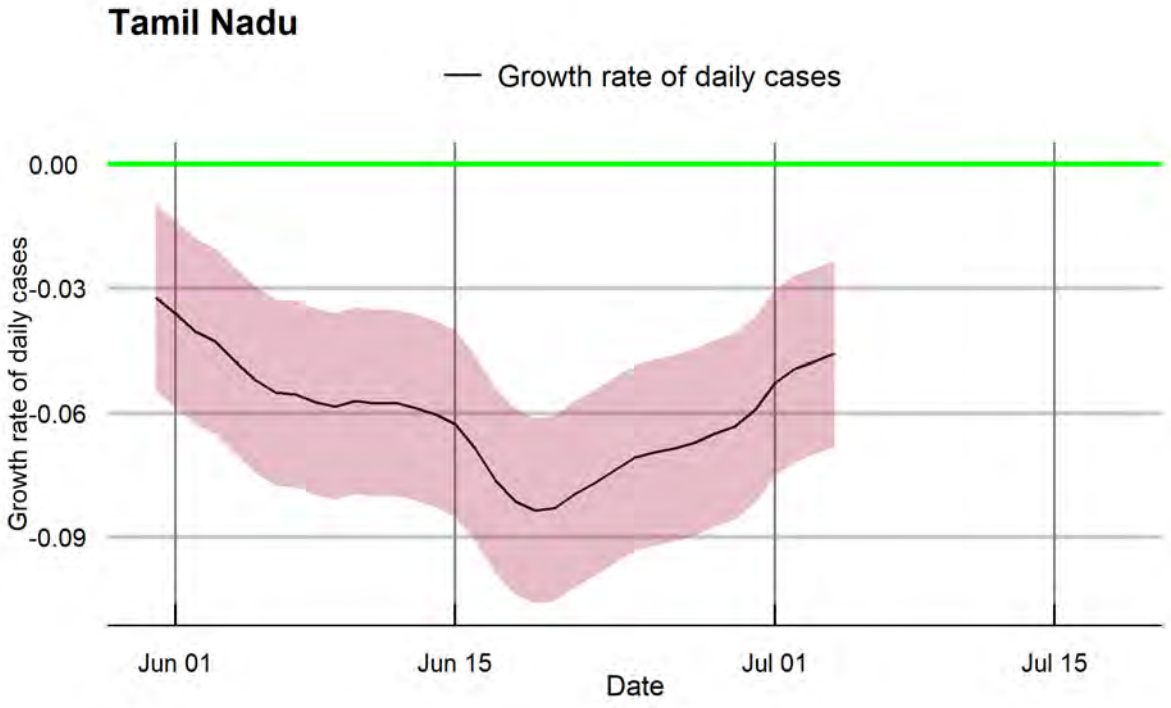

Rajasthan
Data
Forecast
New cases
Forecast
Trend
1,500
1,000
500
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

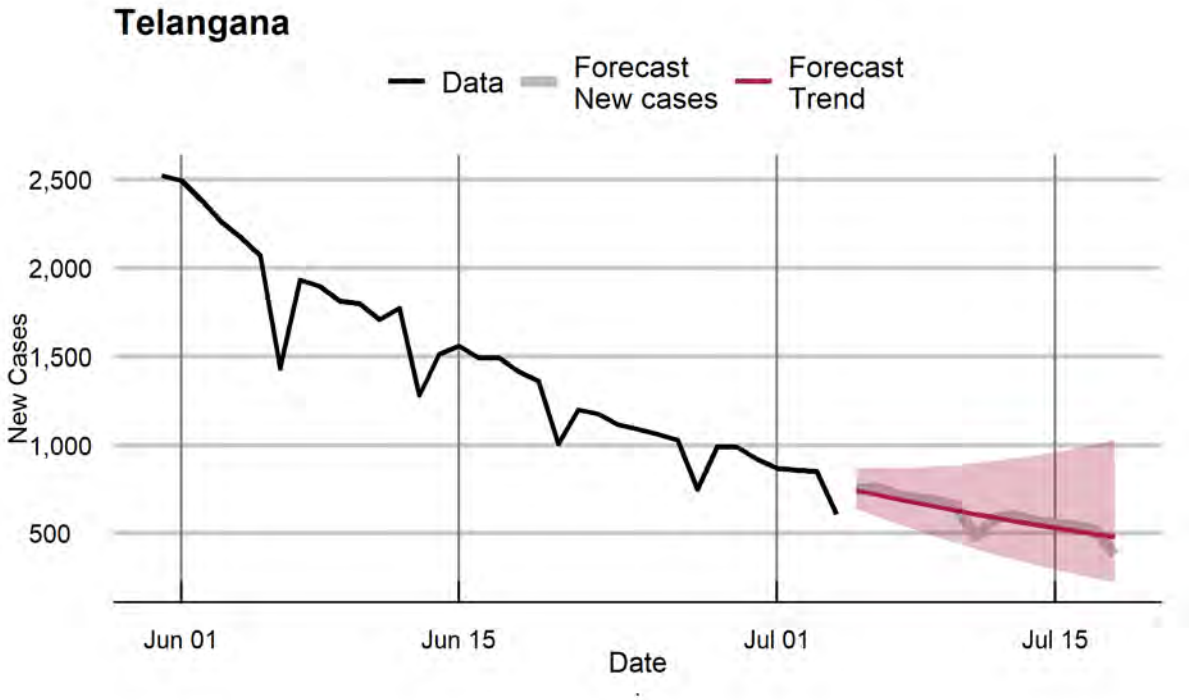

Rajasthan
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
-0.20
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

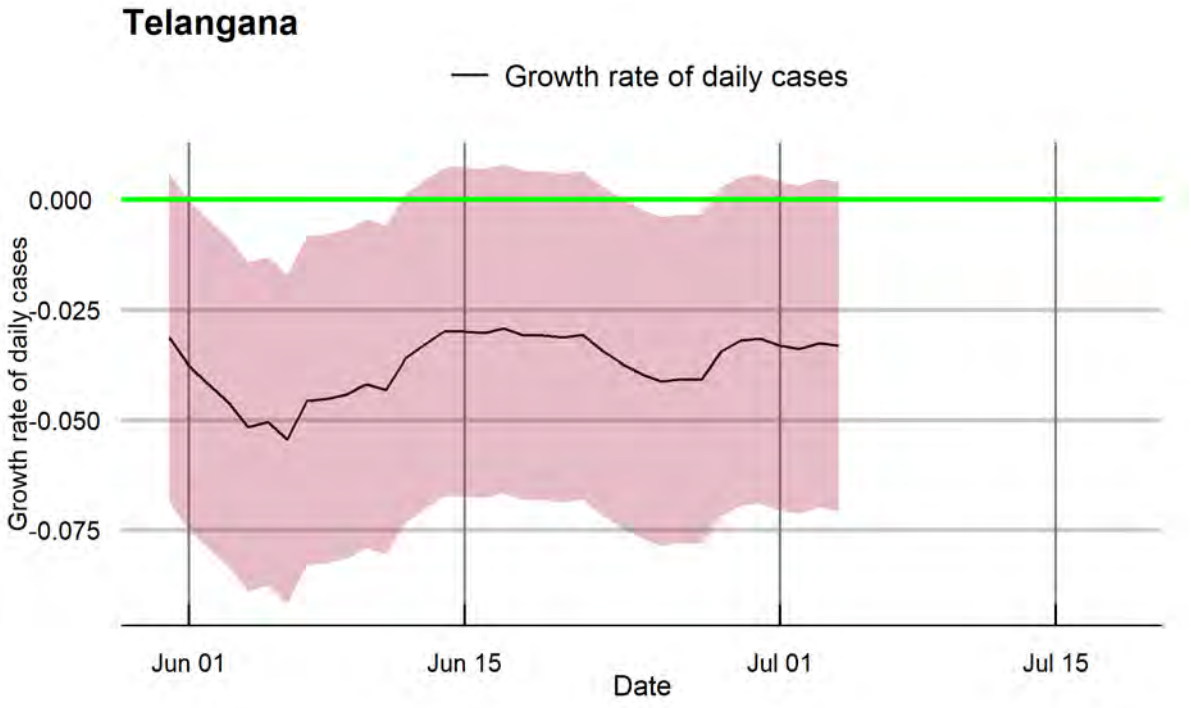

Sikkim
Data
Forecast
New cases
Forecast
Trend
1,500
1,000
500
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

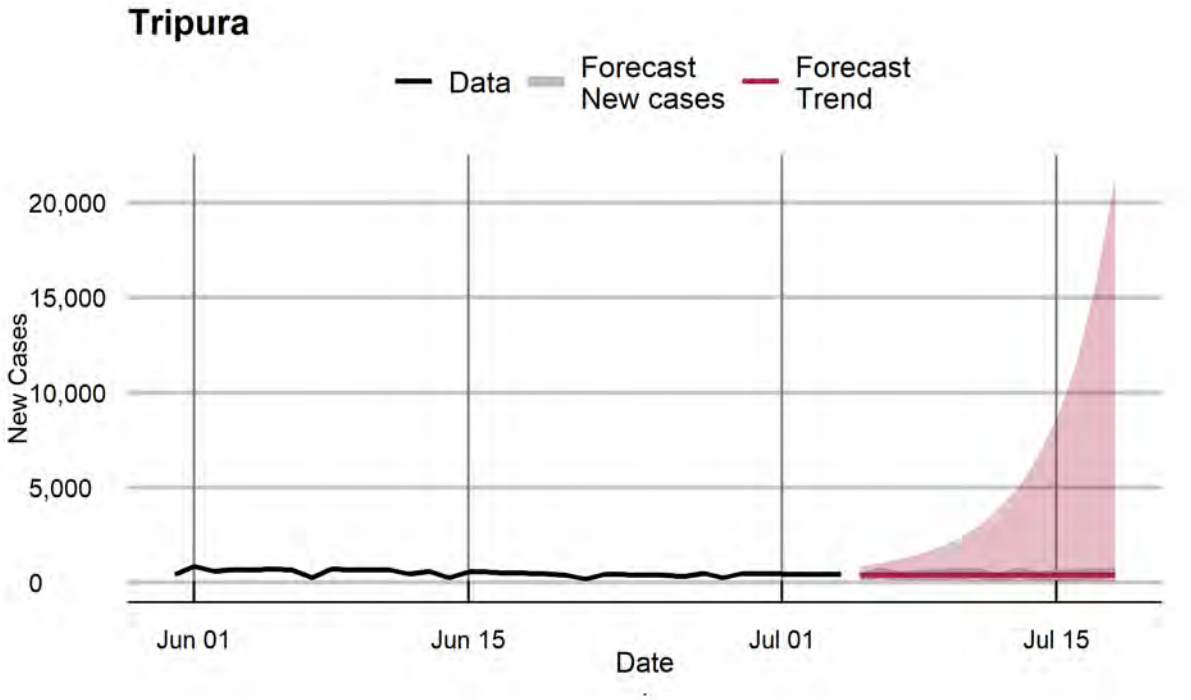

Sikkim
Growth rate of daily cases
0.1
0.0
-0.1
-0.2
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

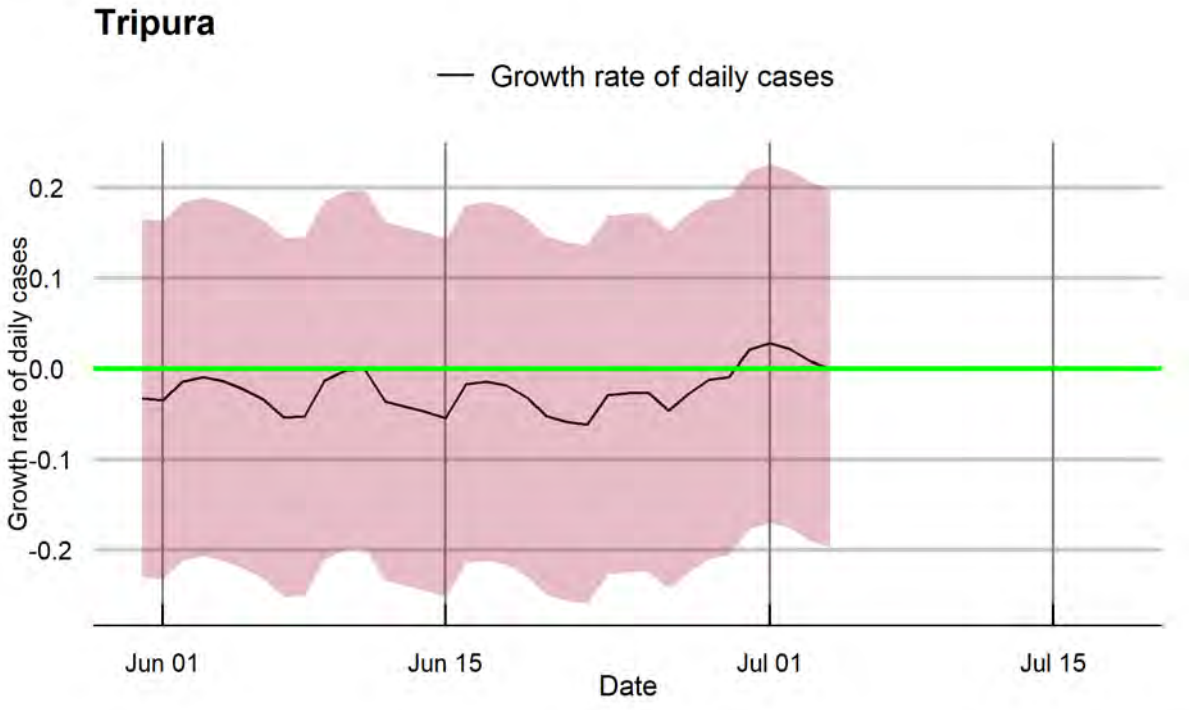

Tamil Nadu
Data
Forecast
New cases
Forecast
Trend
20,000
10,000
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

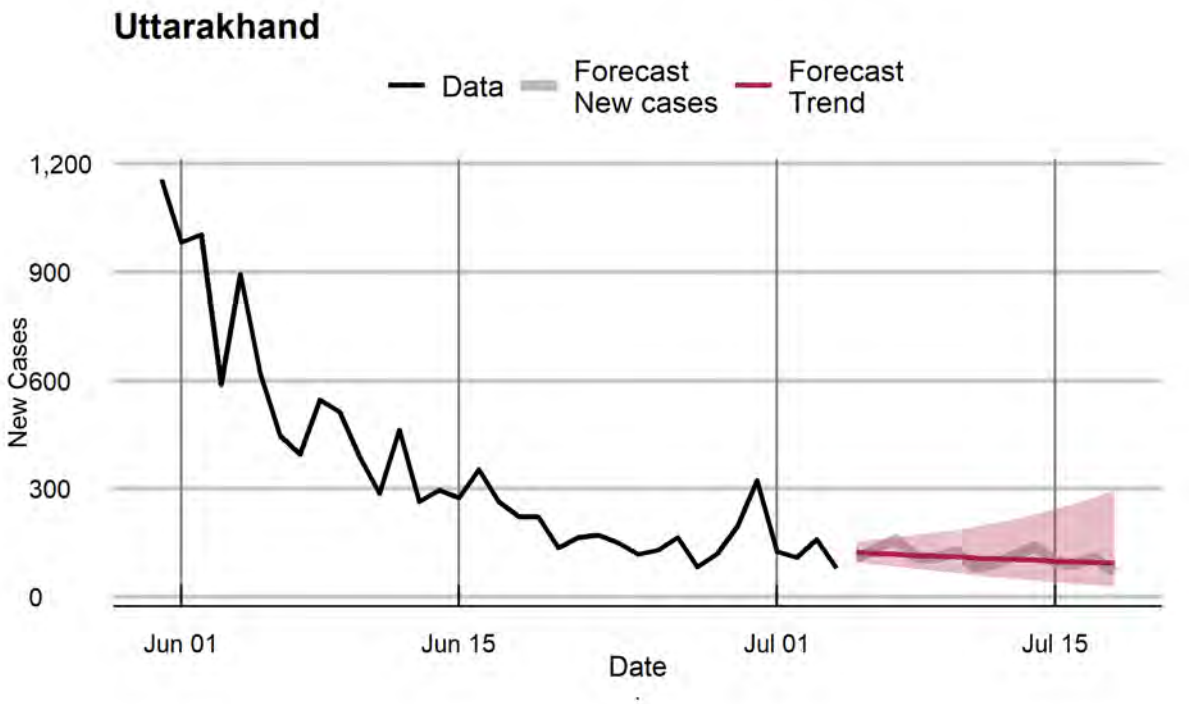

Tamil Nadu
Growth rate of daily cases
0.00
-0.03
-0.06
-0.09
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

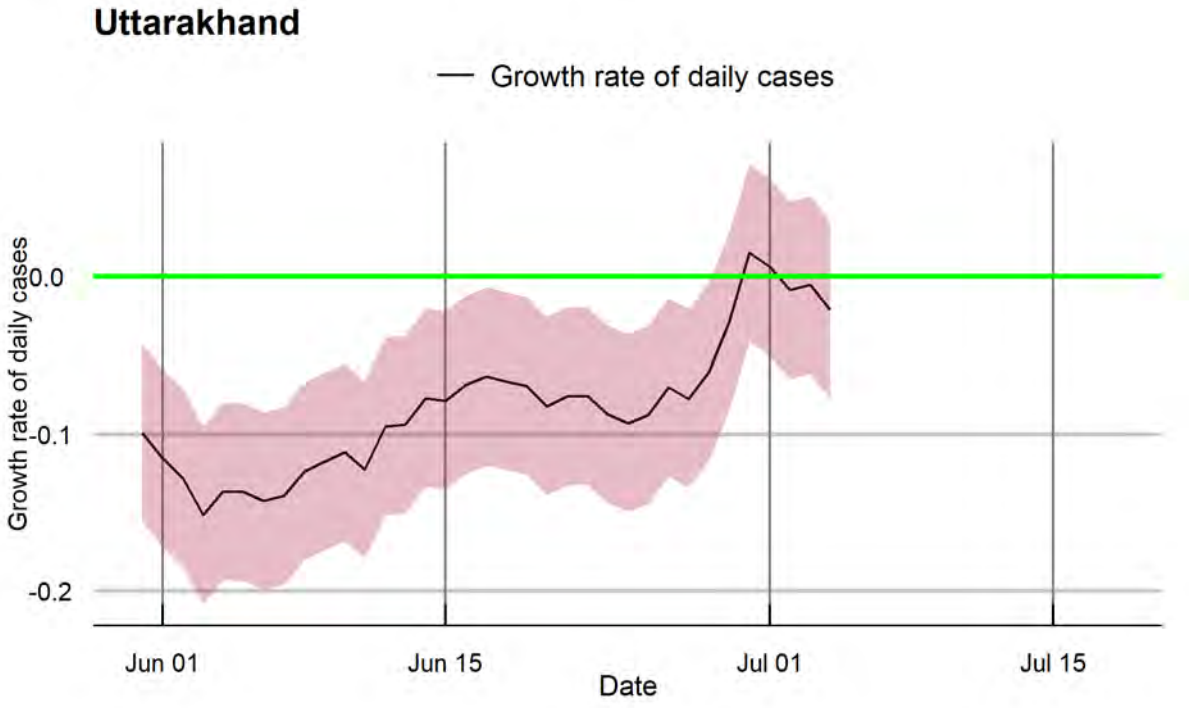

Telangana
Data
Forecast
New cases
Forecast
Trend
2,500
2,000
1,500
1,000
500
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

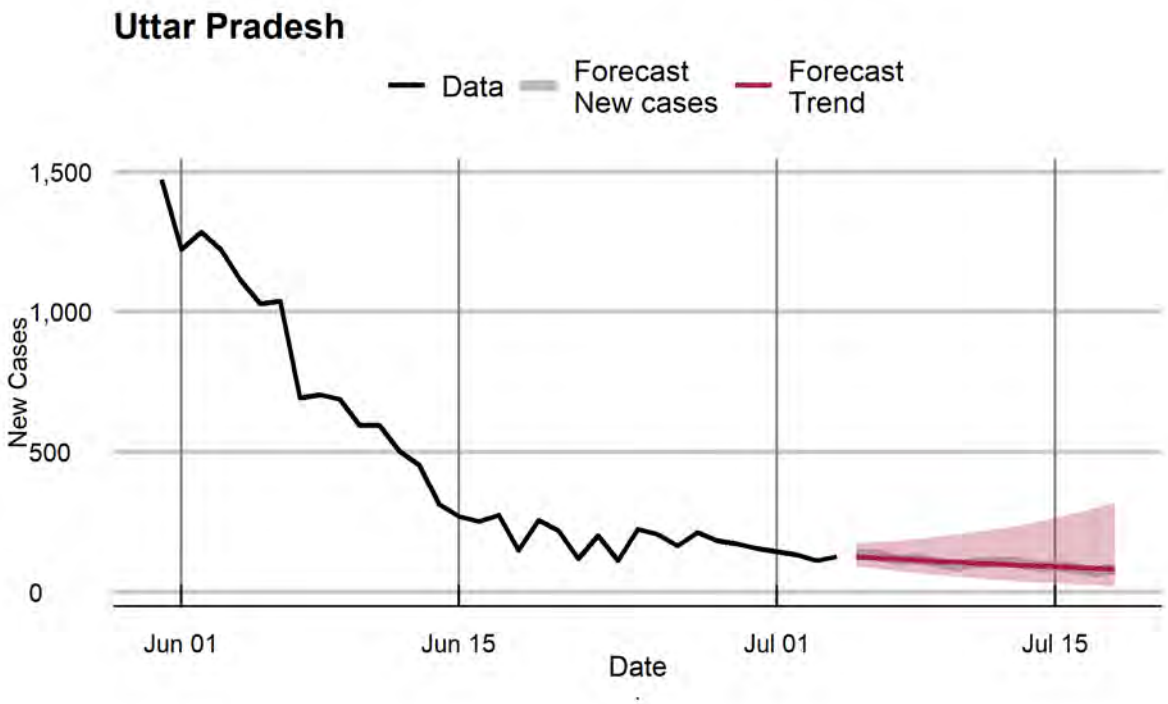

Telangana
Growth rate of daily cases
0.000
-0.025
-0.050
-0.075
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

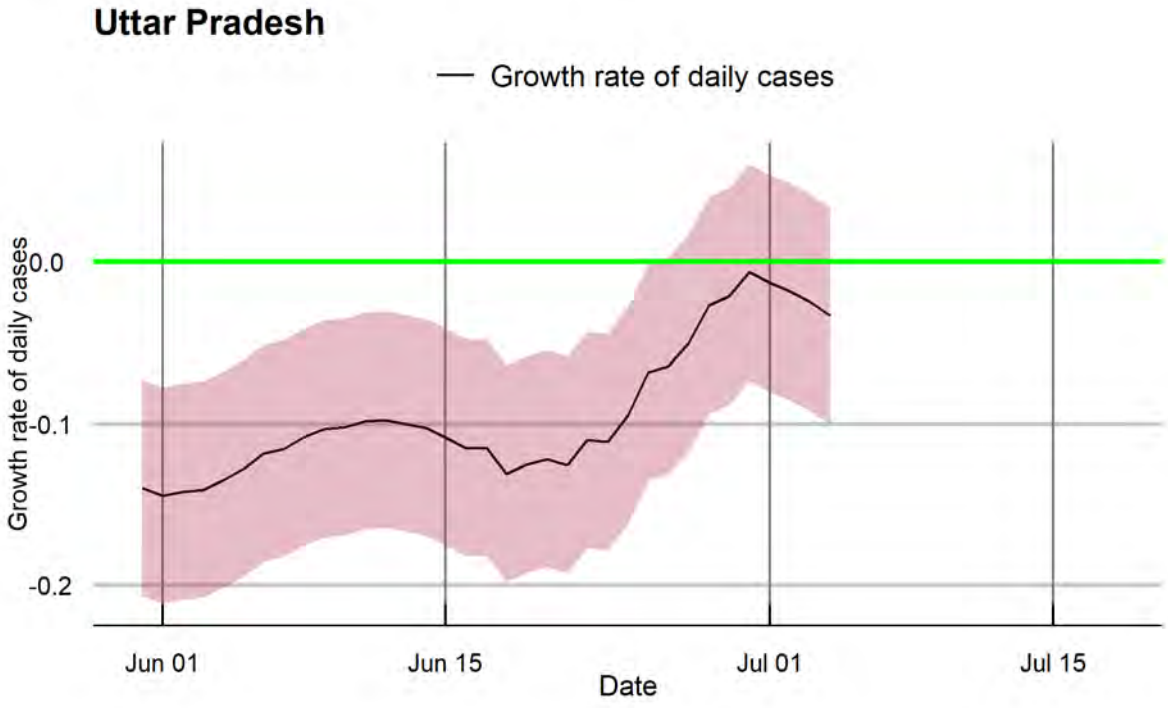

Tripura
Data
Forecast
New cases
Forecast
Trend
20,000
15,000
10,000
5,000
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

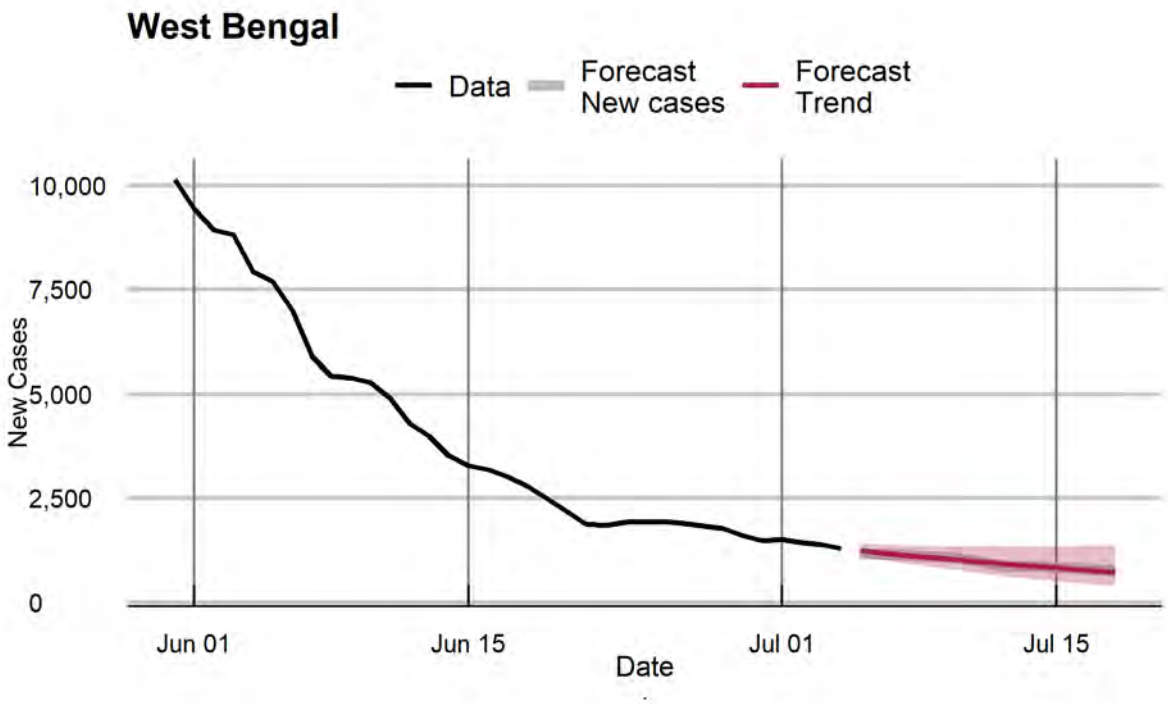

Tripura
Growth rate of daily cases
0.2
0.1
0.0
-0.1
-0.2
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

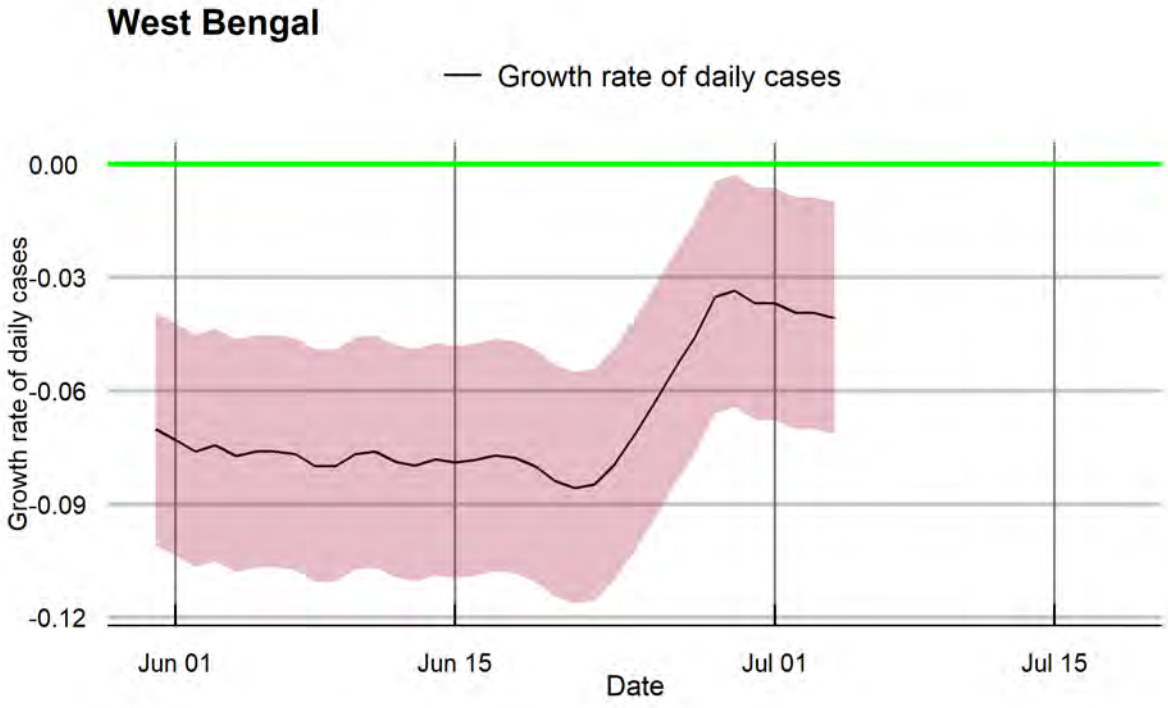

Uttarakhand
Data
Forecast
New cases
Forecast
Trend
1,200
900
600
300
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date


Uttarakhand
Growth rate of daily cases
0.0
-0.1
-0.2
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date


Uttar Pradesh
Data
Forecast
New cases
Forecast
Trend
1,500
1,000
500
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

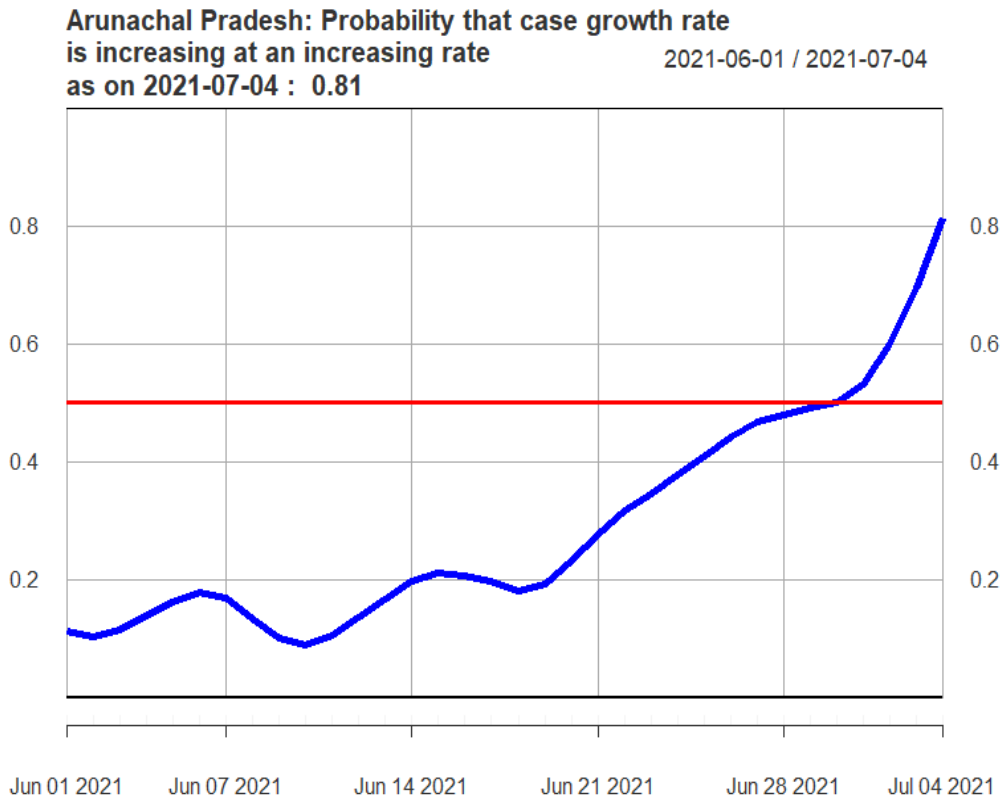

Uttar Pradesh
Growth rate of daily cases
0.0
-0.1
-0.2
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

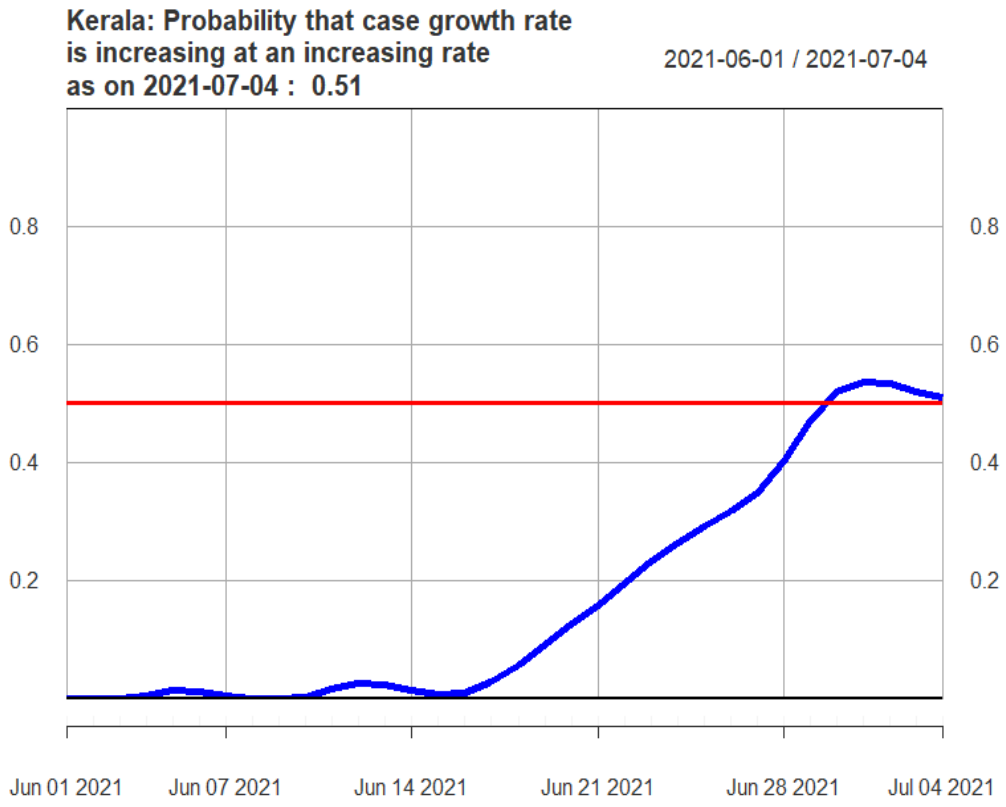

West Bengal
Data
Forecast
New cases
Forecast
Trend
10,000
7,500
5,000
2,500
0
New Cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

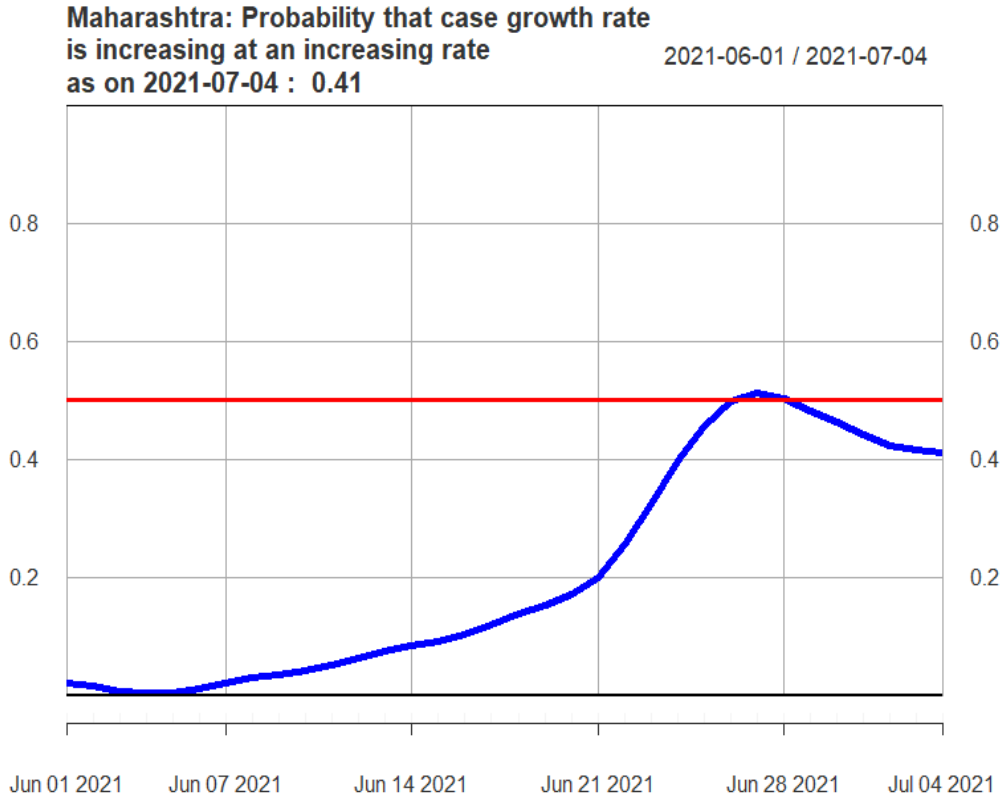

West Bengal
Growth rate of daily cases
0.00
-0.03
-0.06
-0.09
-0.12
Growth rate of daily cases
Jun 01
Jun 15
Jul 01
Jul 15
Date

The nature of growth in new cases:

States where daily growth rates are likely to be accelerating

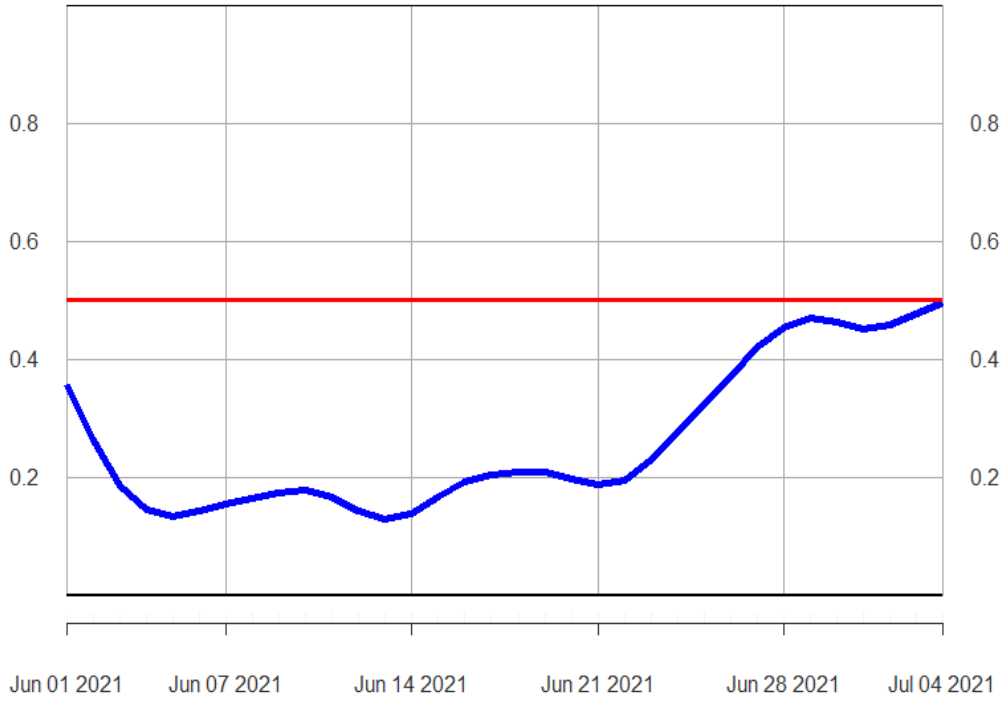



Kerala: Probability that case growth rate
is increasing at an increasing rate
as on 2021-07-04 : 0.51
2021-06-01 / 2021-07-04
0.8
0.6
0.4
0.2
Jun 01 2021
Jun 07 2021
Jun 14 2021
Jun 21 2021
Jun 28 2021
Jul 04 2021


Maharashtra: Probability that case growth rate
is increasing at an increasing rate
as on 2021-07-04 : 0.41
2021-06-01 / 2021-07-04
0.8
0.6
0.4
0.2
Jun 01 2021
Jun 07 2021
Jun 14 2021
Jun 21 2021
Jun 28 2021
Jul 04 2021

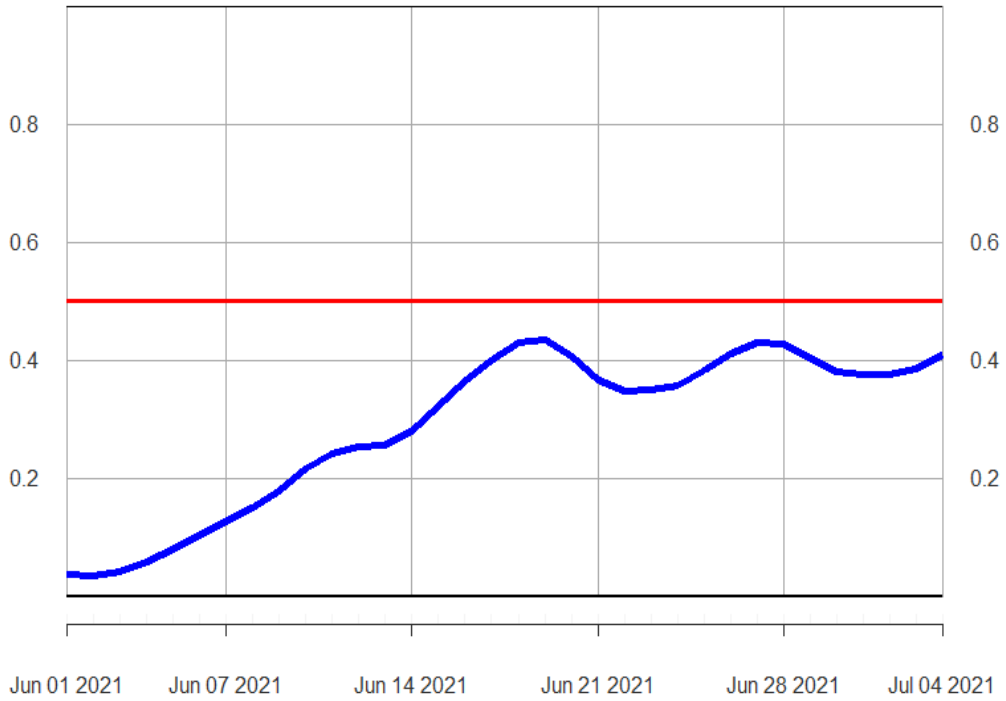
Manipur: Probability that case growth rate is increasing at an increasing rate as on 2021-07-04 : 0.5

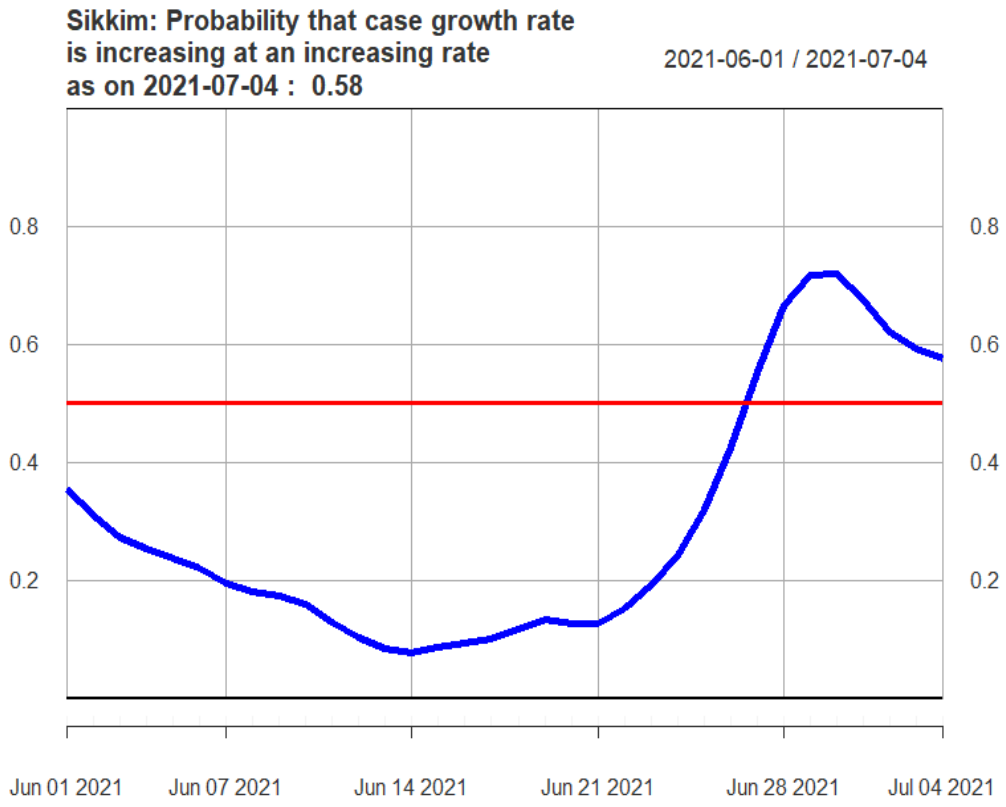
2021-06-01 / 2021-07-04

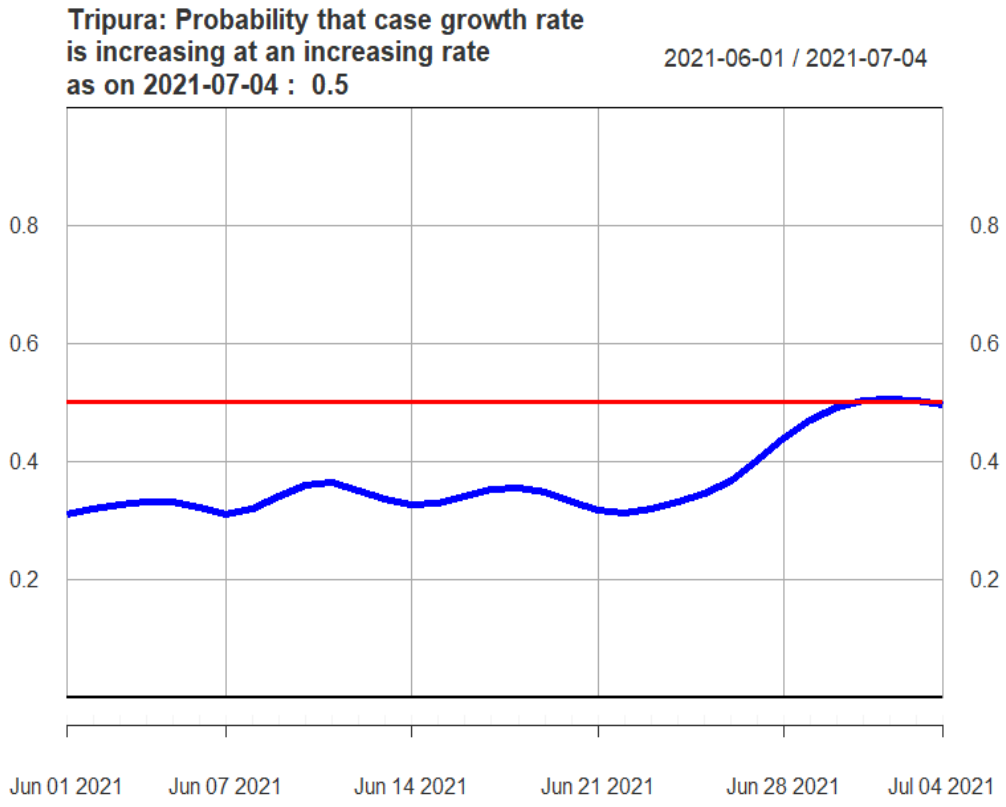


Meghalaya: Probability that case growth rate is increasing at an increasing rate as on 2021-07-04 : 0.41

2021-06-01 / 2021-07-04




Sikkim: Probability that case growth rate
is increasing at an increasing rate
as on 2021-07-04 : 0.58
2021-06-01 / 2021-07-04
0.8
0.6
0.4
0.2
Jun 01 2021
Jun 07 2021
Jun 14 2021
Jun 21 2021
Jun 28 2021
Jul 04 2021


Tripura: Probability that case growth rate
is increasing at an increasing rate
as on 2021-07-04 : 0.5
2021-06-01 / 2021-07-04
0.8
0.6
0.4
0.2
Jun 01 2021
Jun 07 2021
Jun 14 2021
Jun 21 2021
Jun 28 2021
Jul 04 2021

Notes

Data: COVID-19 confirmed cases and deaths data are sourced from COVID19-India API: https://api.covid19india.org/

New cases: forecasts. Forecasts above are based on a structural time series model that uses all the data in estimation but adapts to the trend emerging in the most recent period.

The method is described in: Harvey, A. and P. Kattuman (2020). Time series models based on growth curves with applications to forecasting coronavirus. *Harvard Data Science Review*, Special issue 1 - COVID -19. https://hdsr.mitpress.mit.edu/pub/ozgjx0yn/release/2 , and Harvey, A., P. Kattuman, and C. Thamotheram (2021). Tracking the mutant: forecasting and nowcasting COVID-19 in the UK in 2021. *National Institute Economic Review*. Forthcoming.

Forecast accuracy: When estimated with data up to June 26, the mean absolute percentage error of the forecasts of cases for India over the period, June 28 – July 4, is 7.1%. Forecast accuracy will in general be lower for the smaller states / union territories. It is important to pay attention to the confidence intervals around the forecasts. The coverage of the confidence intervals presented is 68%, implying there is 16% probability of the upper bound being exceeded.

New cases: growth rate. The filtered trends presented for daily growth rates of cases are estimated using the Kalman filter, applied to the observed series. The method filters out day of the week effects and random noise to reveal the underlying signal. Unlike methods such as the moving average, this method adapts the trend to changes in real time and characterises underlying patterns of surges or attenuations that are hidden in the volatile series. The method is described in the papers listed above.

***R*:** The *R*-estimates are based on the nowcast of the growth rate; the estimation approach is described in Harvey, A. and P. Kattuman (2020b). A farewell to R: Time series models for tracking and forecasting epidemics. *Center for Economic Policy Research* (CEPR) working paper, 51. https://cepr.org/content/covid-economics. The confidence interval is based on one standard deviation, with coverage of 68%.

Probability The probability that the growth of new cases is increasing at an increasing rate is extracted from the statistical model. The pandemic phase is of extreme concern when this probability exceeds 0.5.

Note: The accuracy of forecasts rely on the quality of the published data. Further, changes in government pandemic policies and in transmission relevant social behaviour may lead realised numbers to deviate from forecasts.

Andrew Harvey[*], Paul Kattuman[*], Rajeev Sadanandan[#], Stefan Scholtes[*], Craig Thamotheram[+]

[*]University of Cambridge.
[#]Health Systems Transformation Platform.
[+]National Institute of Economic and Social Research

Cambridge Centre for Health Leadership & Enterprise
Cambridge Judge Business School
University of Cambridge
Trumpington Street
Cambridge
CB2 1AG
United Kingdom

T +44(0)1223 339700
health@jbs.cam.ac.uk
www.jbs.cam.ac.uk/health