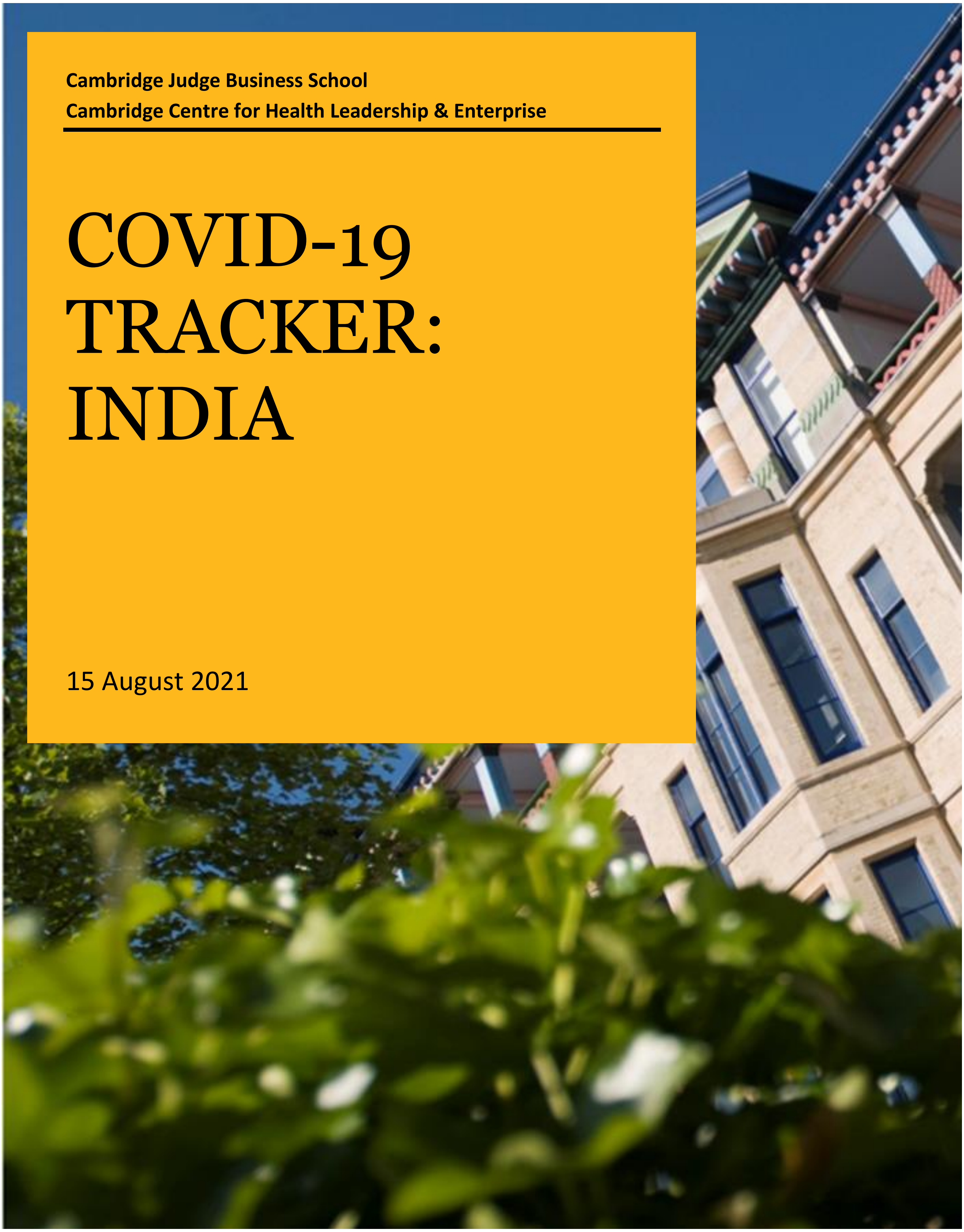


Cambridge Judge Business School
Cambridge Centre for Health Leadership & Enterprise

COVID-19 TRACKER: INDIA

15 August 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 effective reproduction number (R_t) for India as a whole has dropped to 0.95. The trend value of the growth rate of new cases is negative, at -1.2%. Reported cases are likely fall below 30,000 per day by 29th August.

Surges that surfaced earlier in the month in some states have either settled or are settling, while others have sprung up. The downturn of the epidemic in Kerala, the state that currently accounts for half the national total of reported daily cases, has contributed to improvement of the national epidemic trajectory. At the same time, reported cases are expected to increase in 7 states / union territories (Chandigarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Puducherry and Punjab) where cases also appear to be accelerating at the present time (pages 41-44).

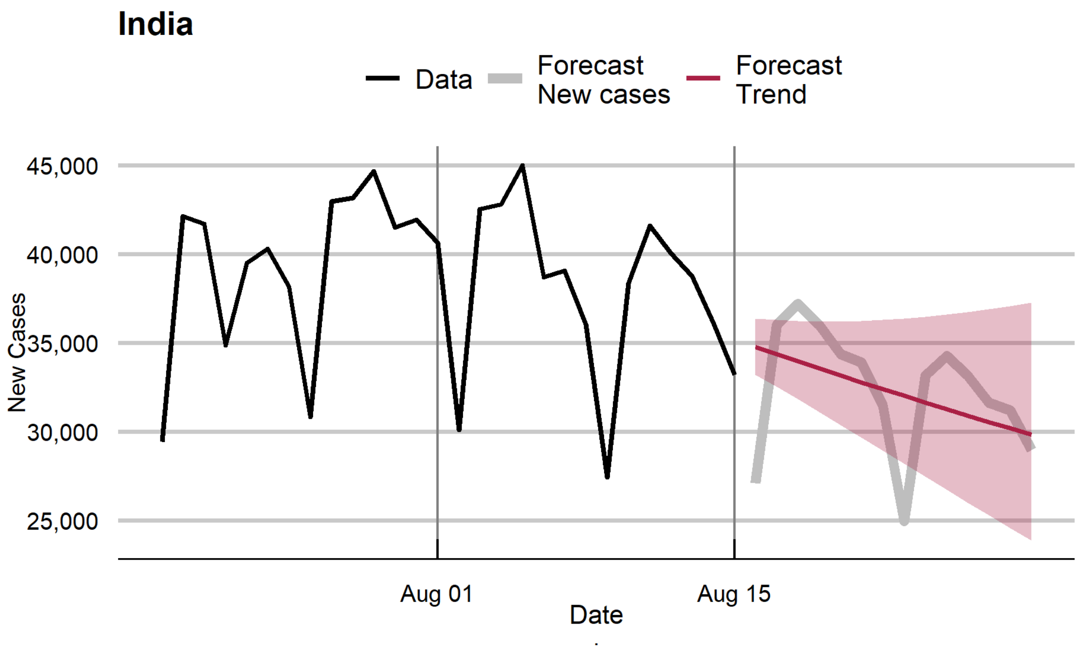
There are considerable differences between Indian states in terms of growth and decline of infection. The geographic contiguity of some states currently experiencing increases – Himachal Pradesh, Punjab, Haryana, Chandigarh – underscores the importance of policies to contain spatial spillover of infection.

Mean absolute percentage error of the forecasts of daily cases in India given in the July 25 tracker, for the period August 2 to 7, was 14.2%. Changes in government pandemic policies and in transmission relevant social behaviour may cause realised numbers to depart from forecasts.

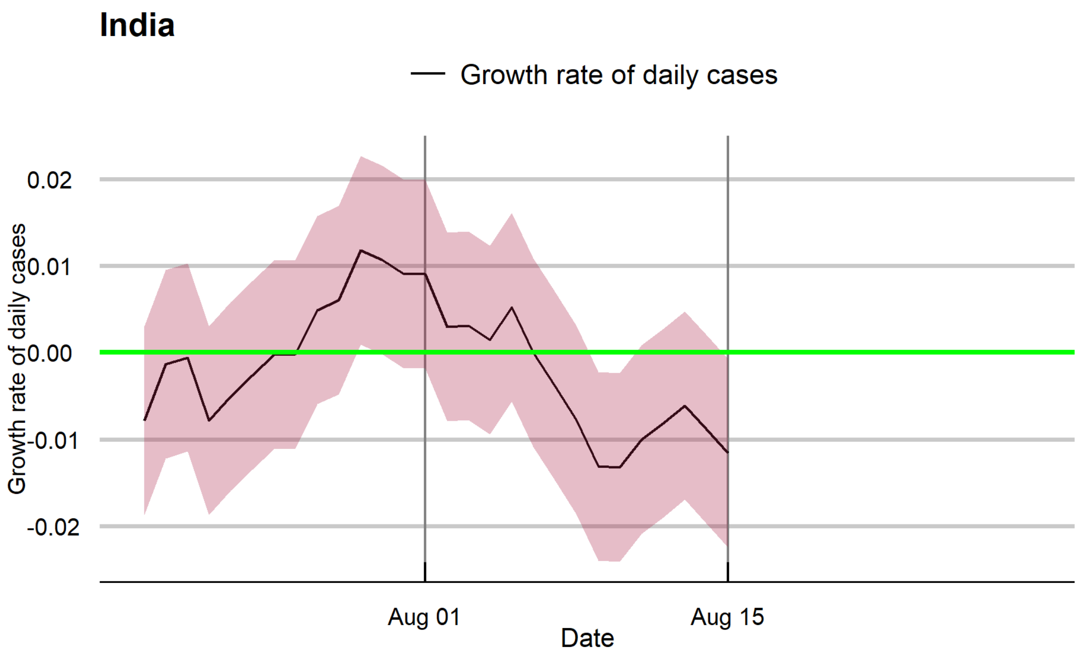
[1] CJBS COVID-19 Tracker for India can be accessed at: www.jbs.cam.ac.uk/covid-india
The companion spreadsheet contains all the estimates and forecasts.

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

Daily Covid-19 cases in India: Forecast

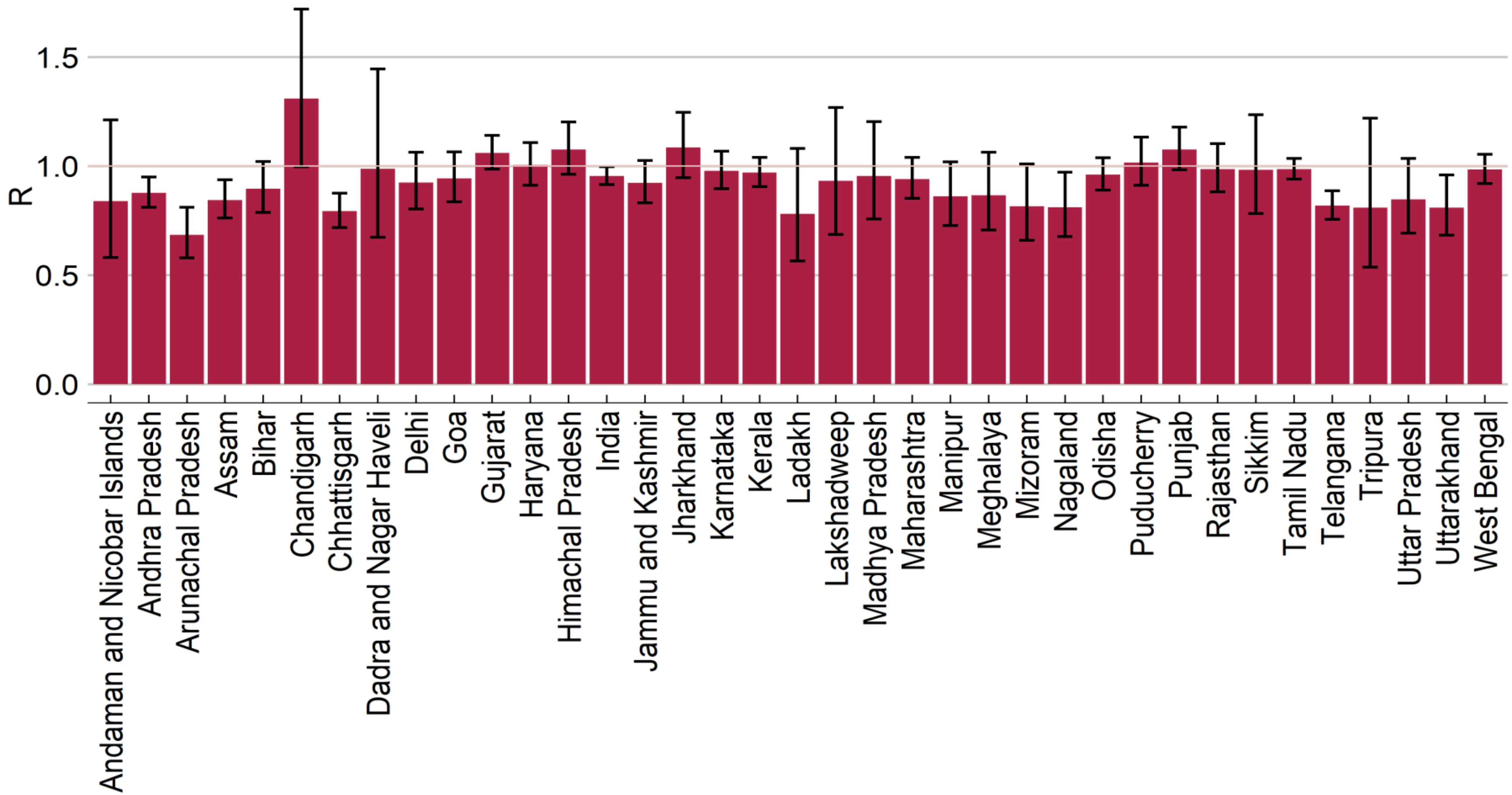


Forecasts of daily new cases for the period 16th to 29th August 2021, based on data till 14th August 2021. New COVID-19 cases is likely to be about 29,500 per day by 29th August 2021.



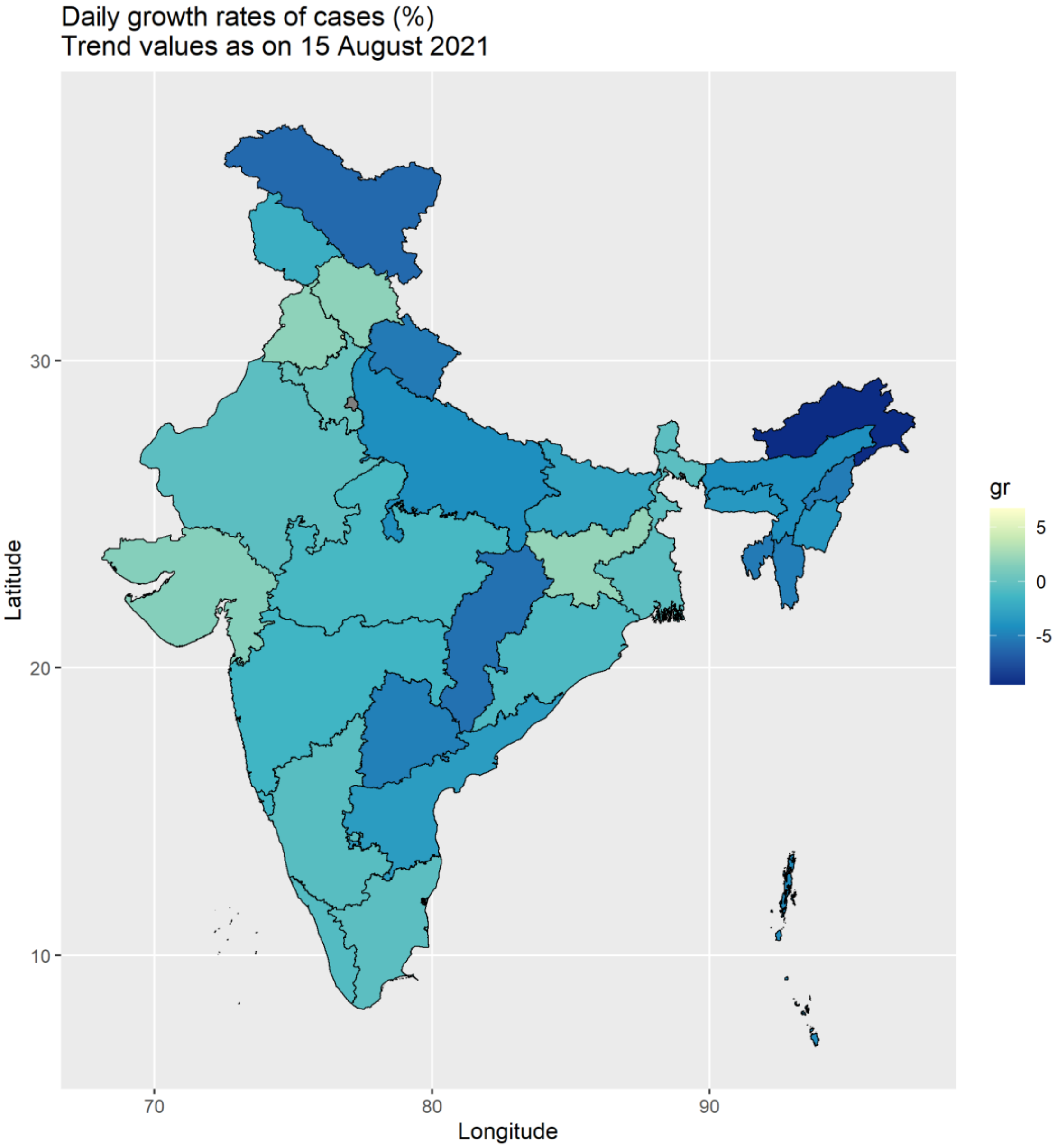
The filtered trend in the growth rate of daily new cases was -0.4% as on 7 August 2021.

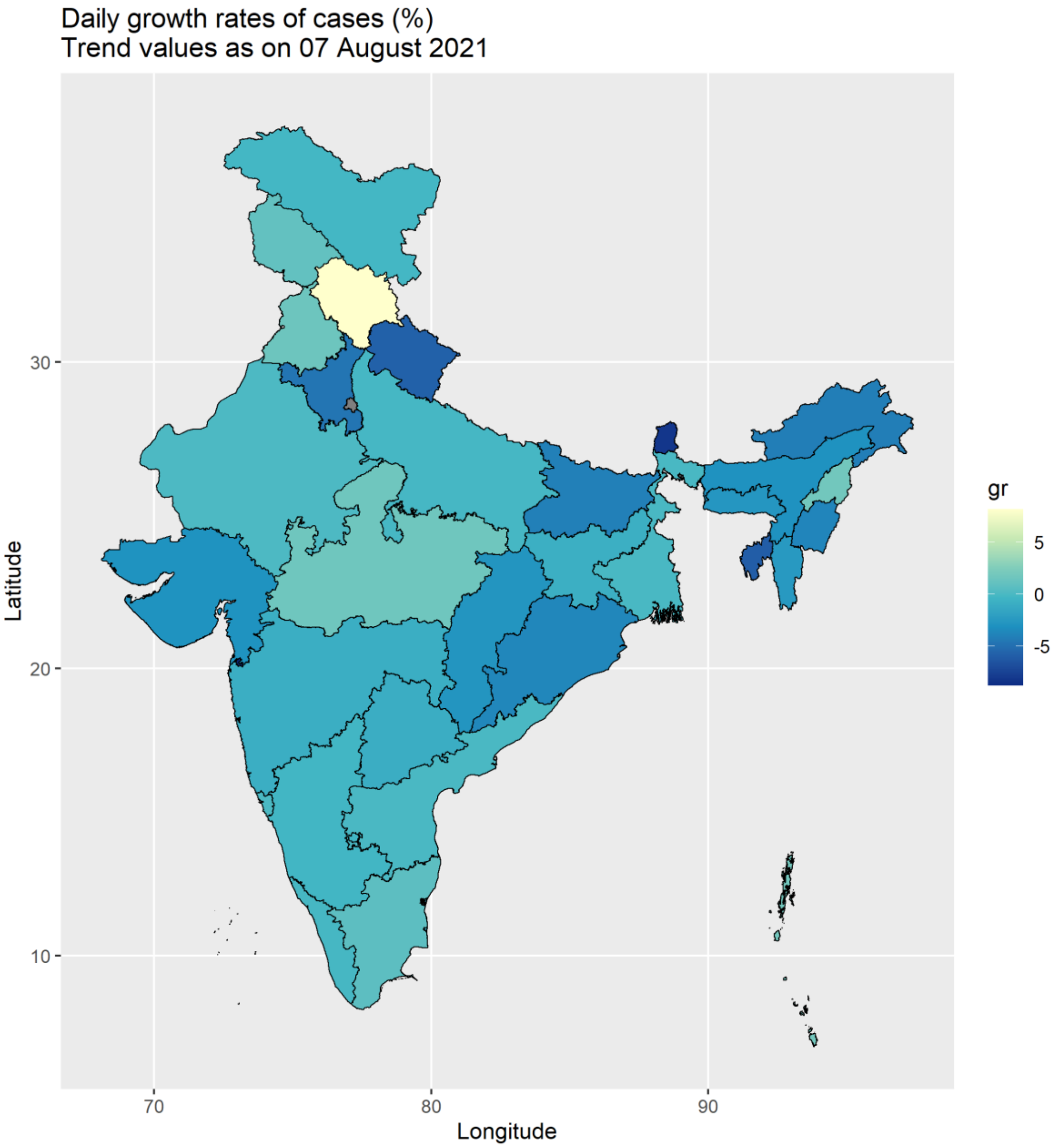
R_t: 15 August 2021

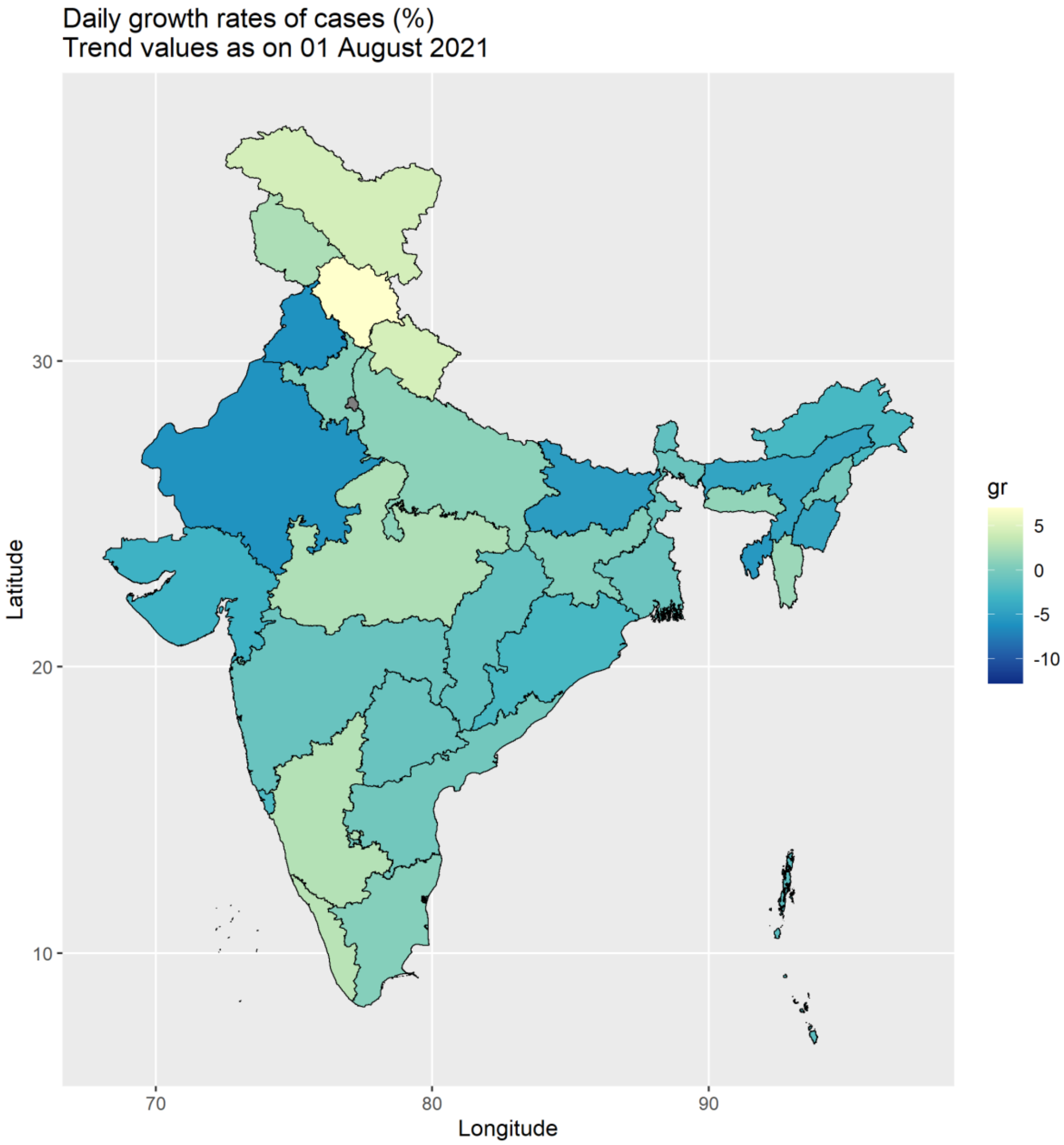


Bar chart shows point estimates of R and the ± 1 standard deviation confidence intervals

Note: Small numbers currently for Andaman and Nicobar Islands, Chandigarh, Dadra and Nagar Haveli, Haryana, Ladakh, Lakshadweep, Madhya Pradesh, Rajasthan and Uttarakhand make the forecasts and estimates less precise.

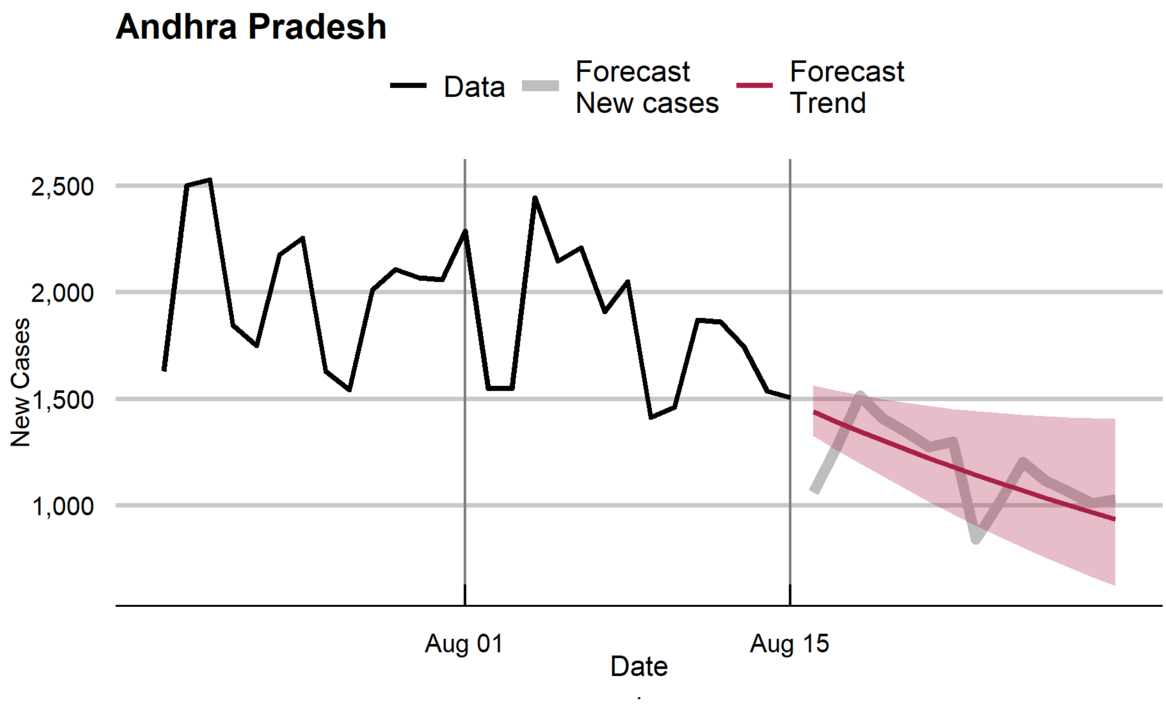

Daily growth rates of cases (%)
Trend values as on 15 August 2021
30
20
10
70
80
90
Latitude
Longitude
gr
5
0
-5

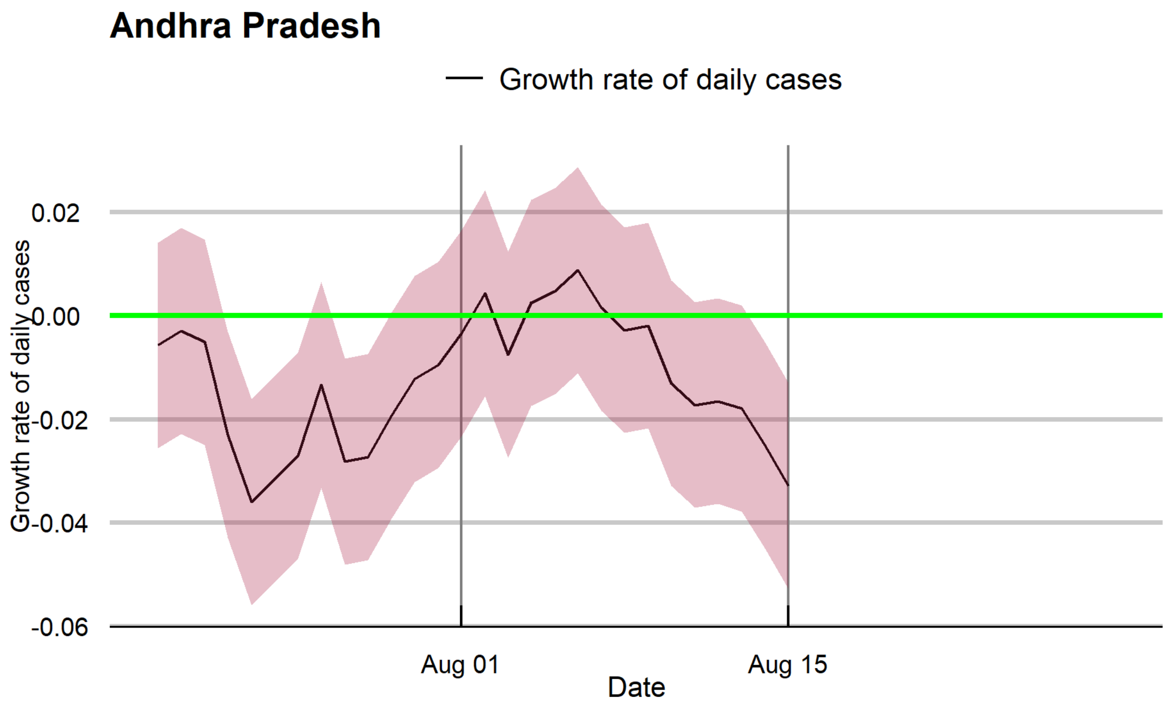

Daily growth rates of cases (%)
Trend values as on 07 August 2021
30
20
10
Latitude
70
80
90
Longitude
gr
5
0
-5

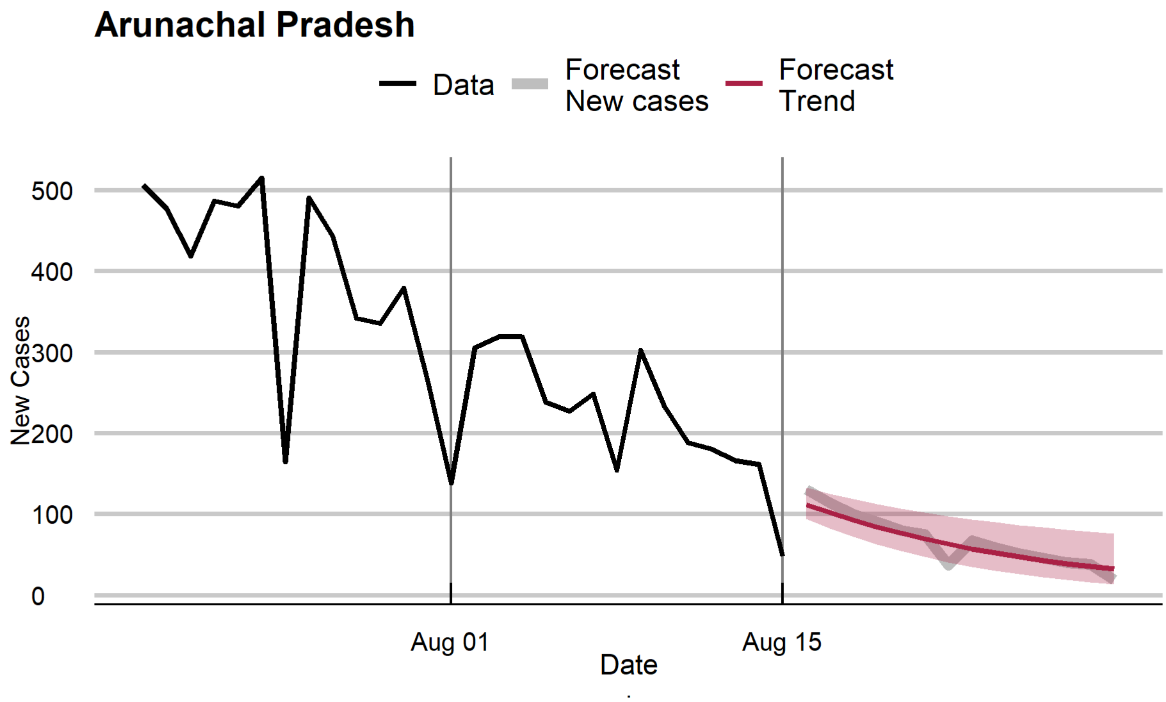


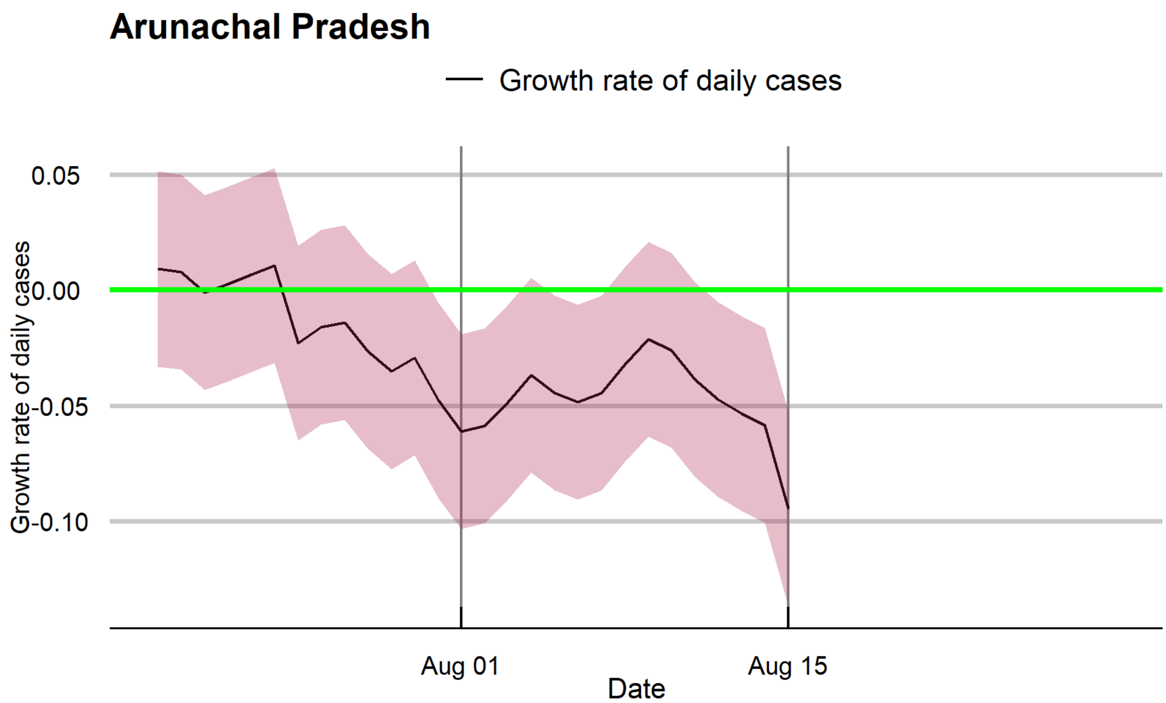
Daily growth rates of cases (%)
Trend values as on 01 August 2021
Latitude
Longitude
30
20
10
70
80
90
gr
5
0
-5
-10

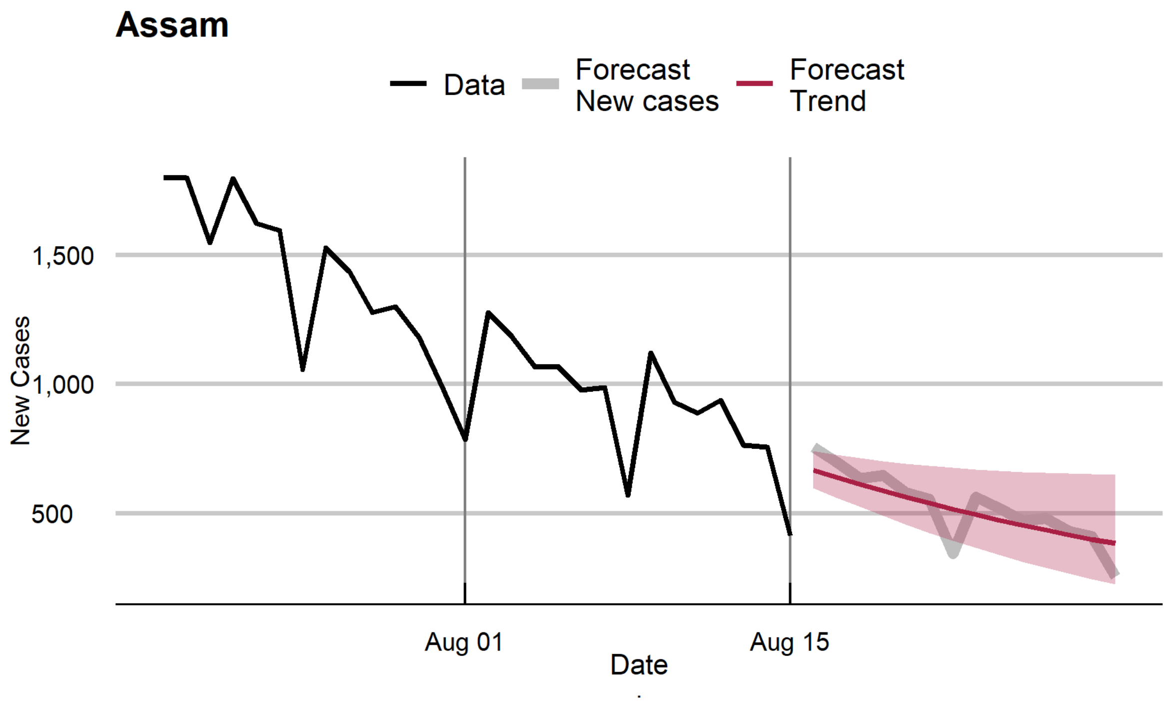
Case forecasts and growth rates: States and Union territories

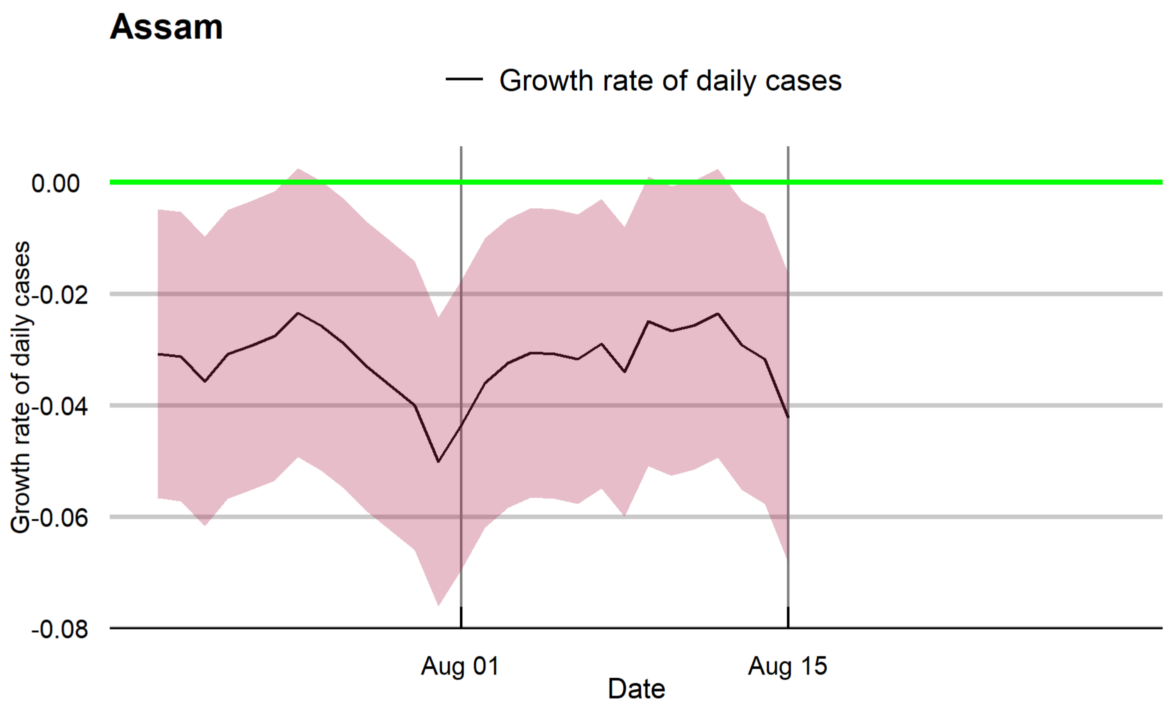


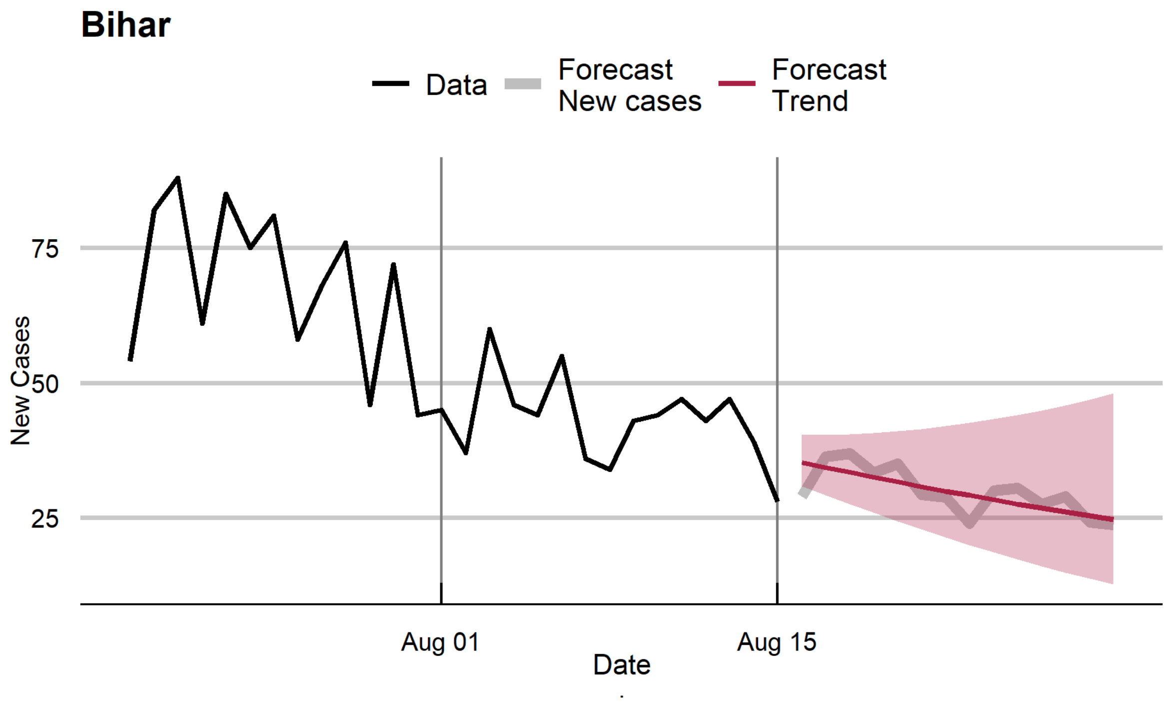


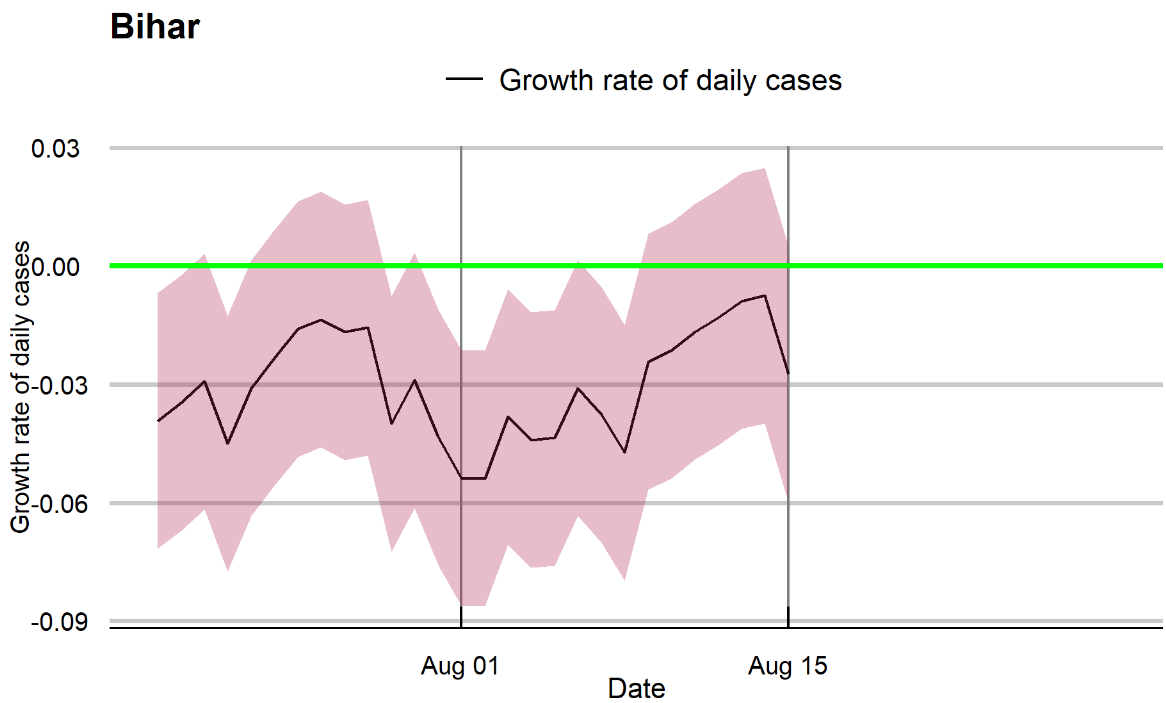

Arunachal Pradesh
Data
Forecast New cases
Forecast Trend
500
400
300
200
100
0
New Cases
Aug 01
Aug 15
Date

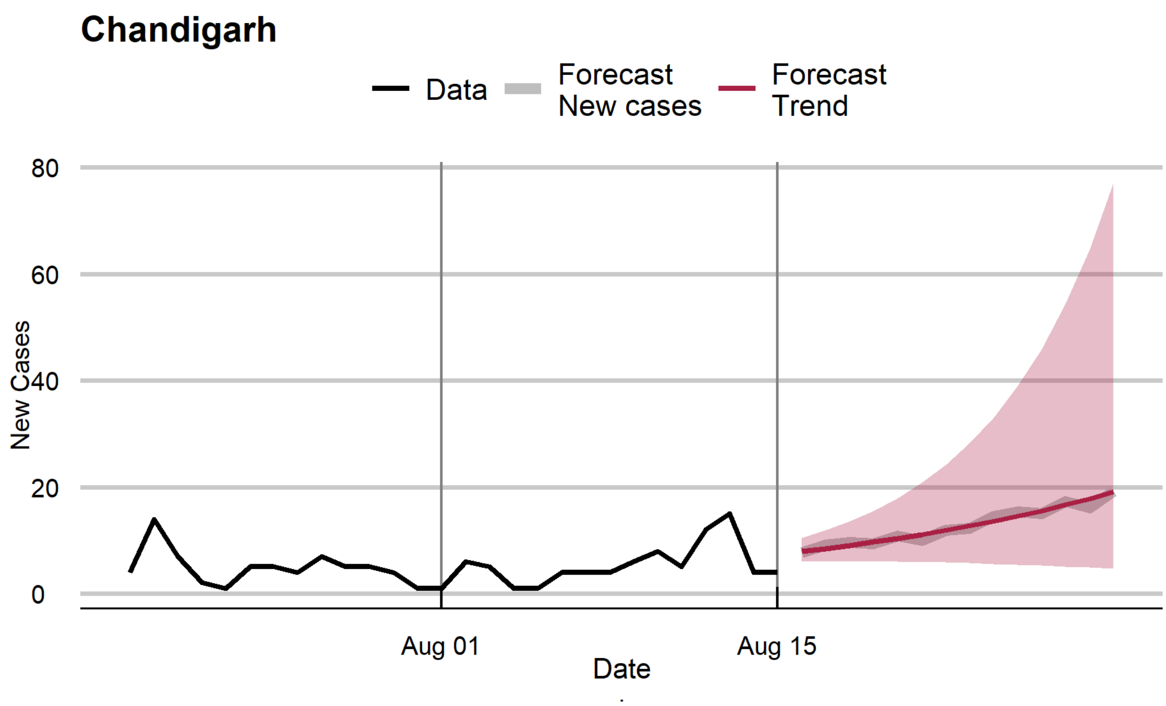

Arunachal Pradesh
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date

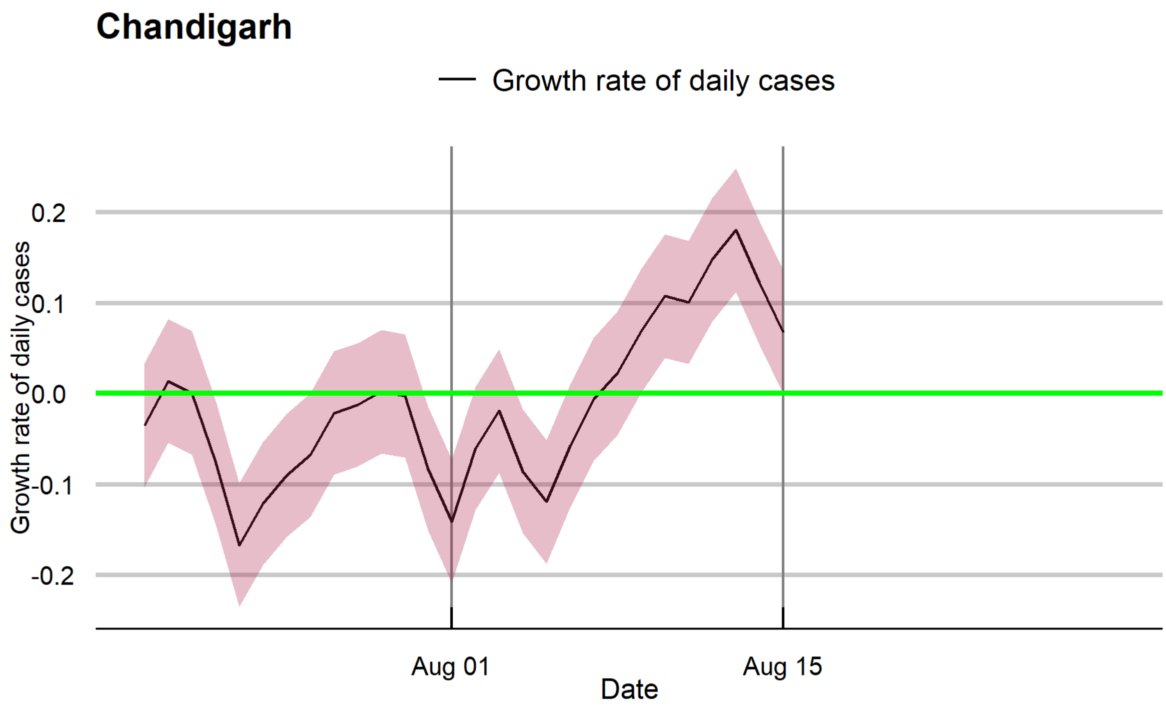

Assam
Data
Forecast New cases
Forecast Trend
1,500
1,000
500
New Cases
Aug 01
Aug 15
Date

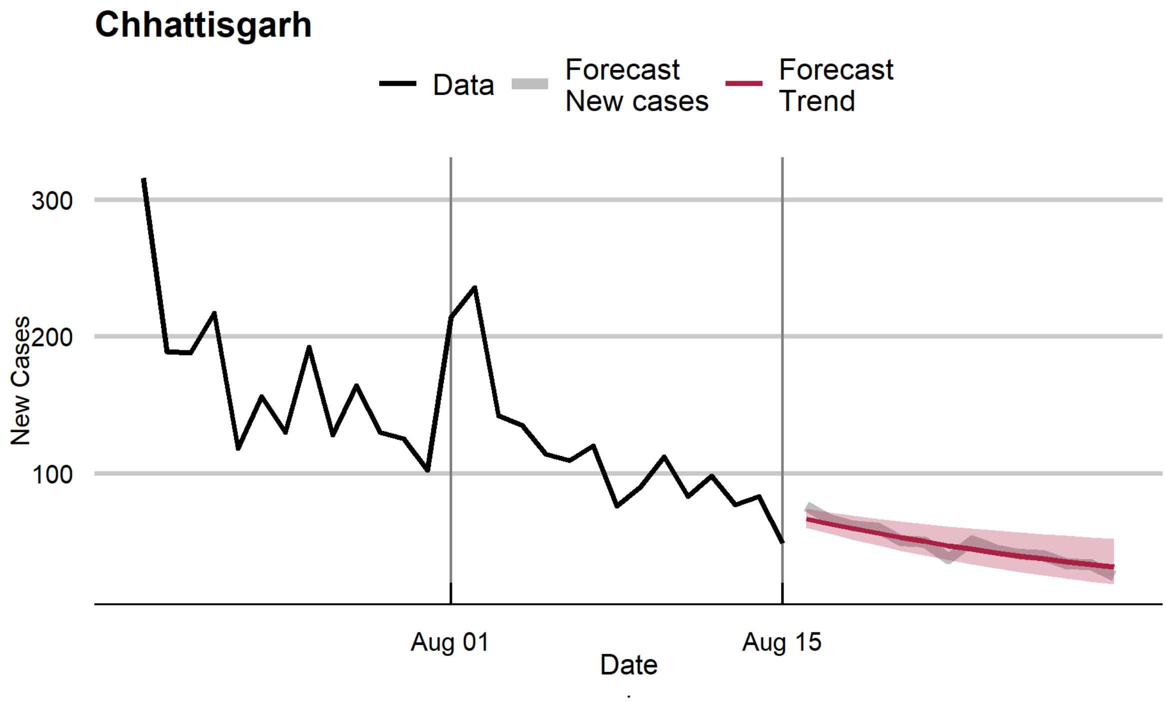

Assam
Growth rate of daily cases
0.00
-0.02
-0.04
-0.06
-0.08
Growth rate of daily cases
Aug 01
Aug 15
Date

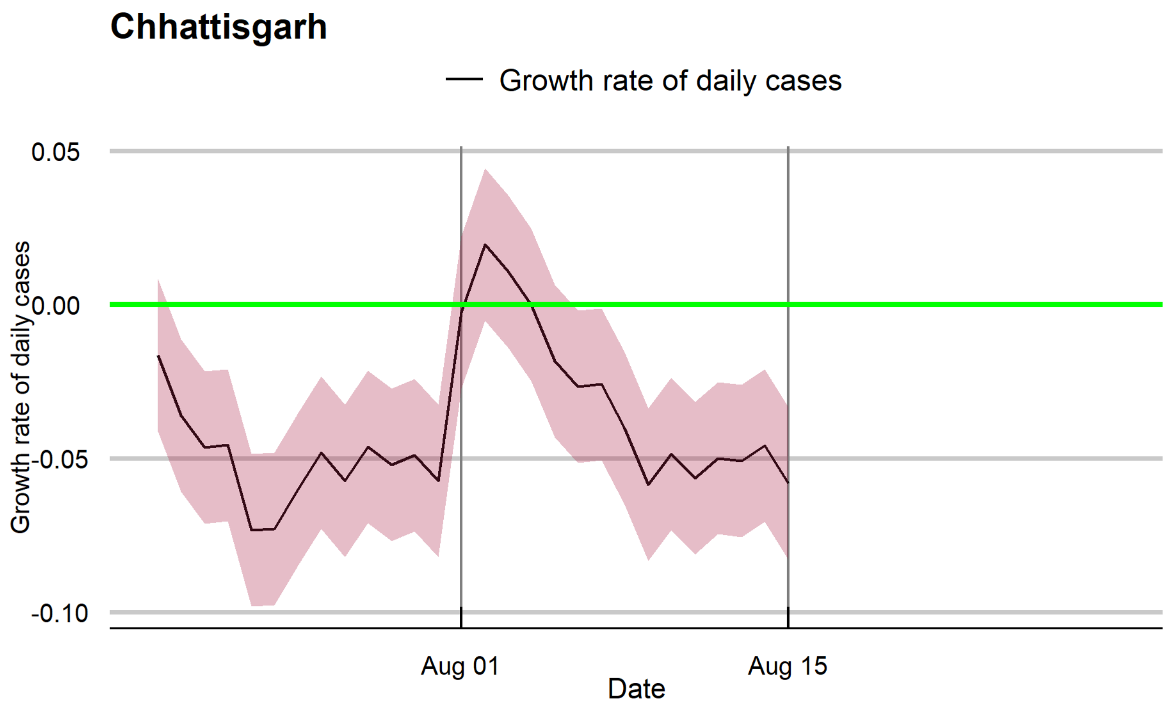

Bihar
Data
Forecast New cases
Forecast Trend
New Cases
75
50
25
Aug 01
Aug 15
Date

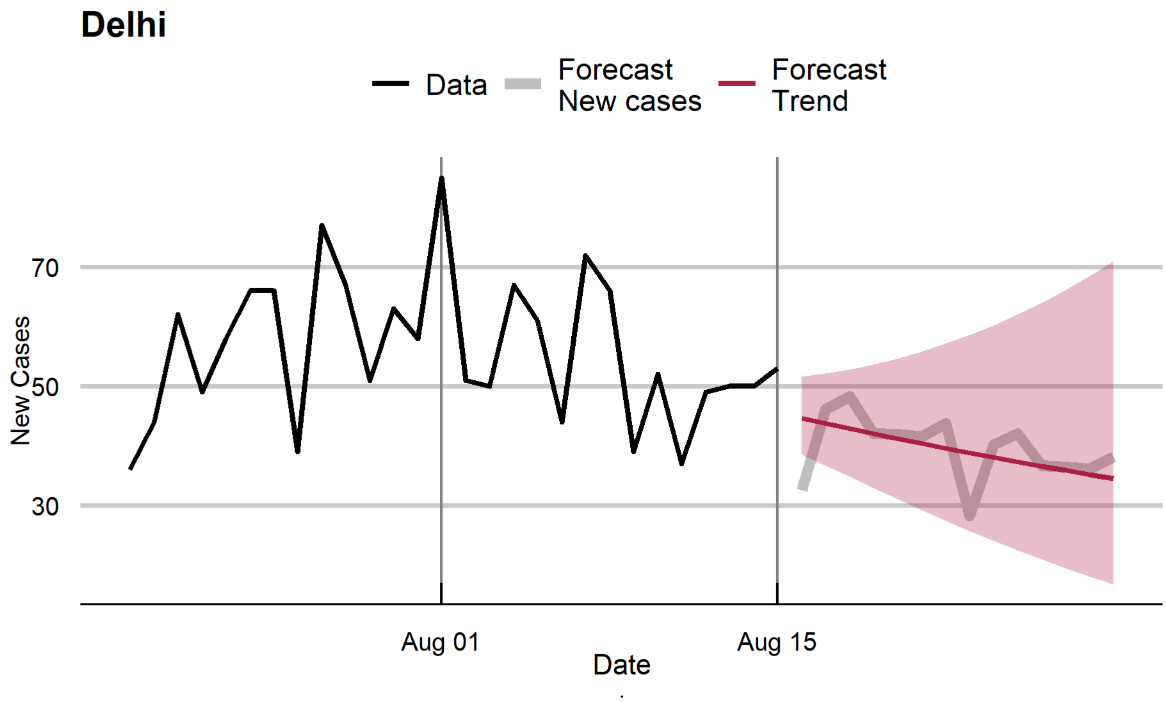

Bihar
Growth rate of daily cases
Growth rate of daily cases
0.03
0.00
-0.03
-0.06
-0.09
Aug 01
Aug 15
Date

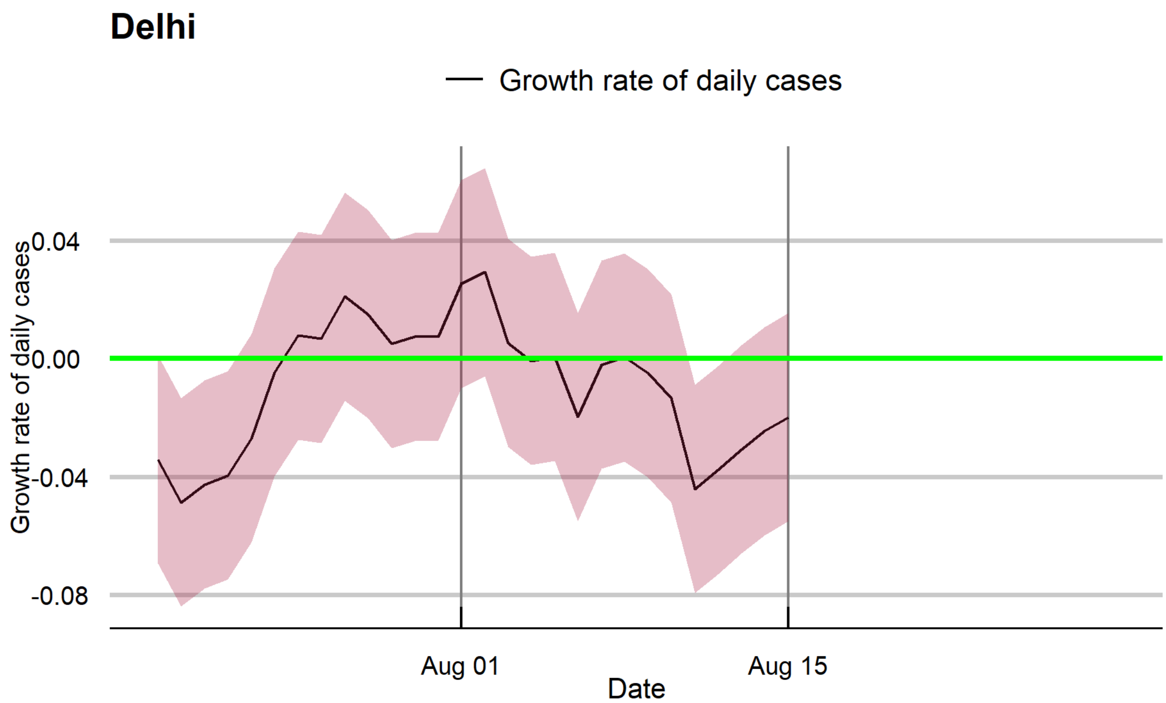

Chandigarh
Data
Forecast New cases
Forecast Trend
80
60
40
20
0
New Cases
Aug 01
Aug 15
Date

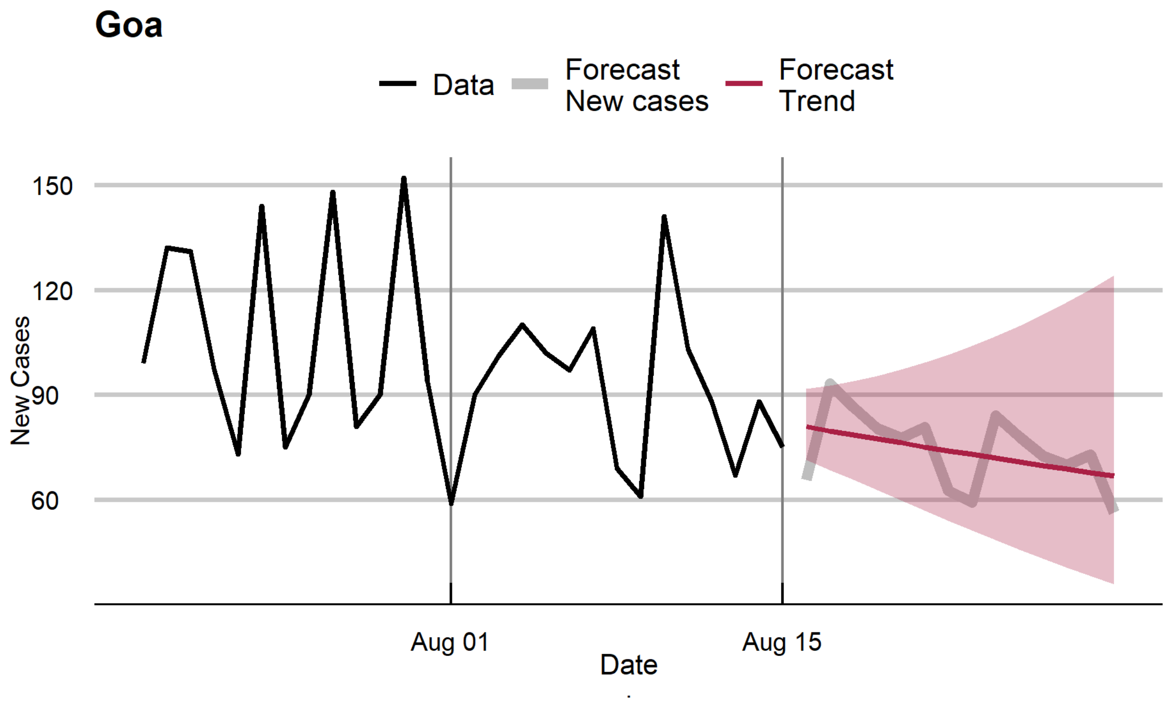

Chandigarh
Growth rate of daily cases
0.2
0.1
0.0
-0.1
-0.2
Growth rate of daily cases
Aug 01
Aug 15
Date

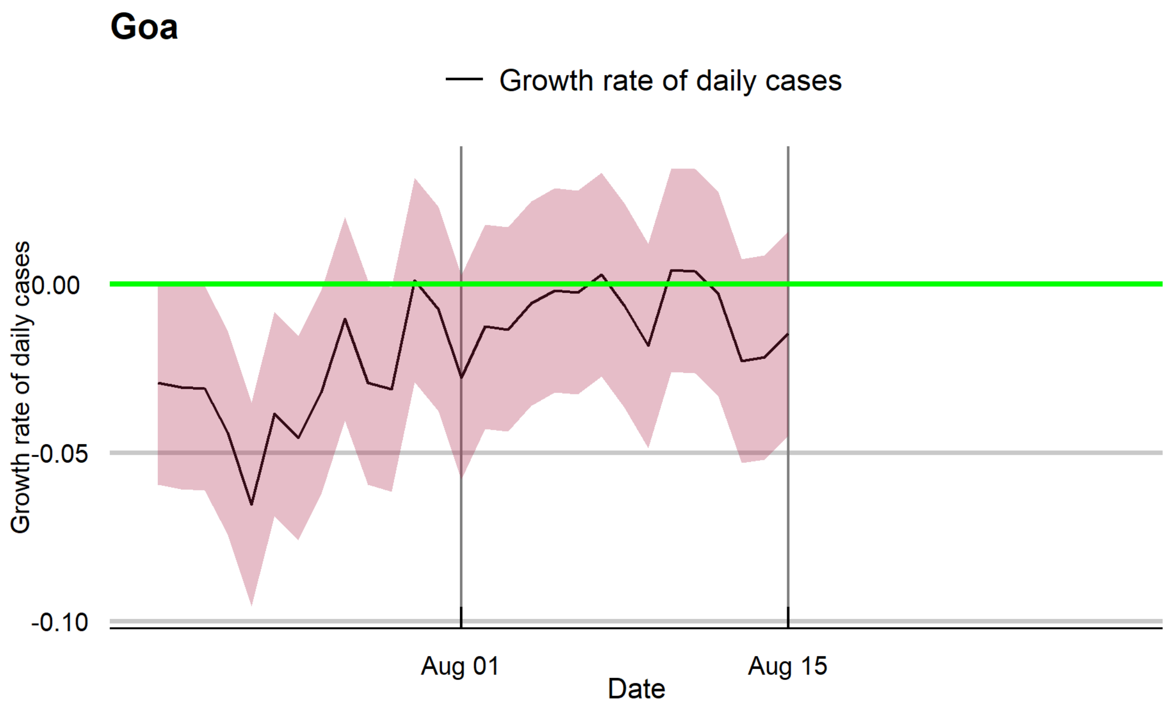

Chhattisgarh
Data
Forecast New cases
Forecast Trend
300
200
100
New Cases
Aug 01
Aug 15
Date

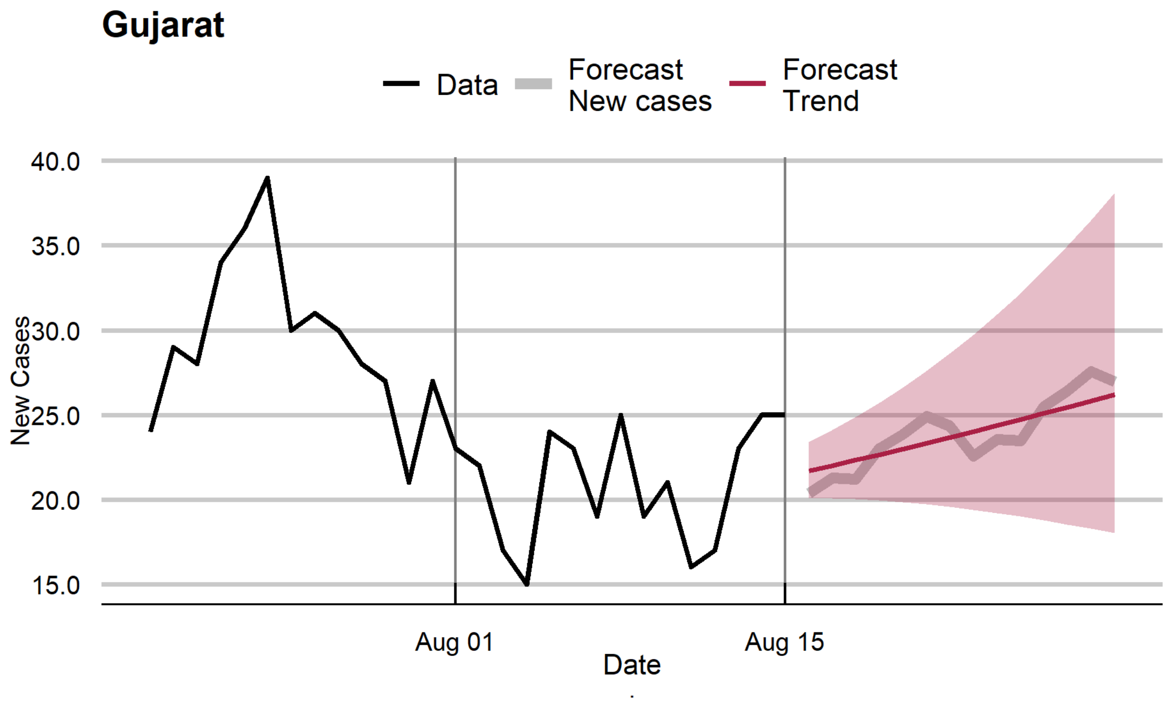

Chhattisgarh
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date

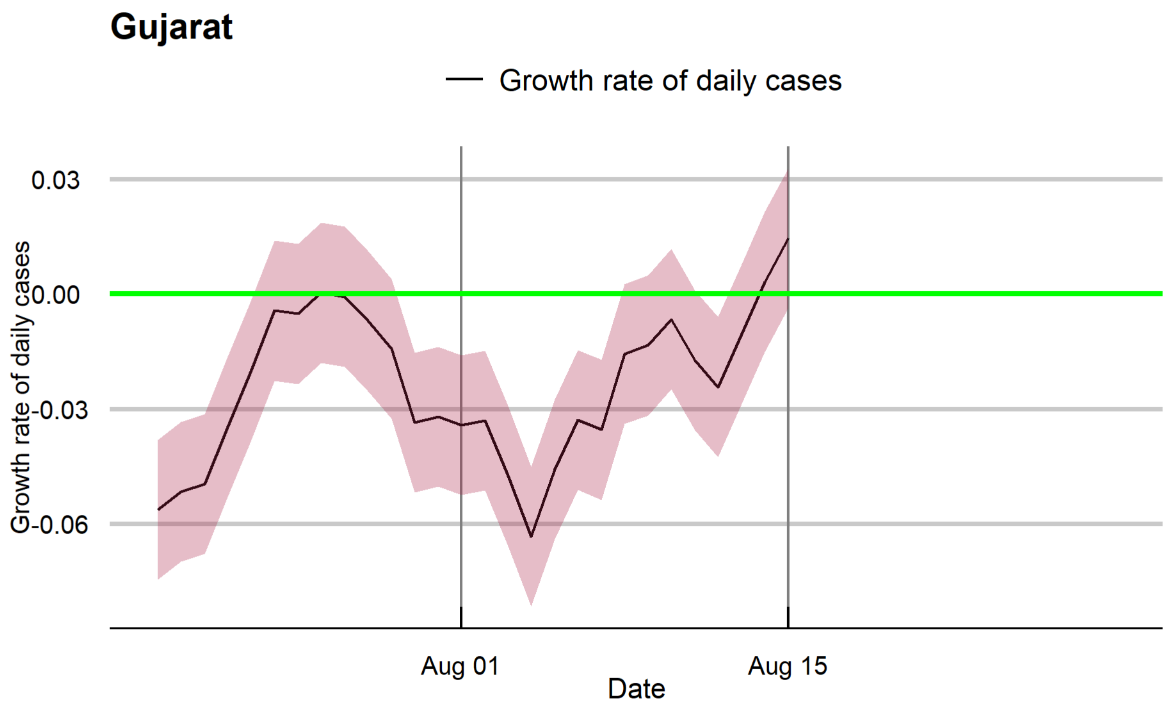

Delhi
Data
Forecast New cases
Forecast Trend
70
50
30
New Cases
Aug 01
Aug 15
Date

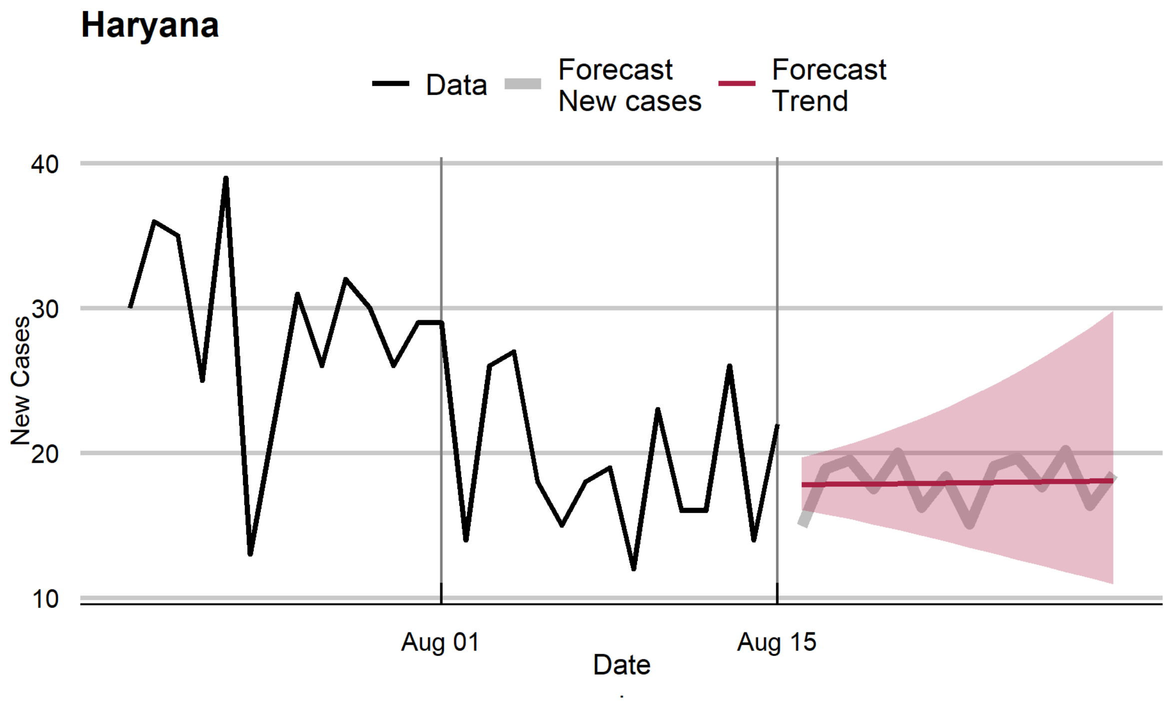

Delhi
Growth rate of daily cases
0.04
0.00
-0.04
-0.08
Growth rate of daily cases
Aug 01
Aug 15
Date

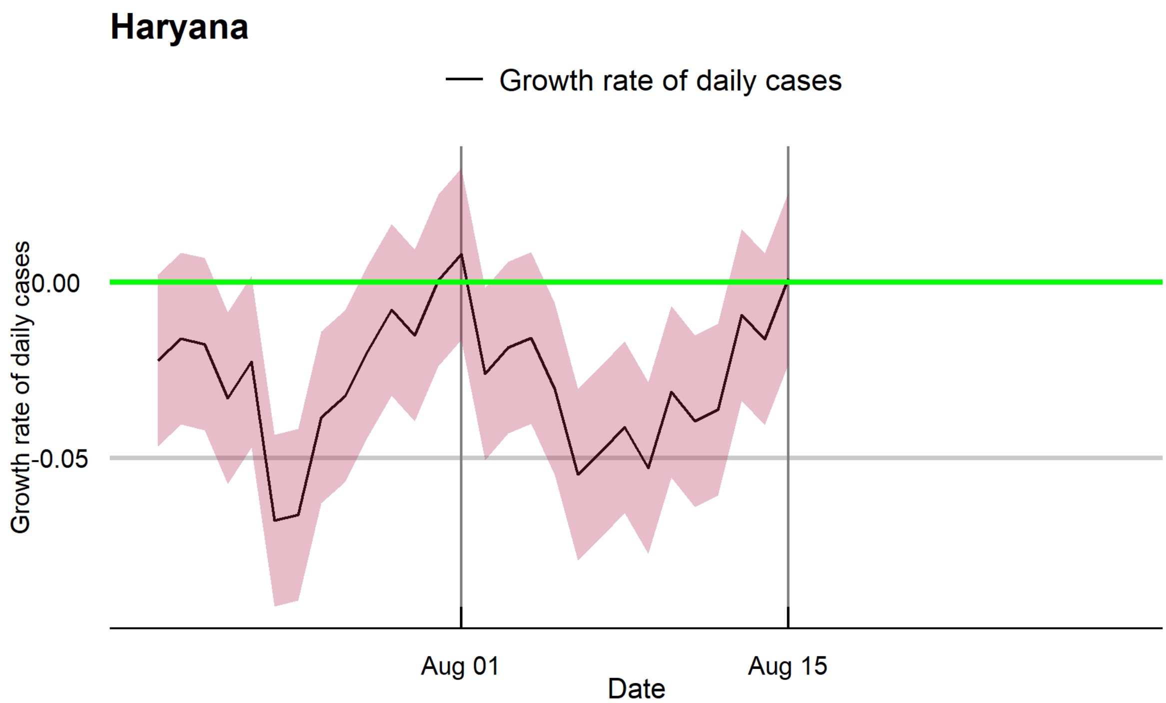

Goa
Data
Forecast New cases
Forecast Trend
150
120
90
60
New Cases
Aug 01
Aug 15
Date

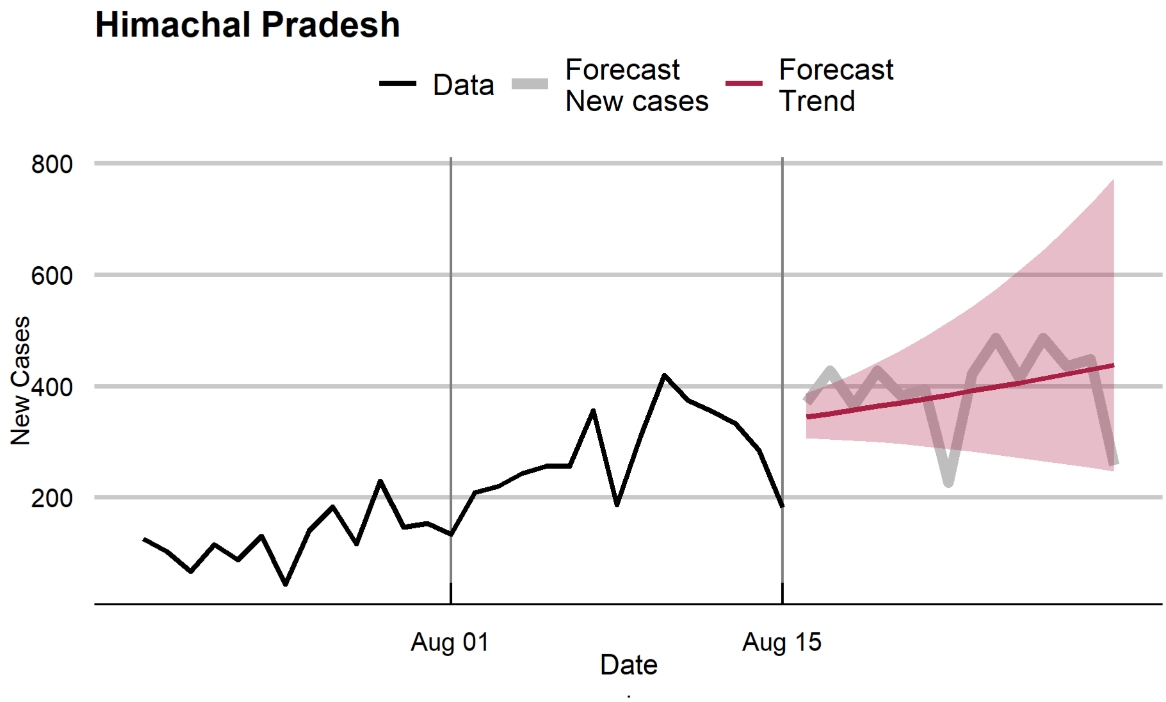

Goa
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date

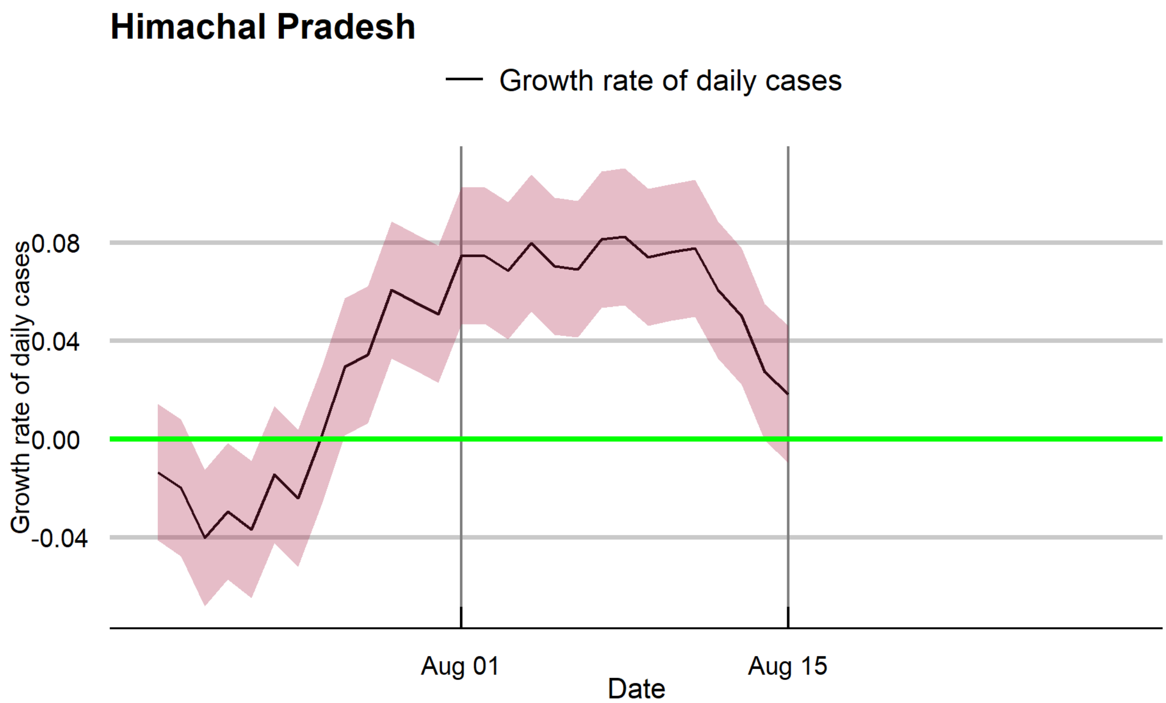

Gujarat
Data
Forecast New cases
Forecast Trend
40.0
35.0
30.0
25.0
20.0
15.0
New Cases
Aug 01
Aug 15
Date

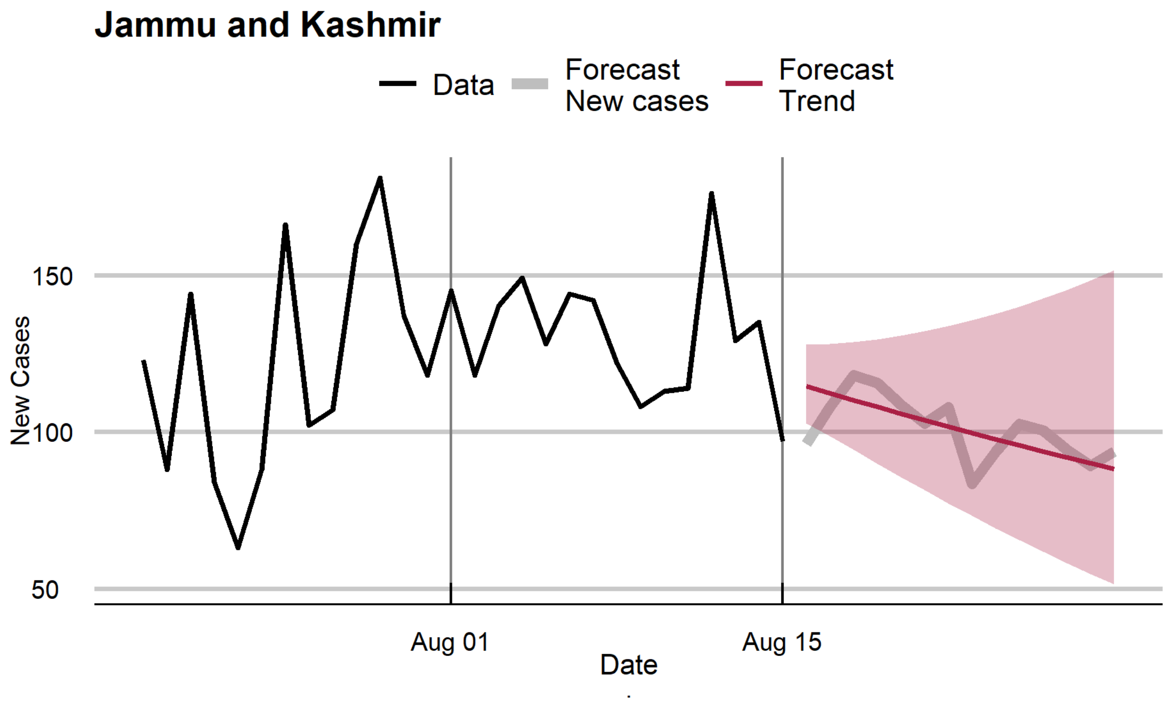

Gujarat
Growth rate of daily cases
0.03
0.00
-0.03
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Date

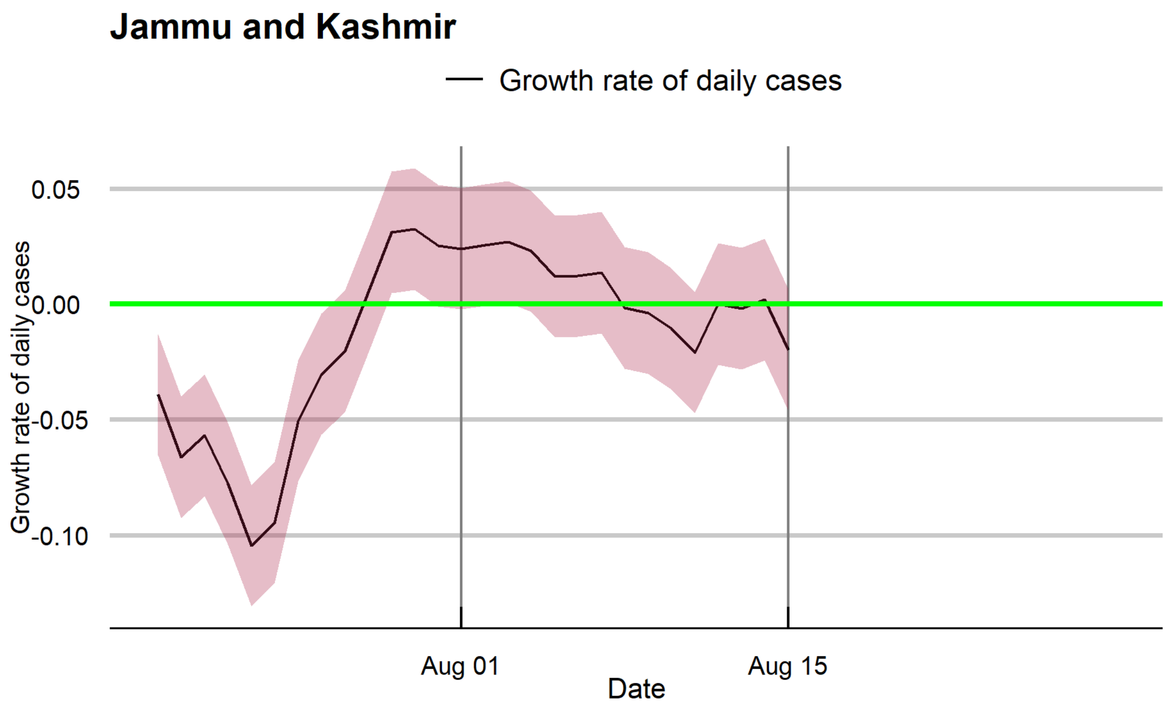

Haryana
Data
Forecast New cases
Forecast Trend
40
30
20
10
New Cases
Aug 01
Aug 15
Date

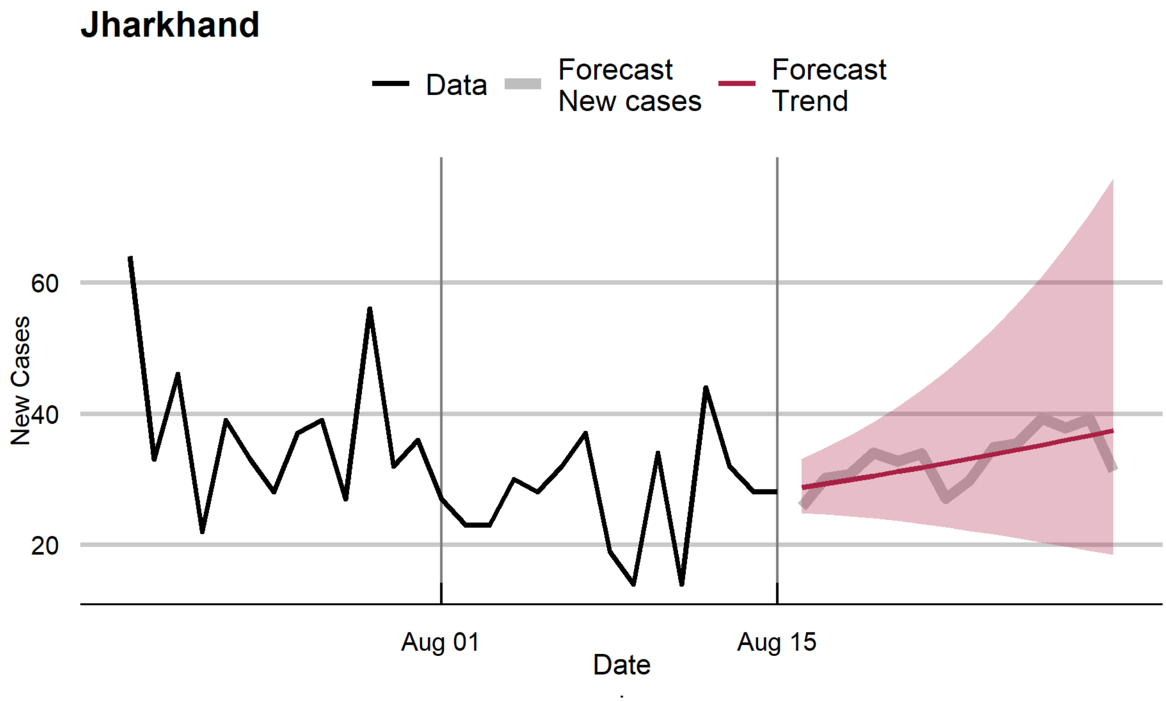

Haryana
Growth rate of daily cases
0.00
-0.05
Growth rate of daily cases
Aug 01
Aug 15
Date

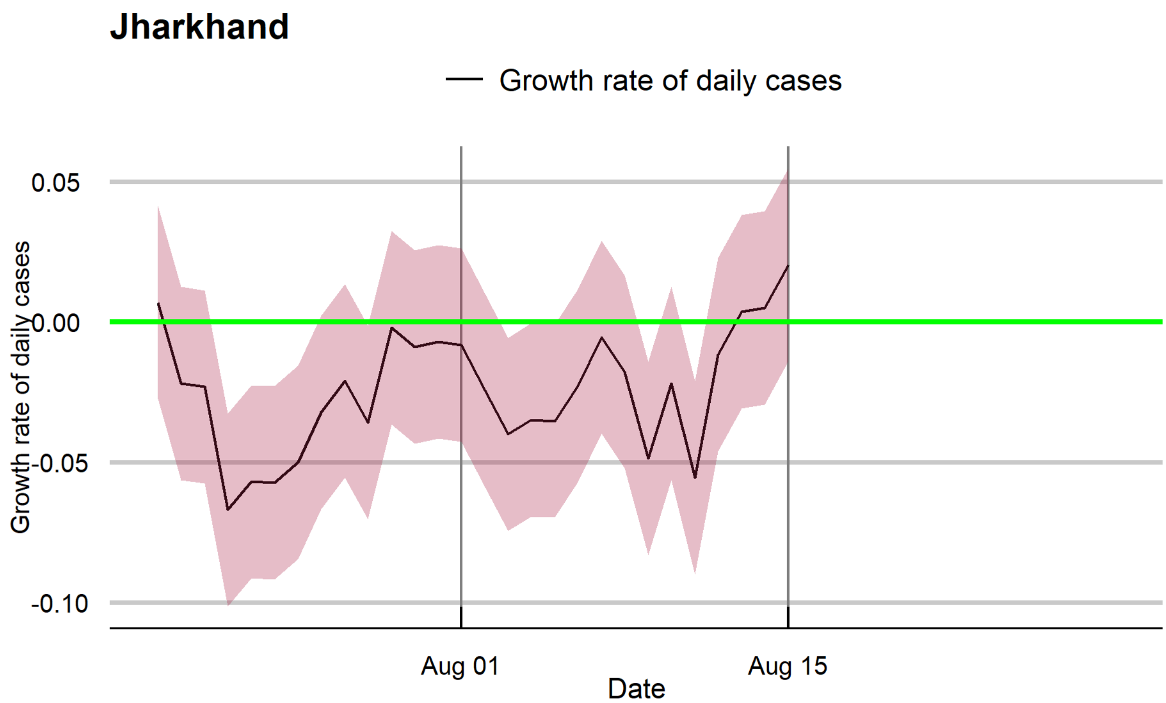

Himachal Pradesh
Data
Forecast New cases
Forecast Trend
800
600
400
200
New Cases
Aug 01
Aug 15
Date

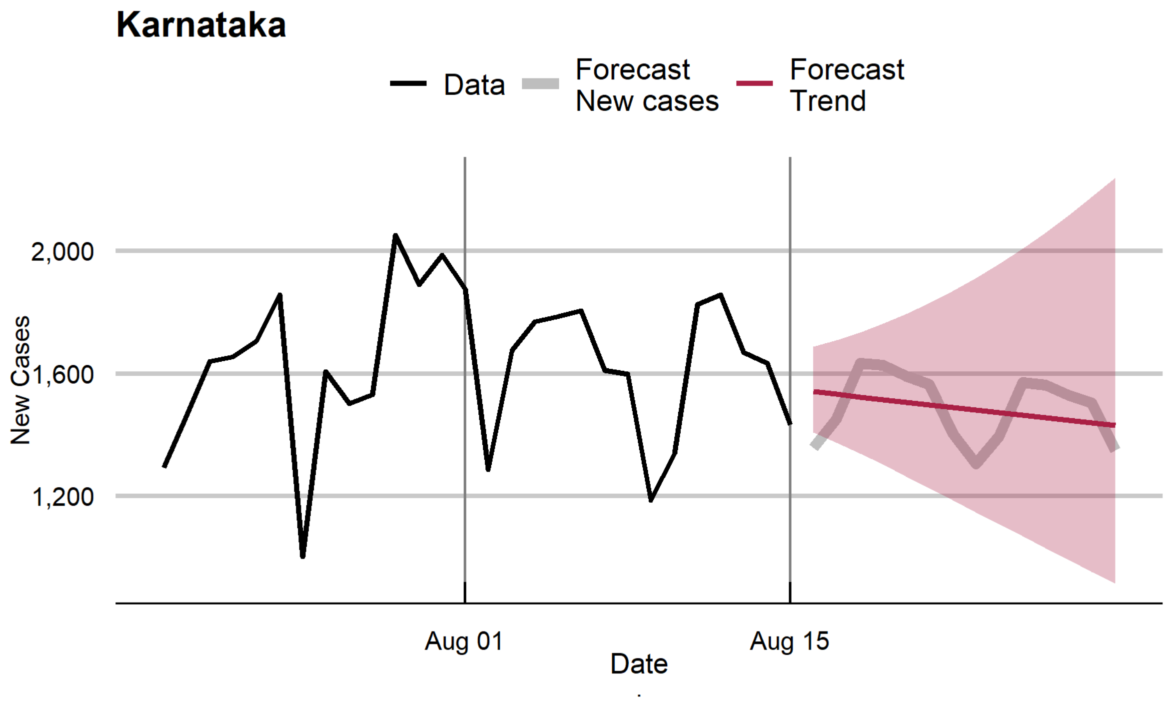

Himachal Pradesh
Growth rate of daily cases
0.08
0.04
0.00
-0.04
Growth rate of daily cases
Aug 01
Aug 15
Date

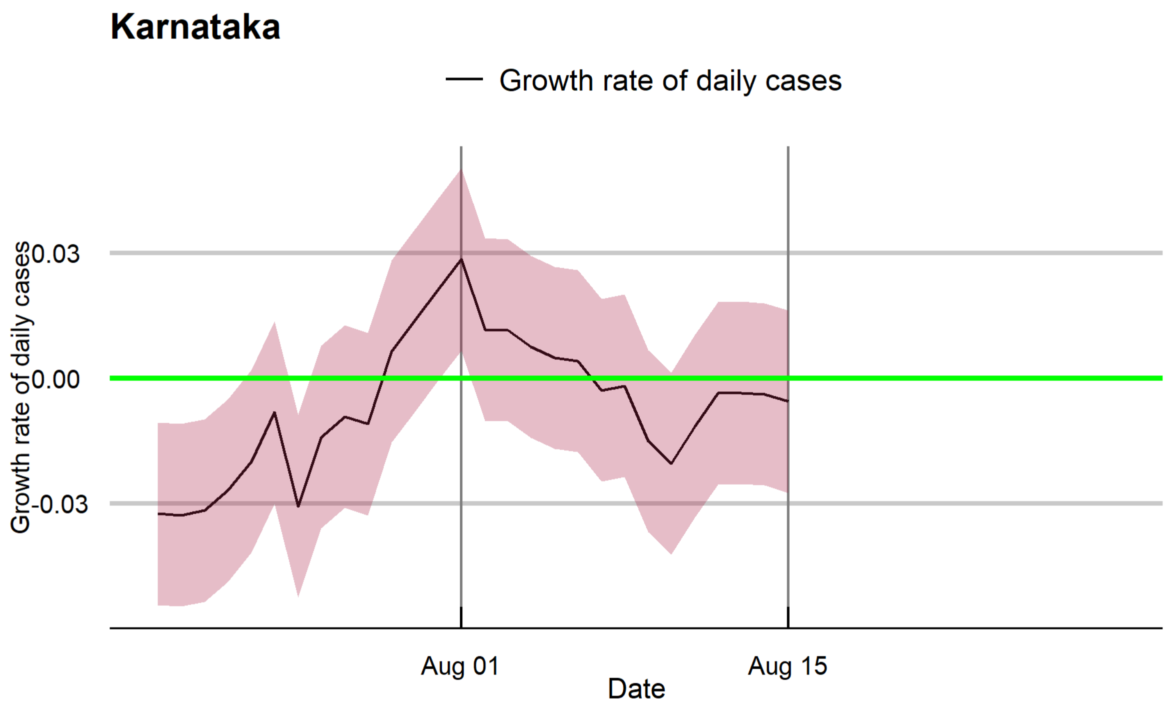

Jammu and Kashmir
Data
Forecast New cases
Forecast Trend
150
100
50
New Cases
Aug 01
Aug 15
Date

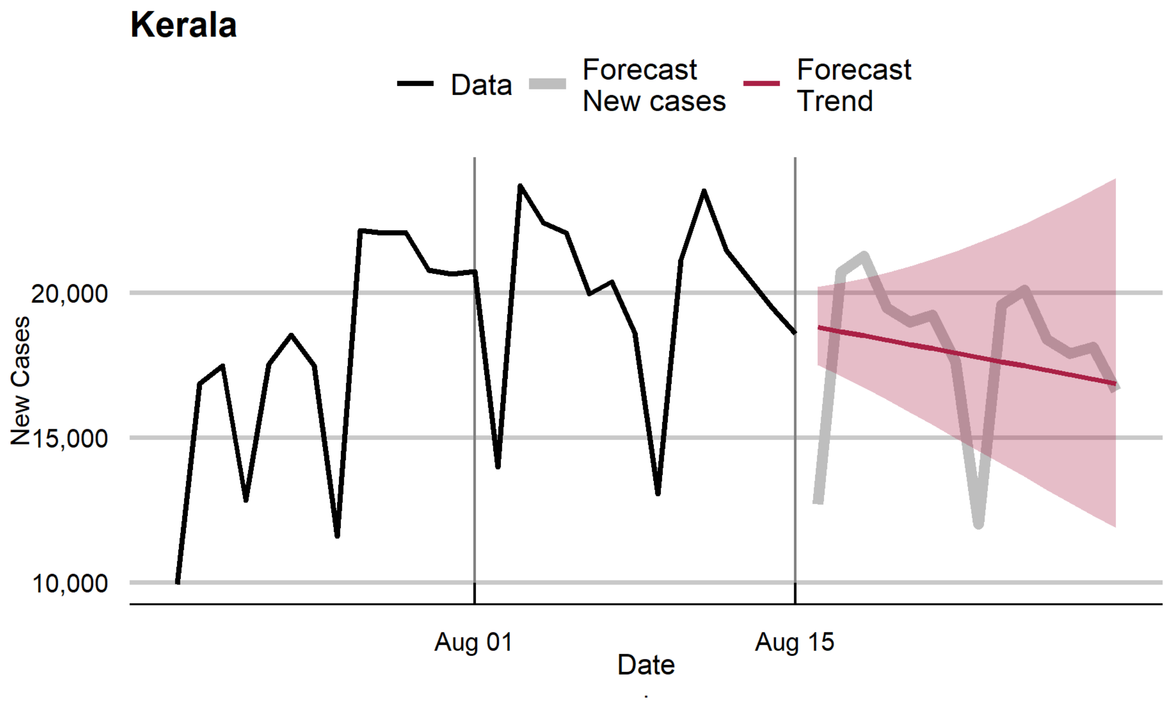

Jammu and Kashmir
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date

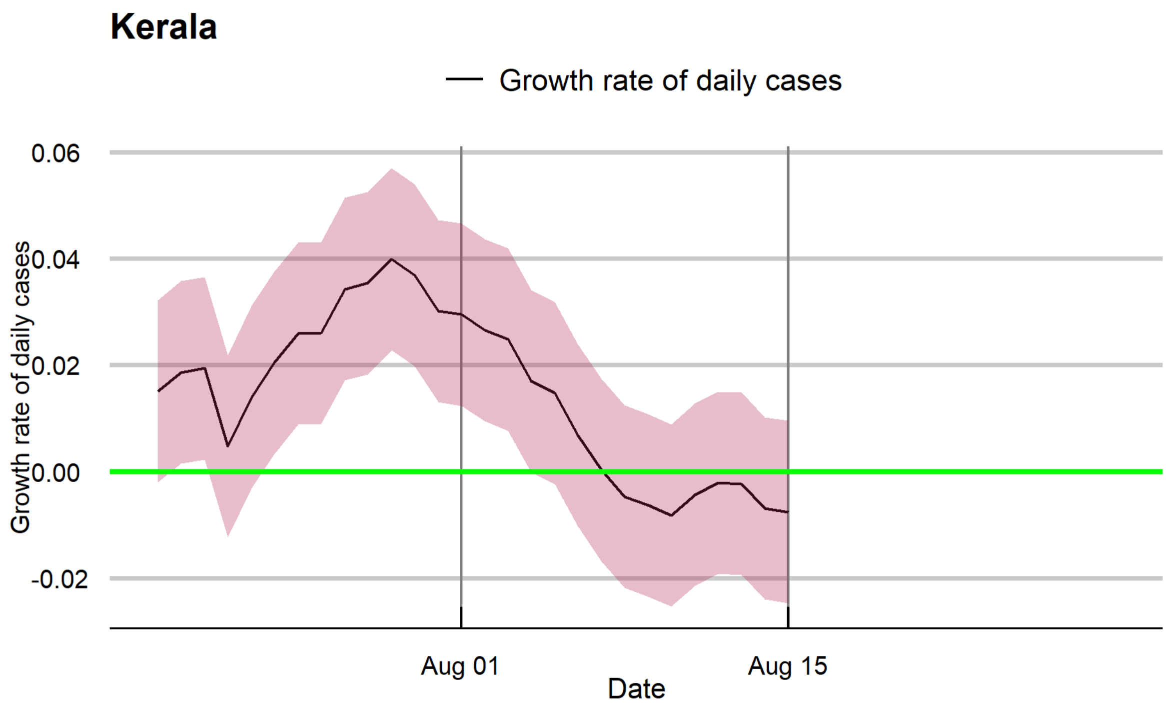

Jharkhand
Data
Forecast New cases
Forecast Trend
60
40
20
New Cases
Aug 01
Aug 15
Date

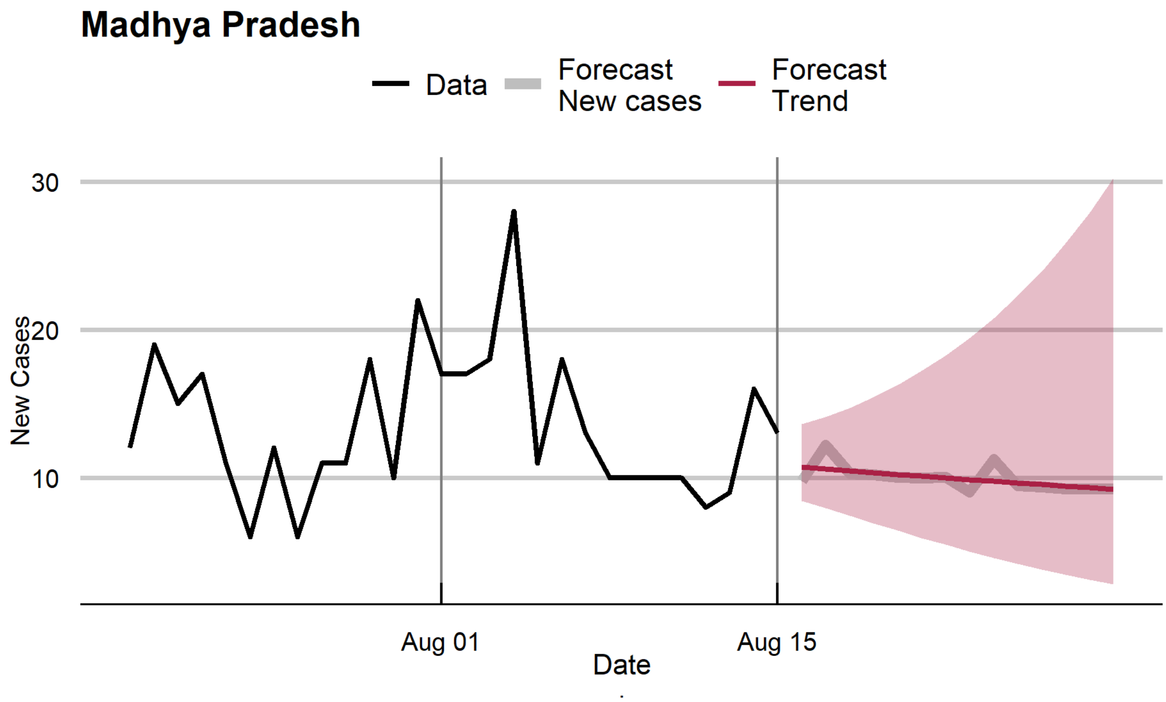

Jharkhand
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date

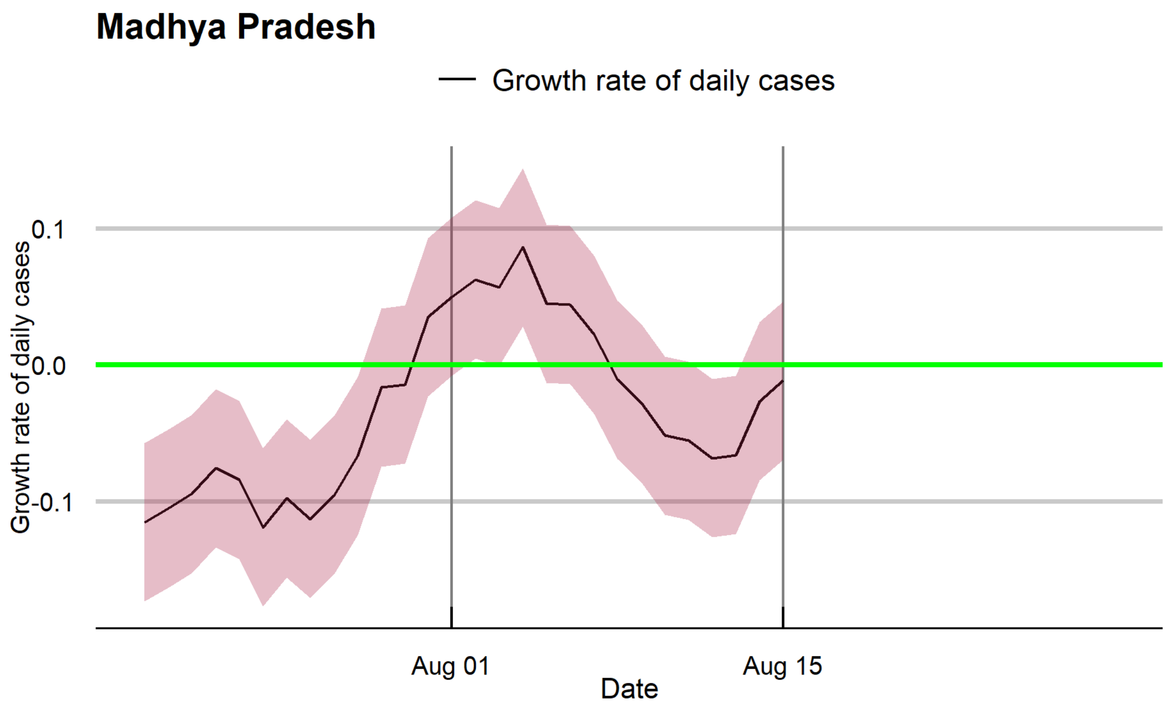

Karnataka
Data
Forecast New cases
Forecast Trend
2,000
1,600
1,200
New Cases
Aug 01
Aug 15
Date

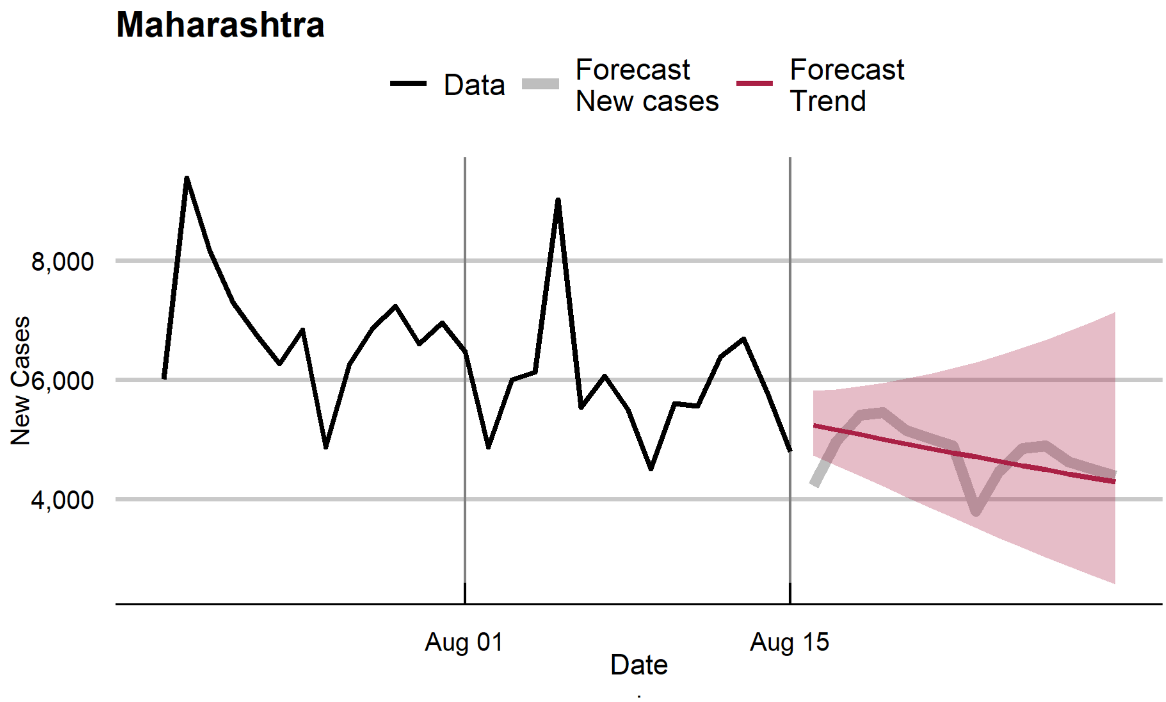

Karnataka
Growth rate of daily cases
0.03
0.00
-0.03
Growth rate of daily cases
Aug 01
Aug 15
Date

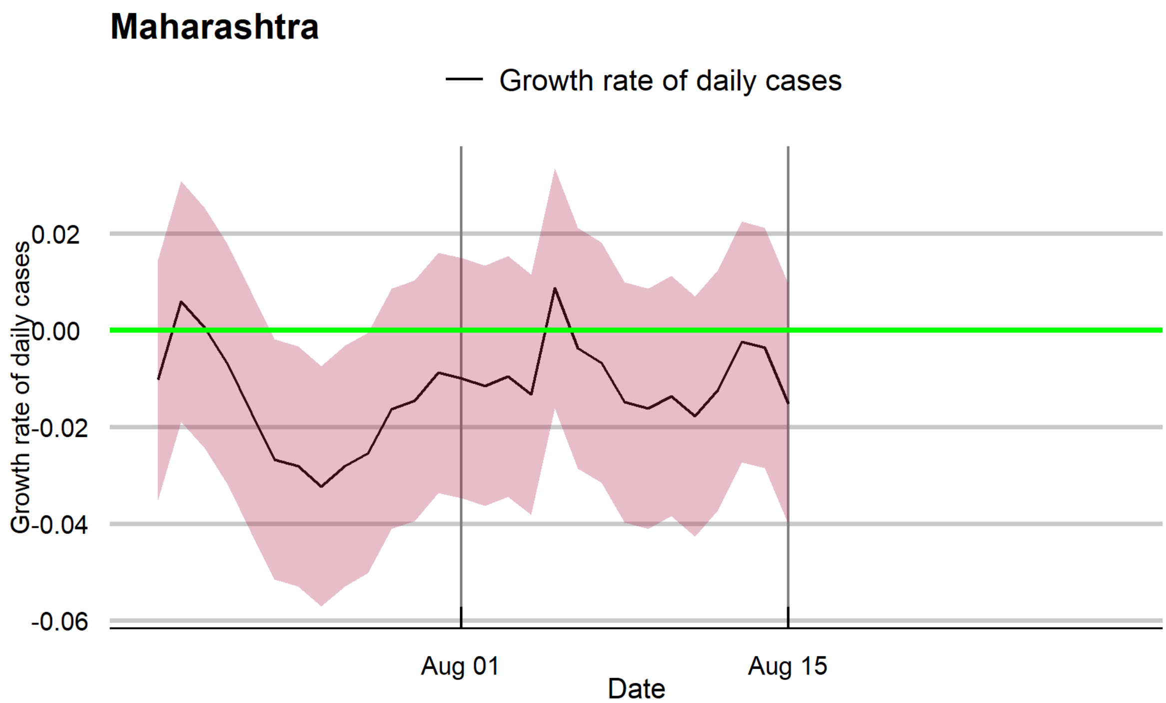

Kerala
Data
Forecast New cases
Forecast Trend
New Cases
20,000
15,000
10,000
Aug 01
Aug 15
Date

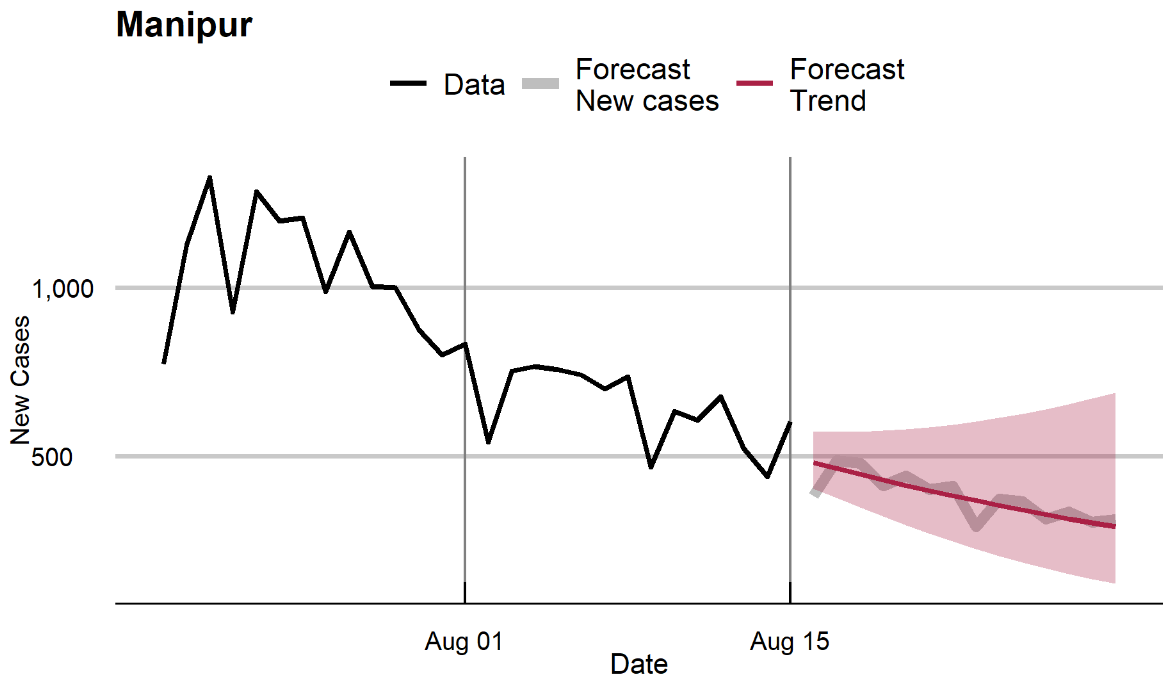

Kerala
Growth rate of daily cases
Growth rate of daily cases
0.06
0.04
0.02
0.00
-0.02
Aug 01
Aug 15
Date

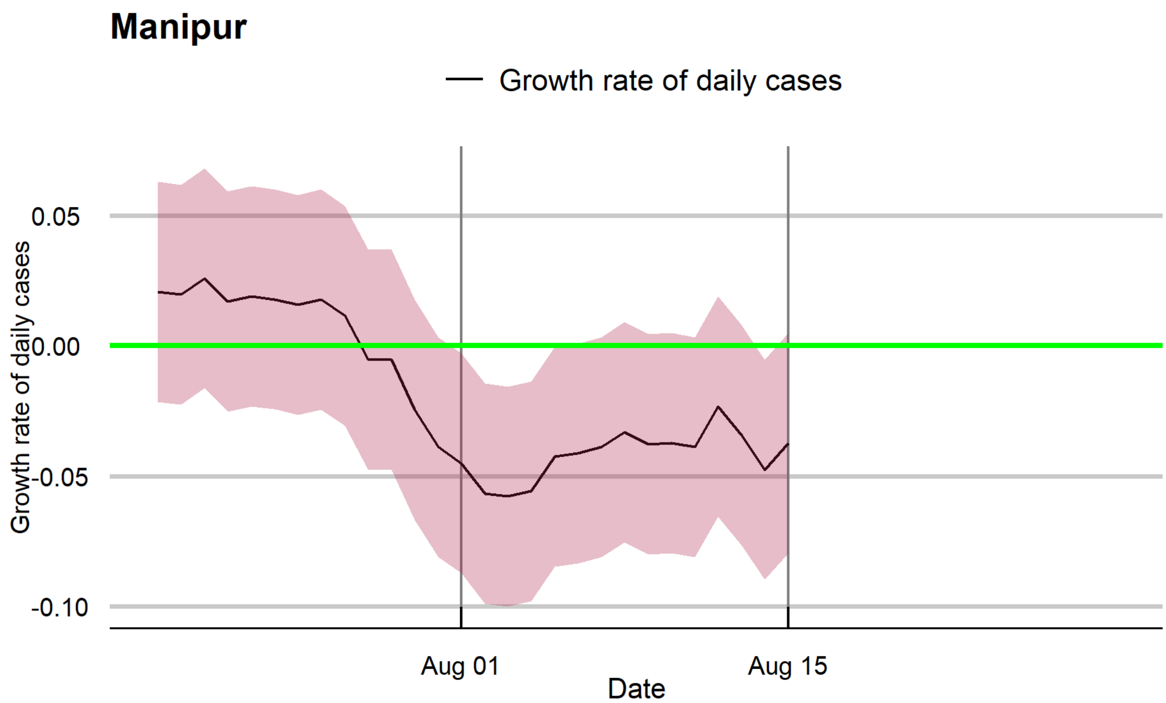

Madhya Pradesh
Data
Forecast New cases
Forecast Trend
30
20
10
New Cases
Aug 01
Aug 15
Date

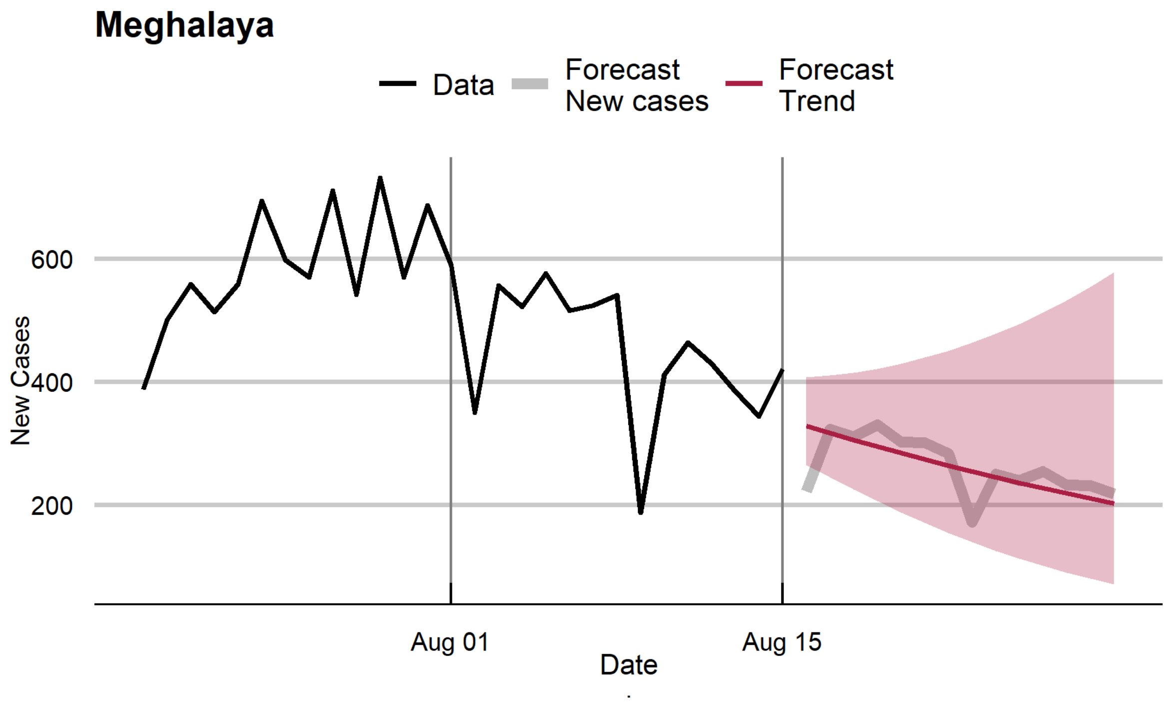

Madhya Pradesh
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Date

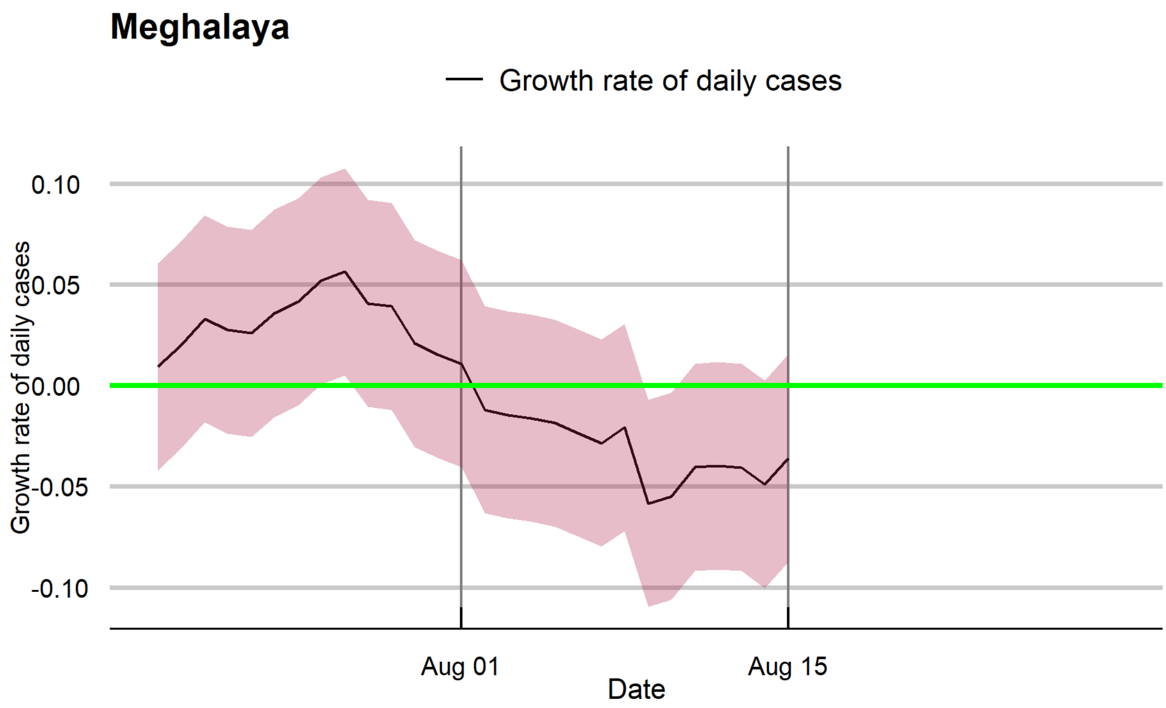

Maharashtra
Data
Forecast New cases
Forecast Trend
8,000
6,000
4,000
New Cases
Aug 01
Aug 15
Date

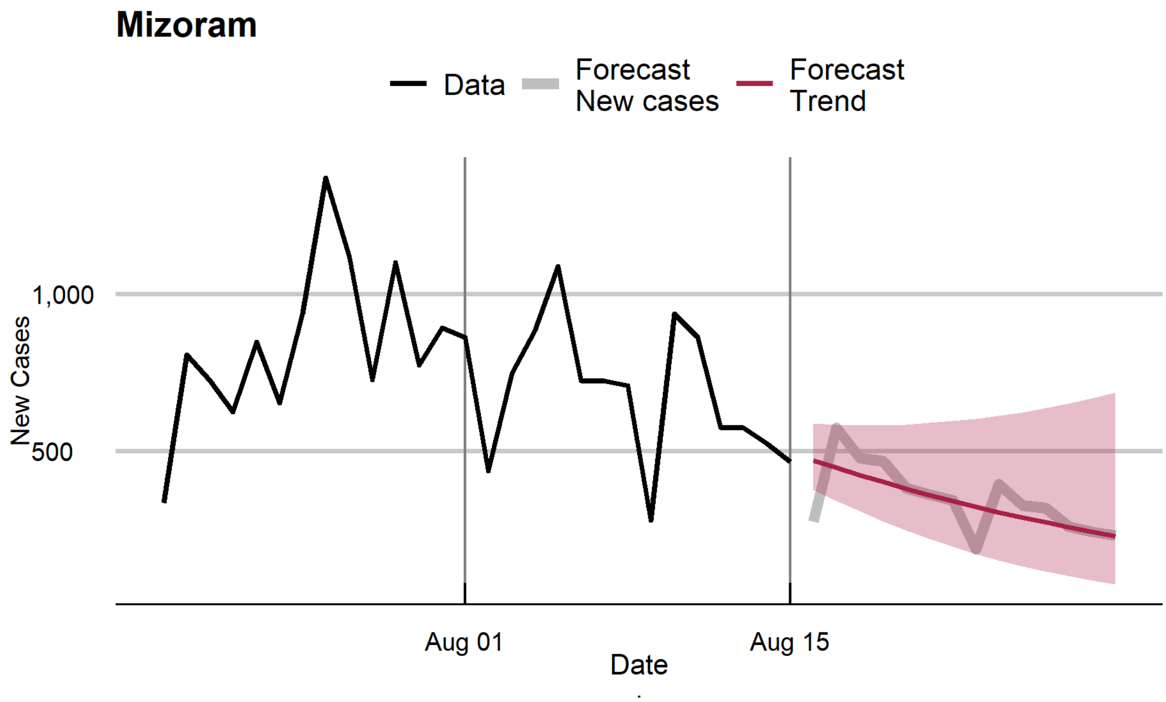

Maharashtra
Growth rate of daily cases
0.02
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Date

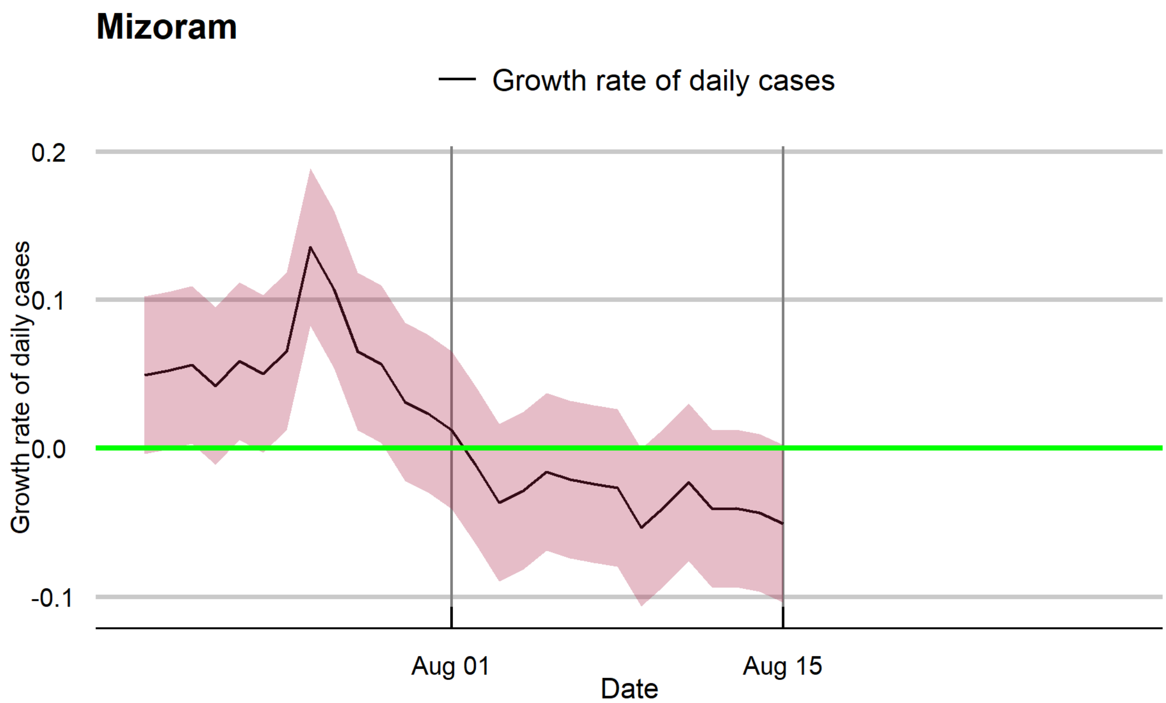

Manipur
Data
Forecast New cases
Forecast Trend
1,000
500
New Cases
Aug 01
Aug 15
Date

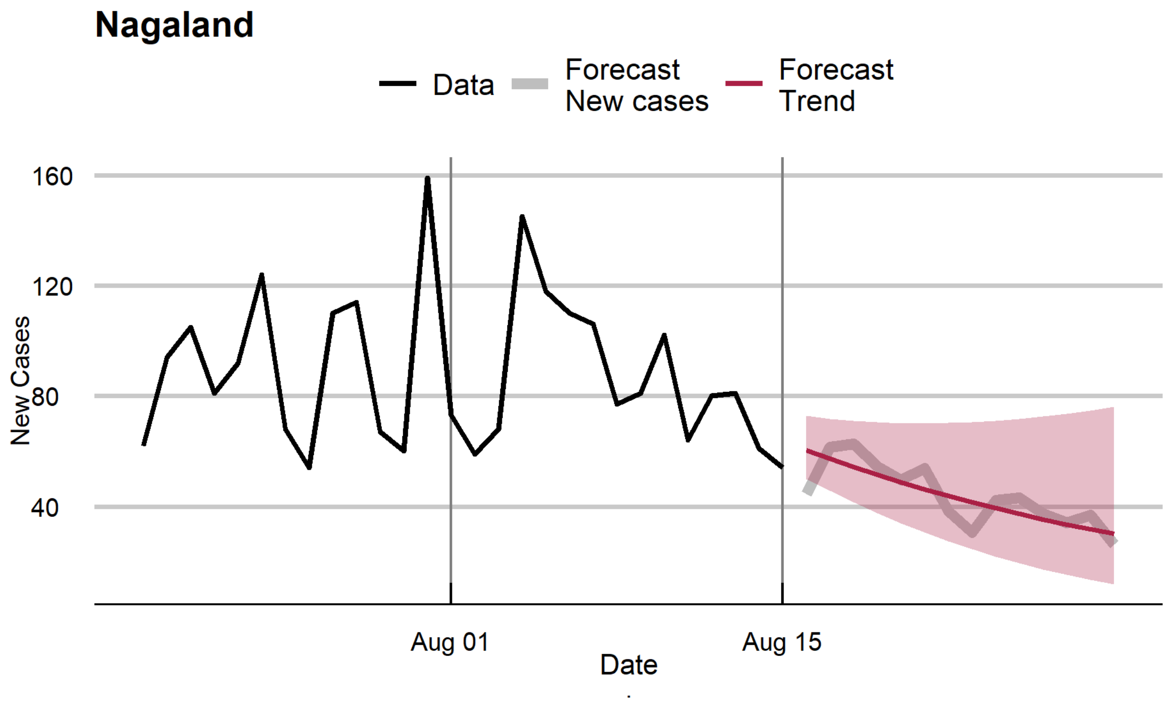

Manipur
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date

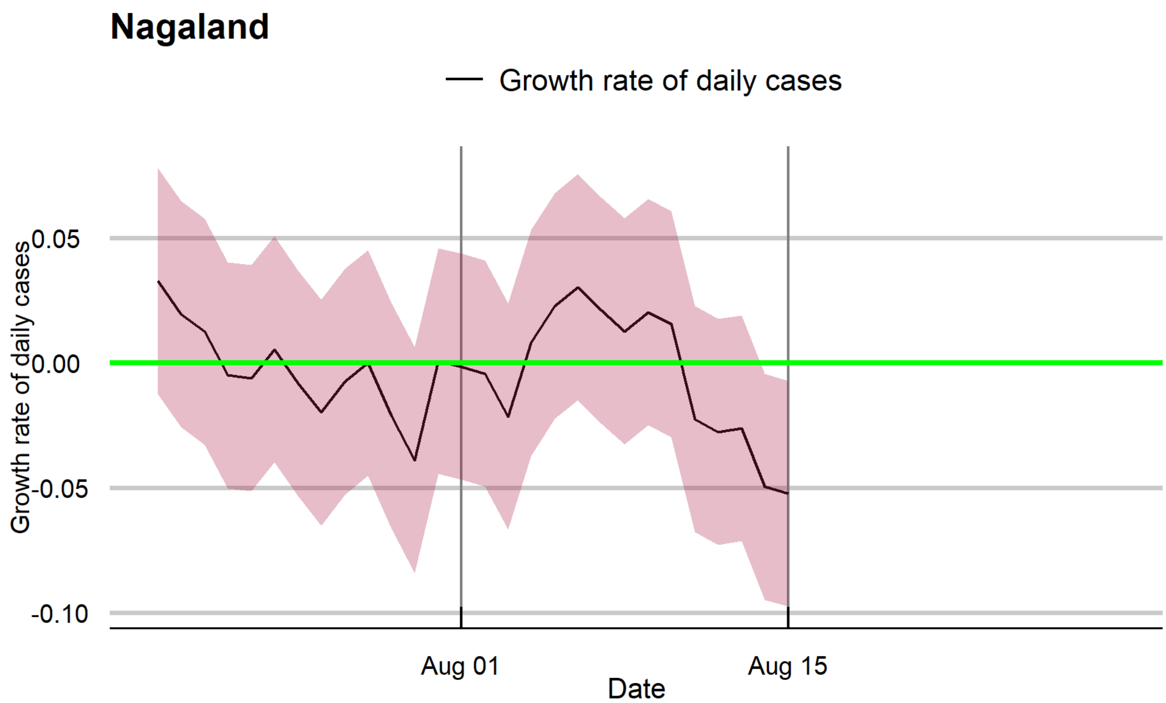

Meghalaya
Data
Forecast New cases
Forecast Trend
600
400
200
New Cases
Aug 01
Aug 15
Date

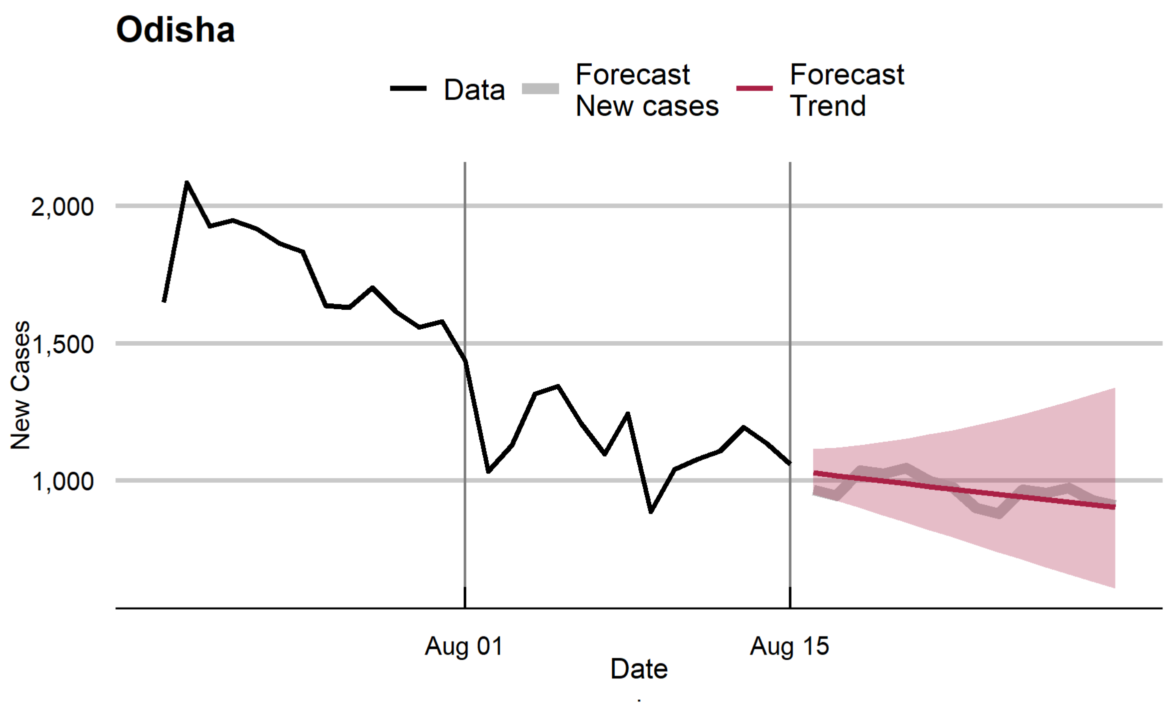

Meghalaya
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date


Mizoram
Data
Forecast New cases
Forecast Trend
1,000
500
New Cases
Aug 01
Aug 15
Date

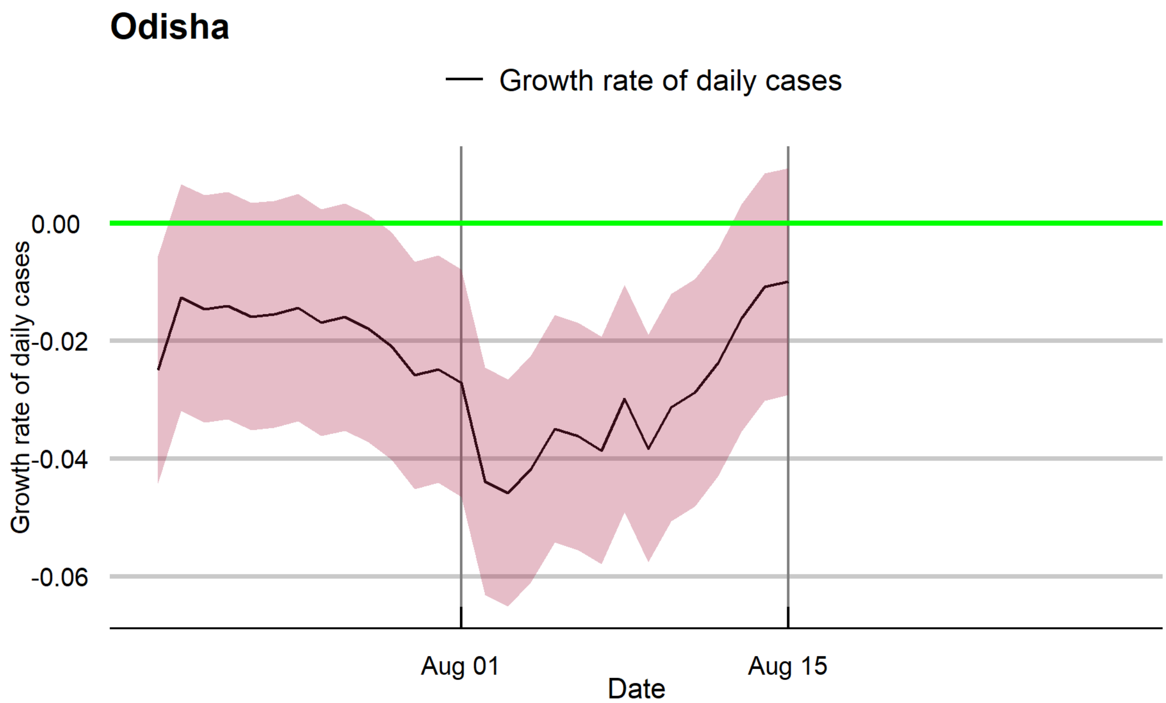

Mizoram
Growth rate of daily cases
0.2
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Date


Nagaland
Data
Forecast New cases
Forecast Trend
160
120
80
40
New Cases
Aug 01
Aug 15
Date

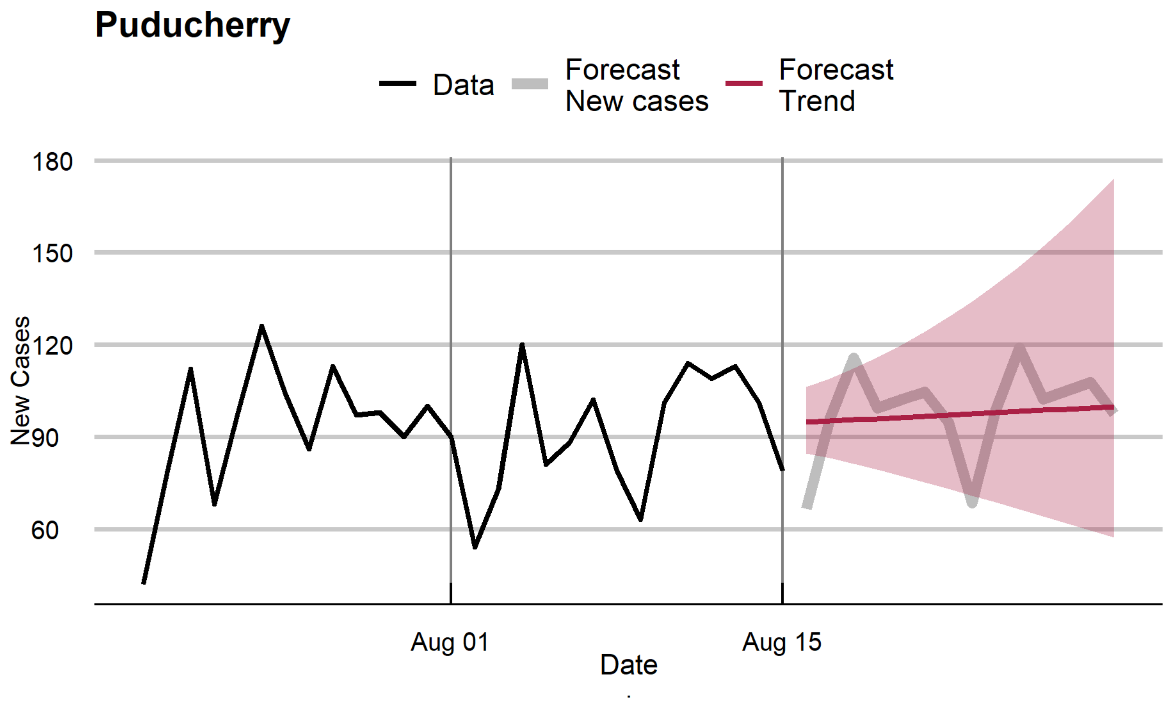

Nagaland
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date

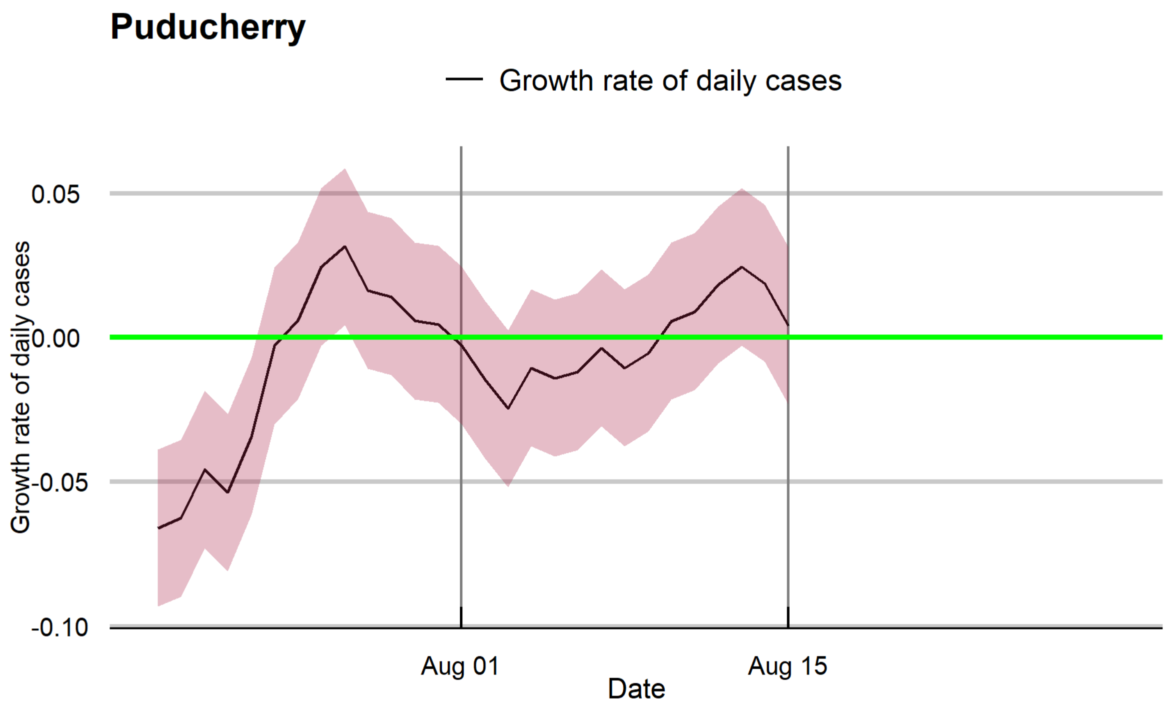


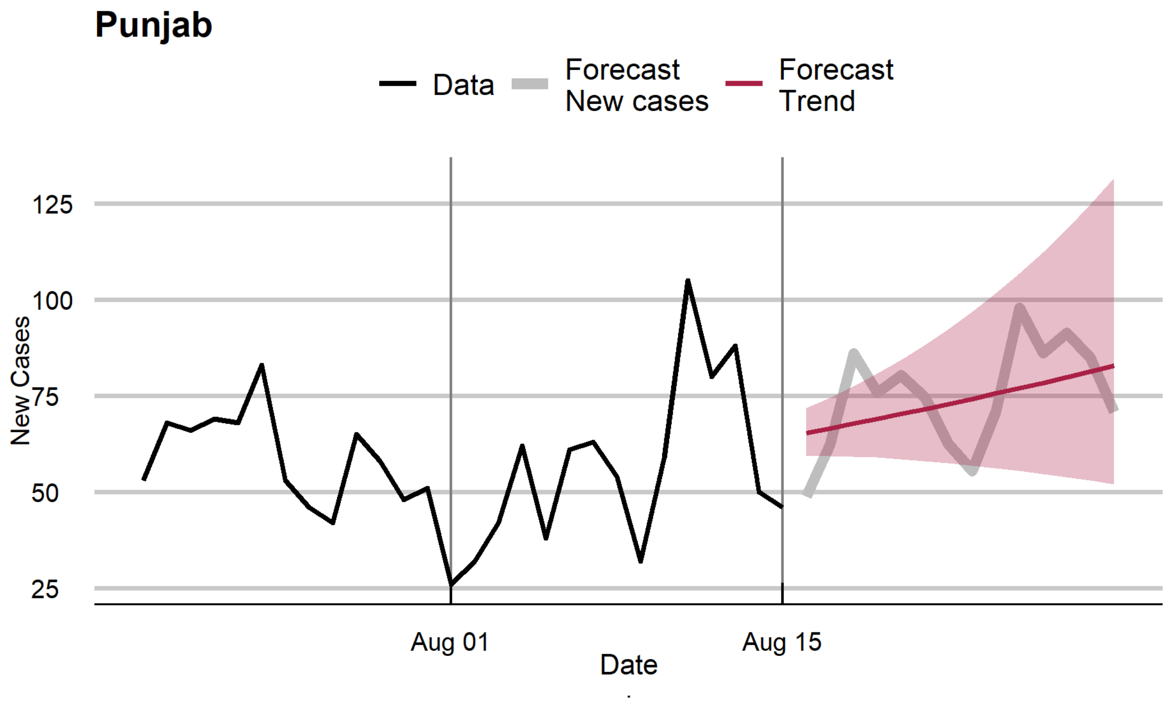
Odisha
Data
Forecast New cases
Forecast Trend
2,000
1,500
1,000
New Cases
Aug 01
Aug 15
Date



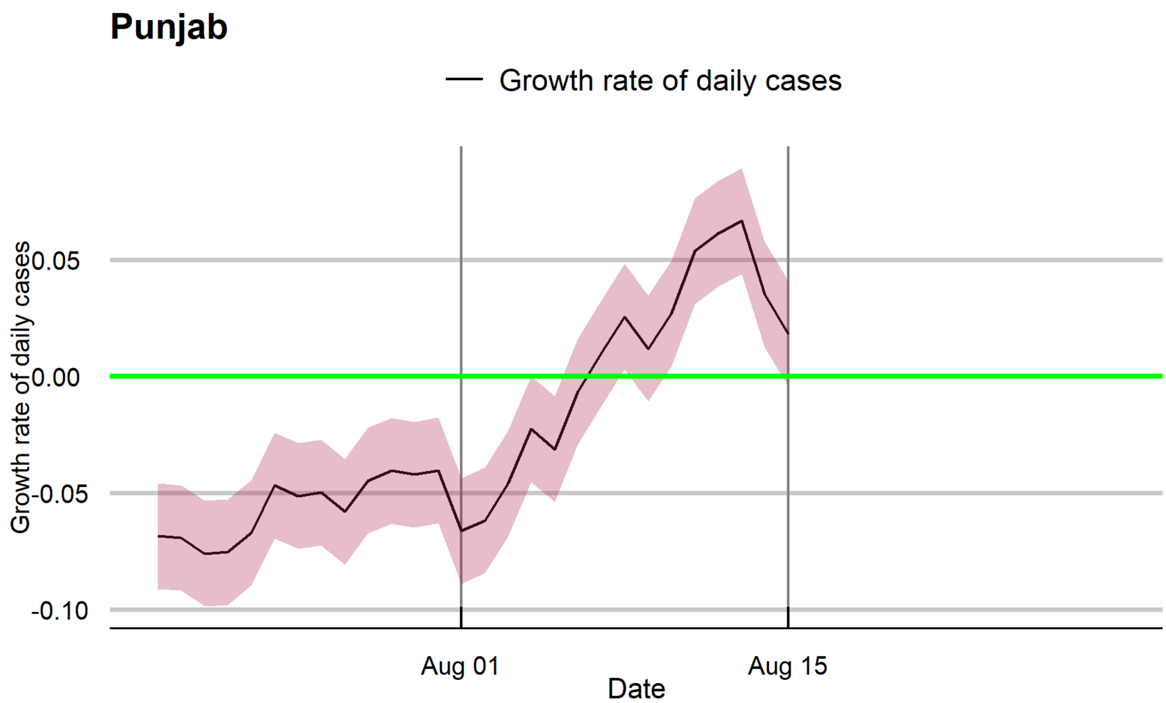
Odisha
Growth rate of daily cases
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Date


Puducherry
Data
Forecast New cases
Forecast Trend
180
150
120
90
60
New Cases
Aug 01
Aug 15
Date

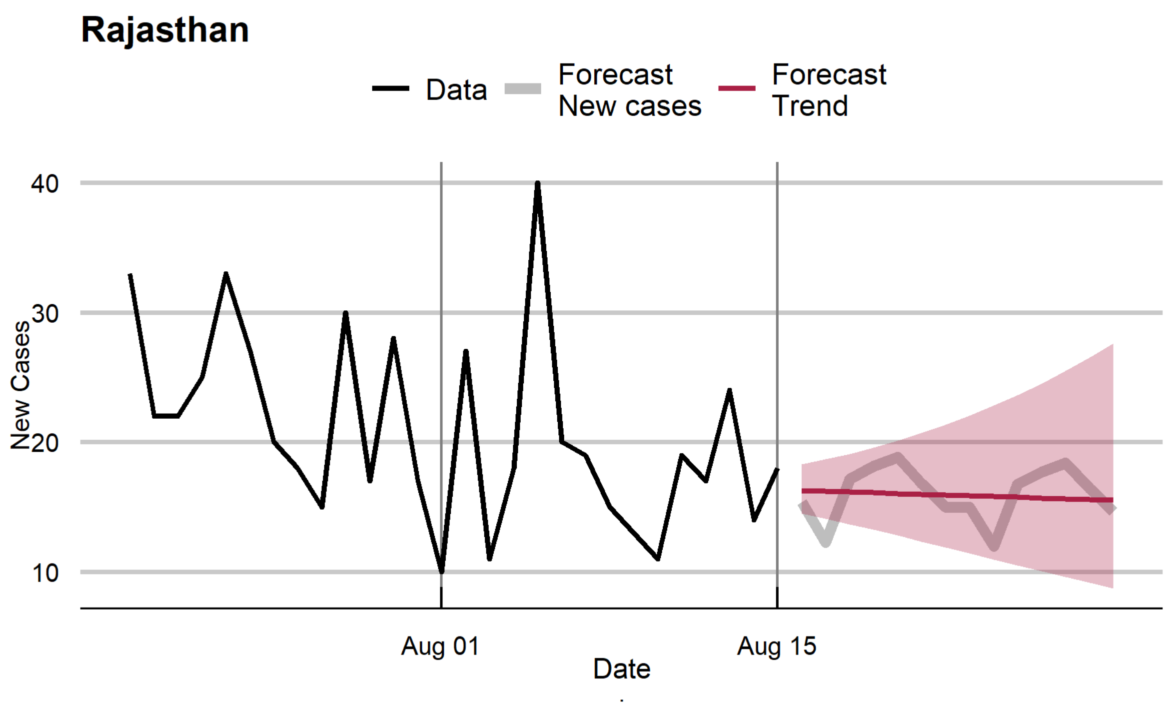

Puducherry
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date

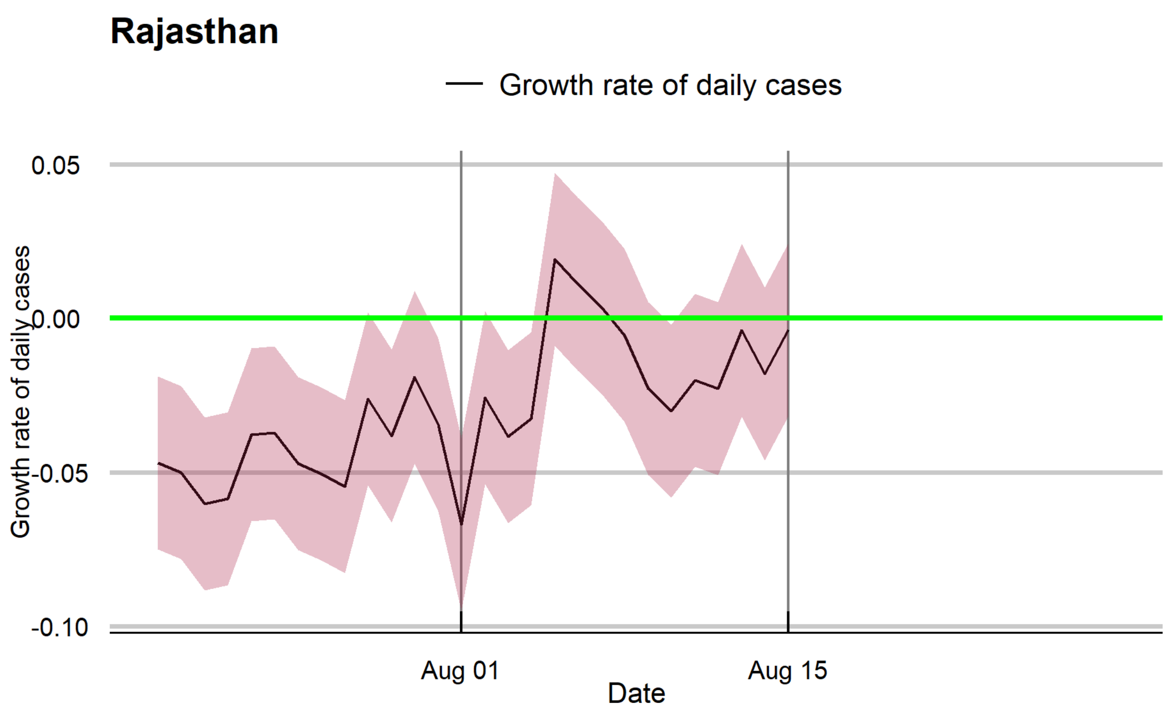


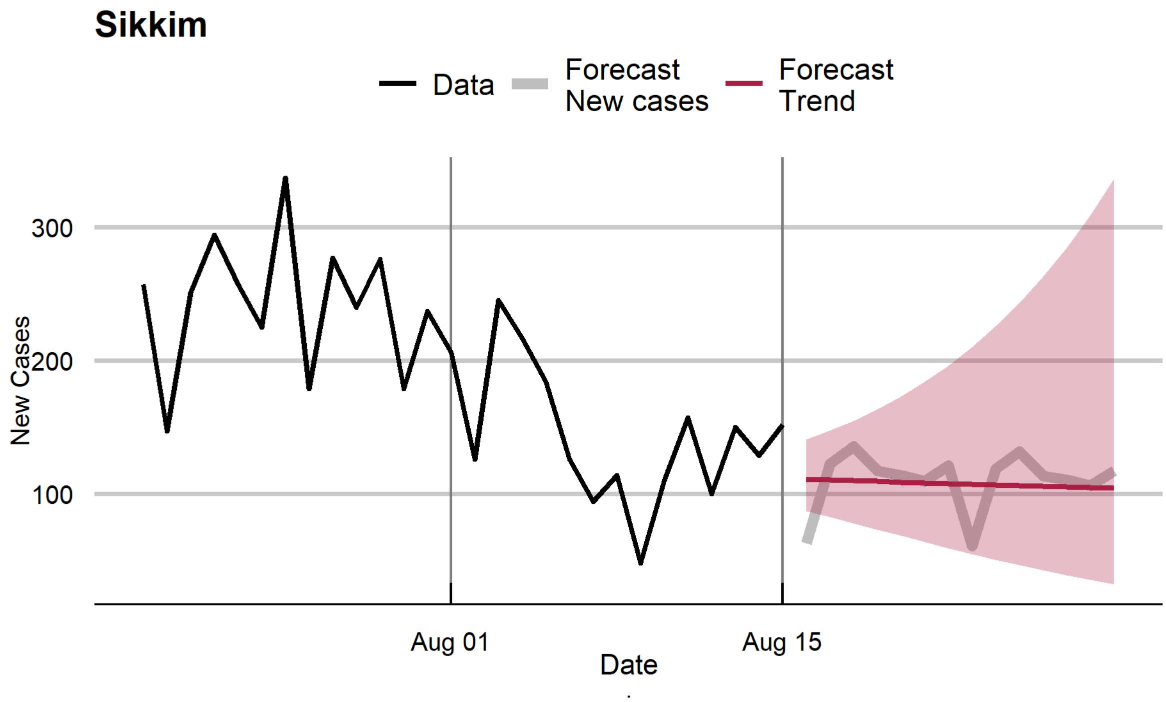
Punjab
Data
Forecast New cases
Forecast Trend
New Cases
125
100
75
50
25
Aug 01
Aug 15
Date

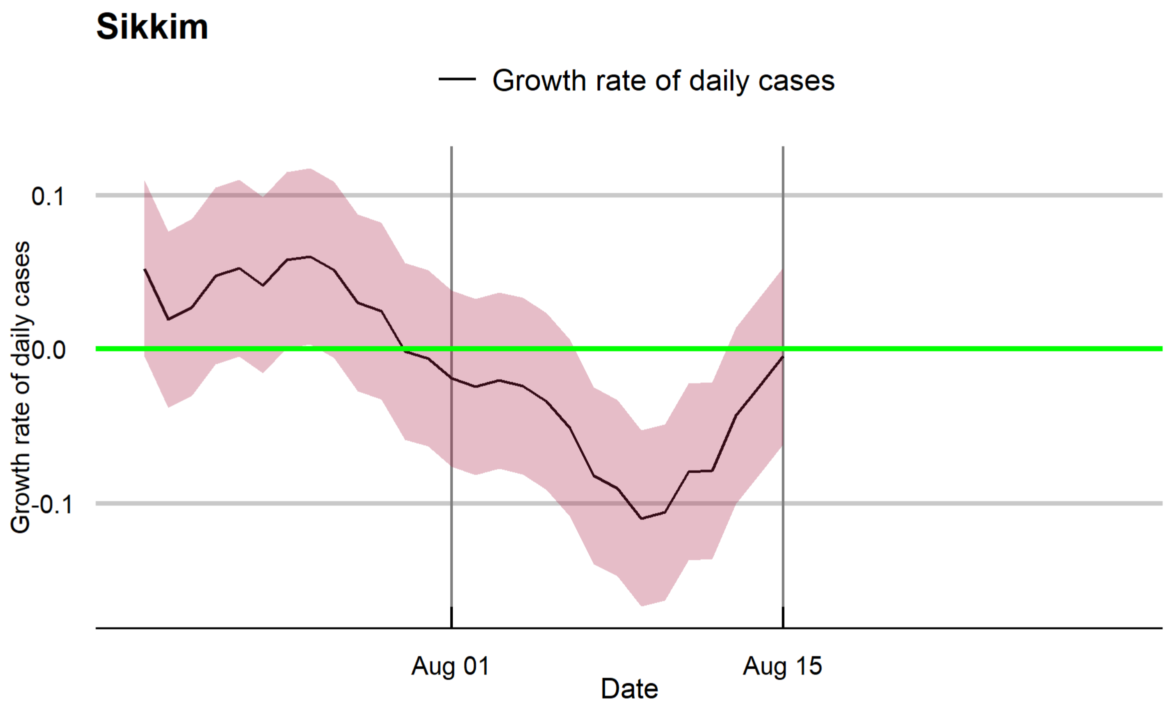


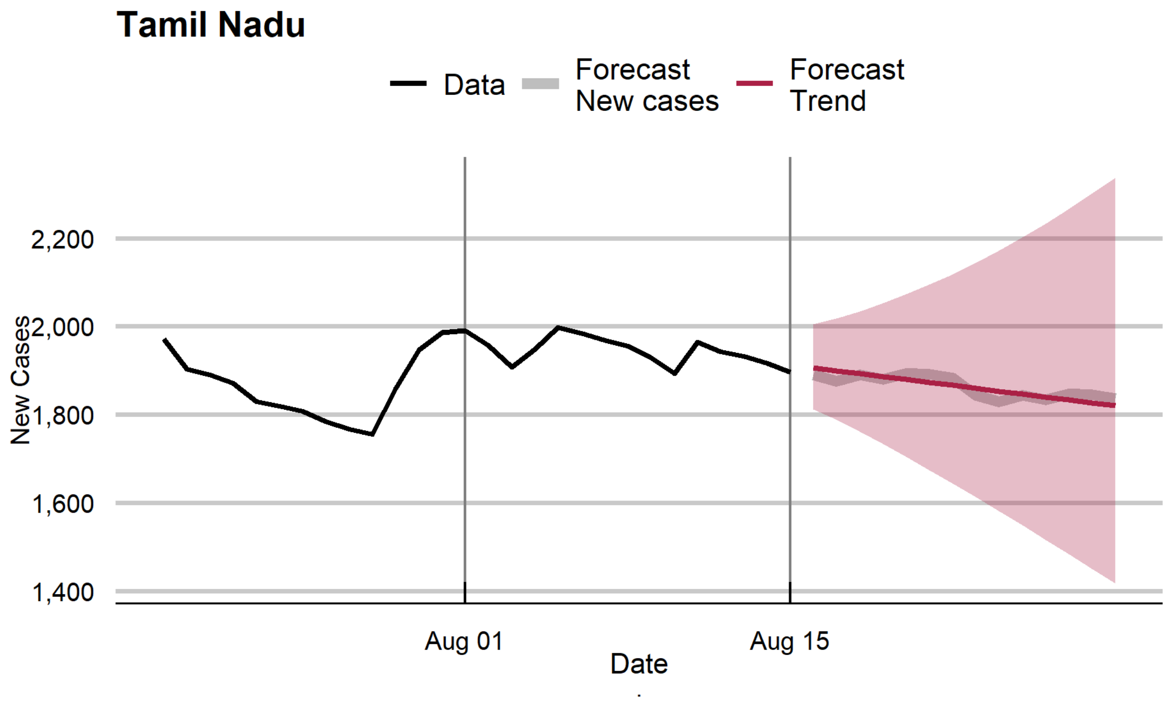
Punjab
Growth rate of daily cases
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Aug 01
Aug 15
Date

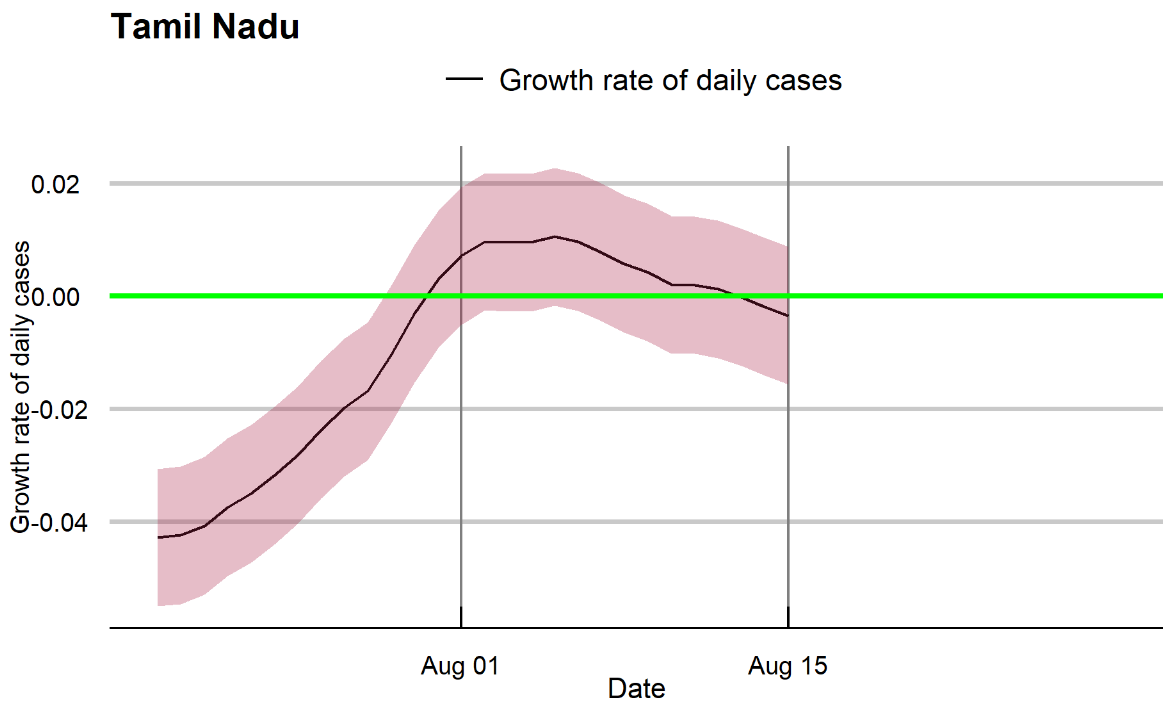

Rajasthan
Data
Forecast New cases
Forecast Trend
40
30
20
10
New Cases
Aug 01
Aug 15
Date

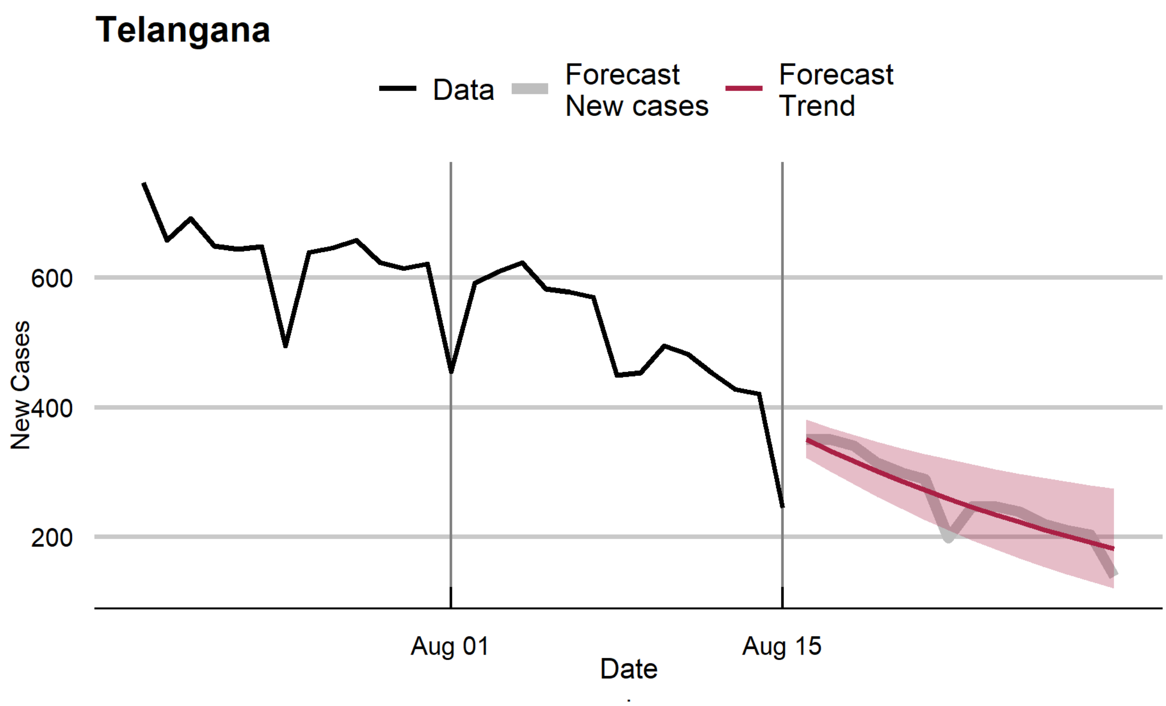

Rajasthan
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date

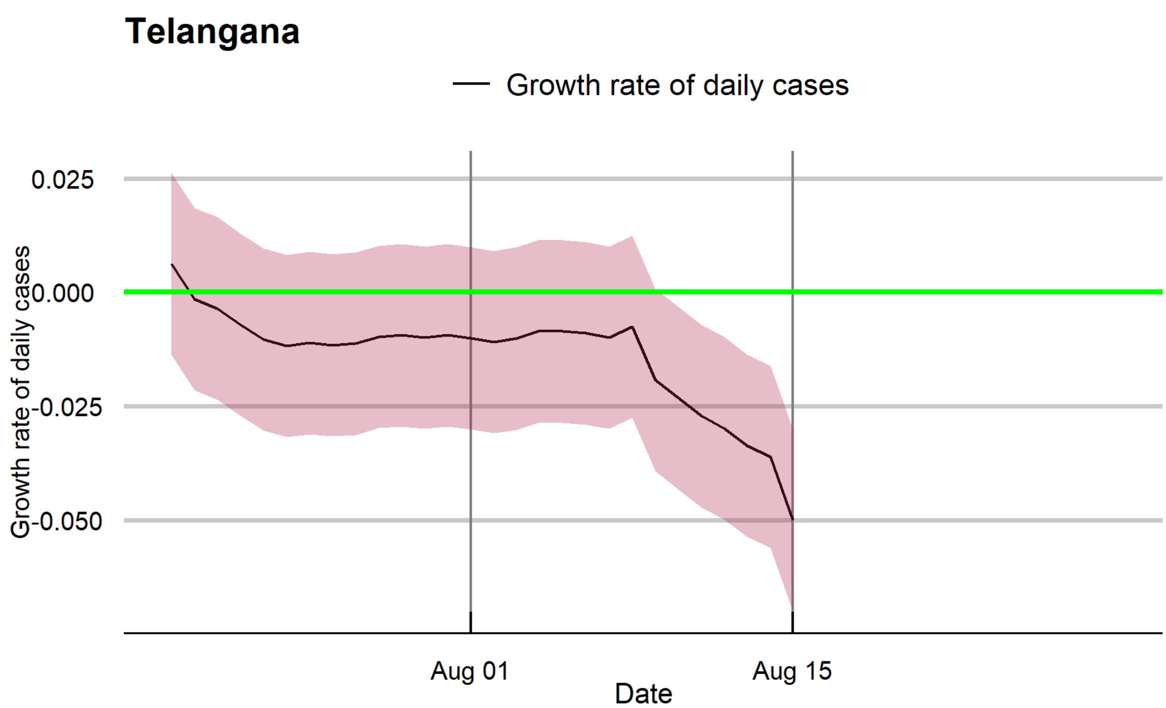

Sikkim
Data
Forecast New cases
Forecast Trend
300
200
100
New Cases
Aug 01
Aug 15
Date

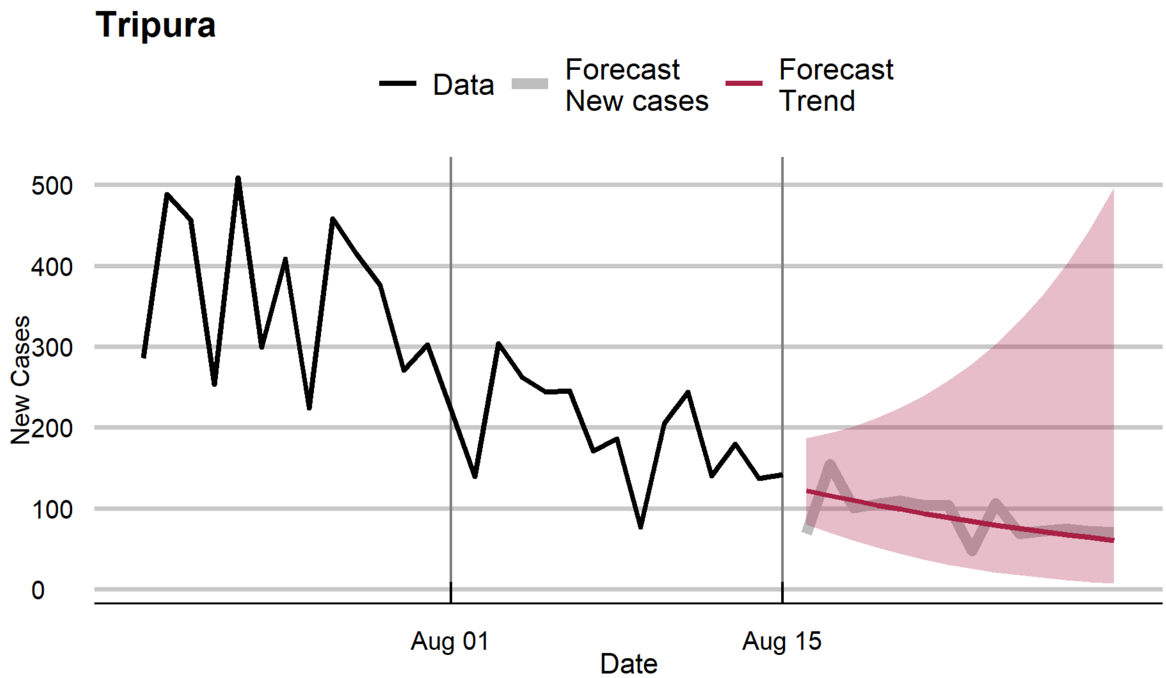

Sikkim
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Date

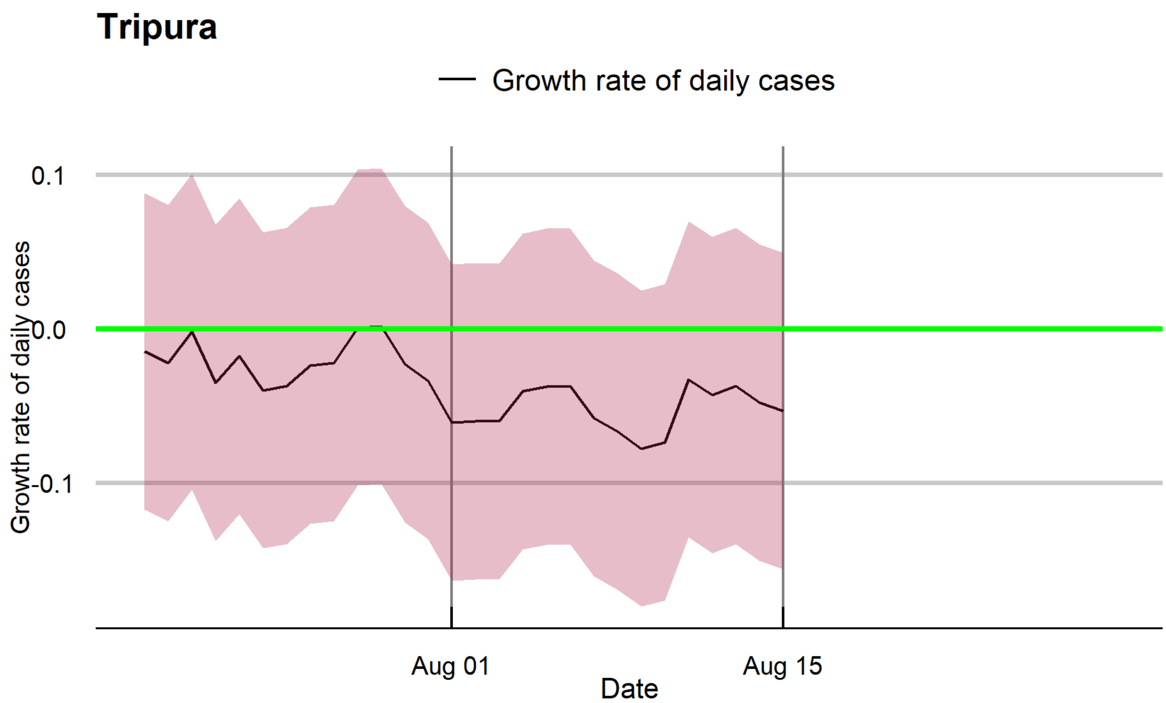

Tamil Nadu
Data
Forecast New cases
Forecast Trend
2,200
2,000
1,800
1,600
1,400
New Cases
Aug 01
Aug 15
Date

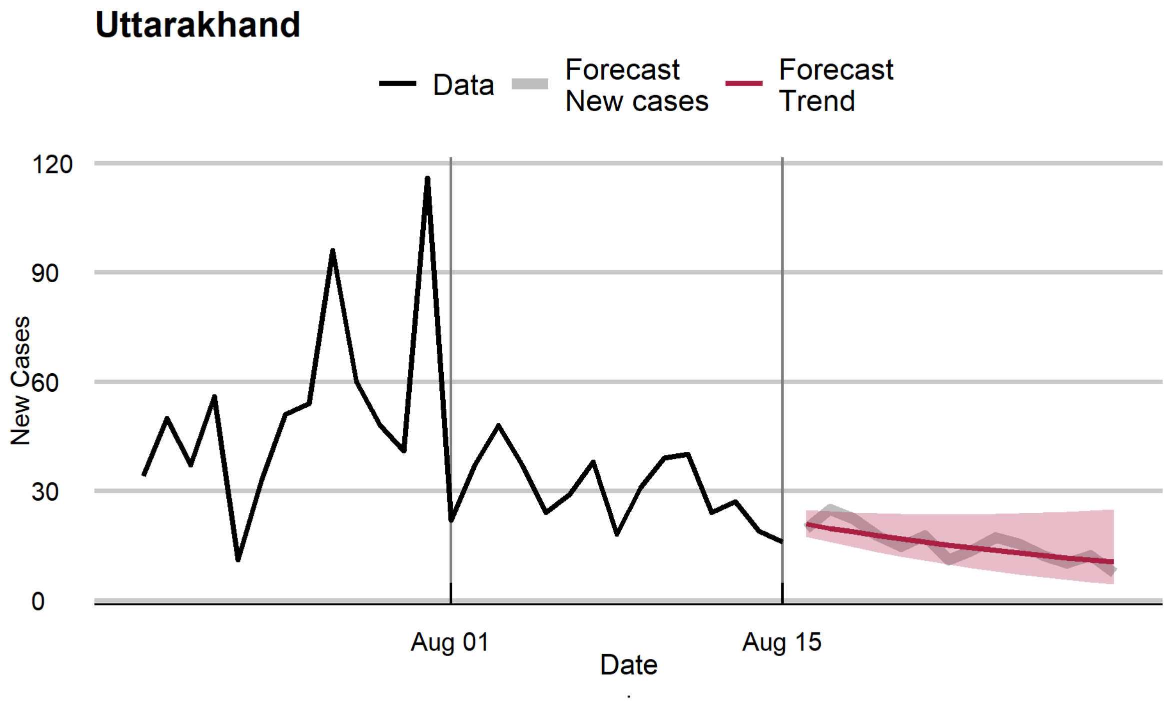

Tamil Nadu
Growth rate of daily cases
0.02
0.00
-0.02
-0.04
Growth rate of daily cases
Aug 01
Aug 15
Date

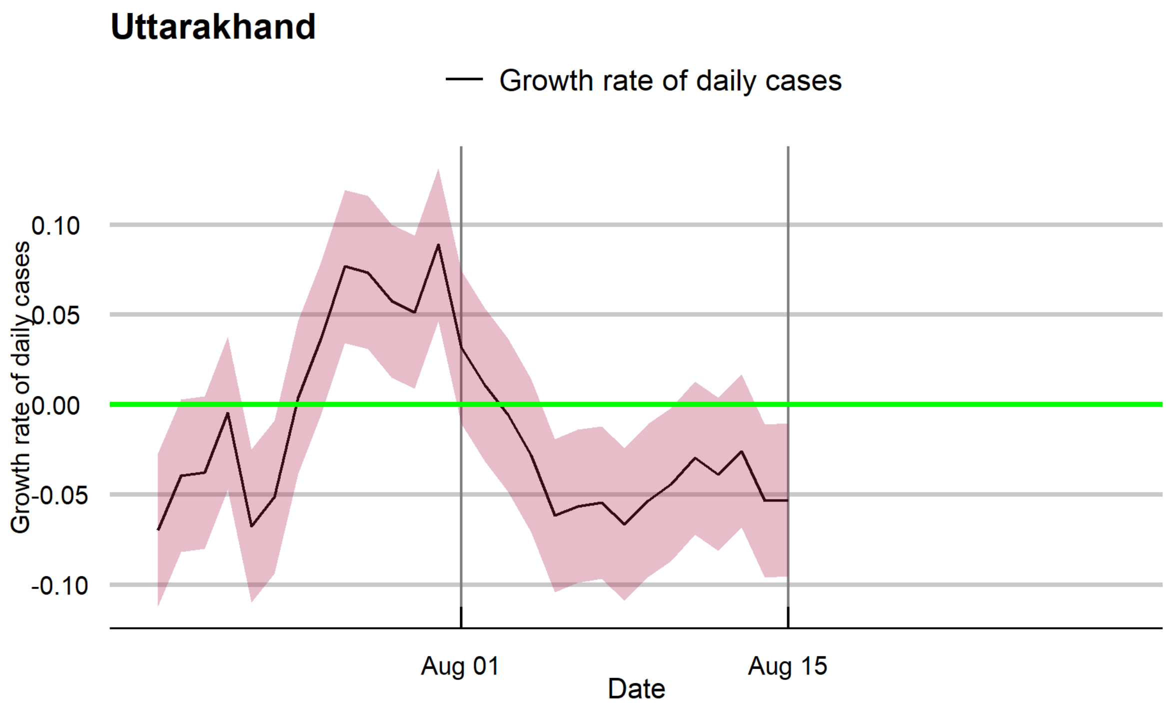

Telangana
Data
Forecast New cases
Forecast Trend
600
400
200
New Cases
Aug 01
Aug 15
Date

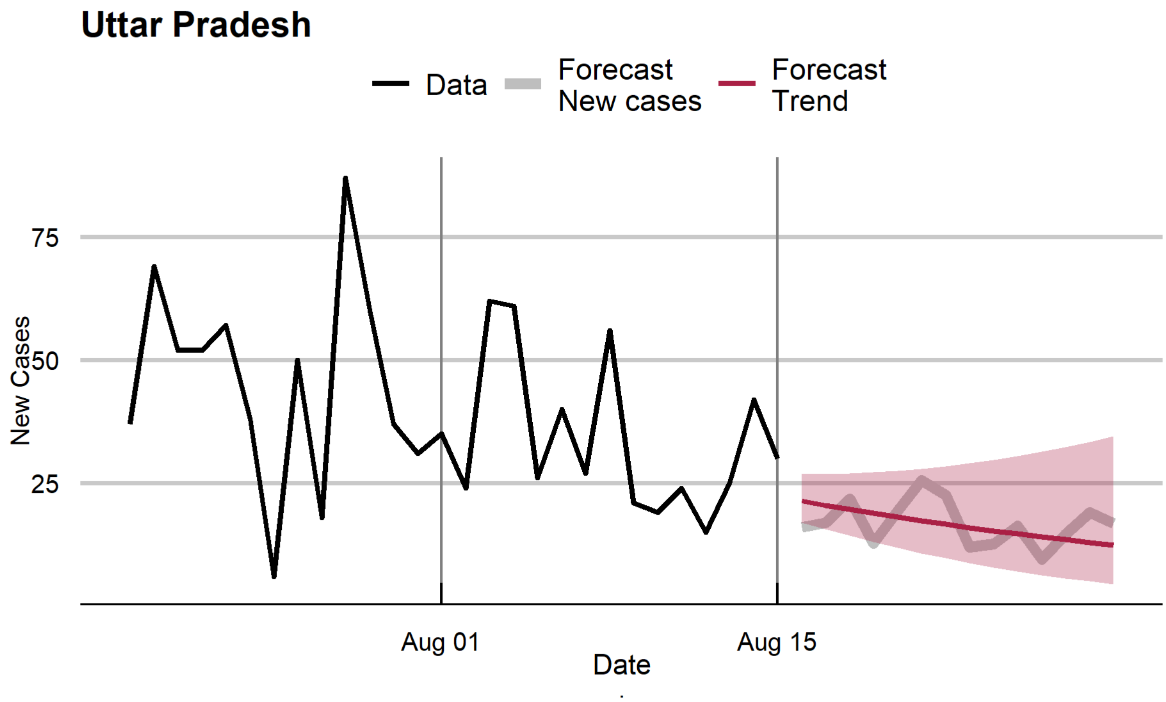

Telangana
Growth rate of daily cases
0.025
0.000
-0.025
-0.050
Growth rate of daily cases
Aug 01
Aug 15
Date

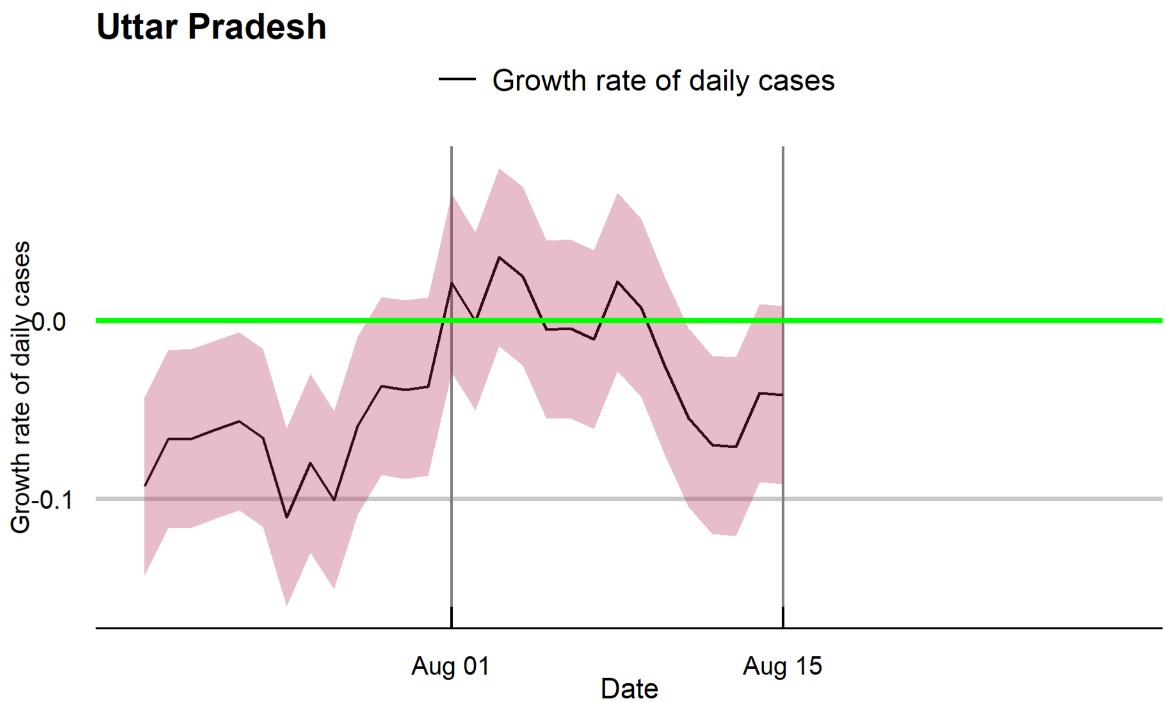

Tripura
Data
Forecast New cases
Forecast Trend
500
400
300
200
100
0
New Cases
Aug 01
Aug 15
Date

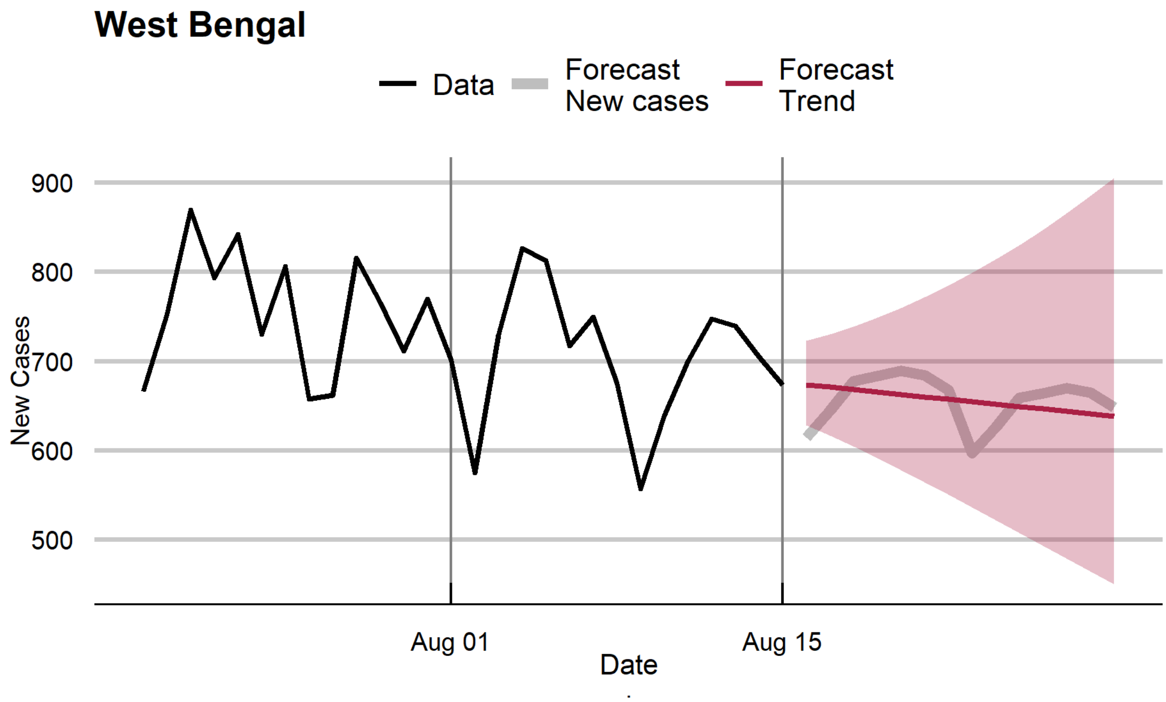

Tripura
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Date

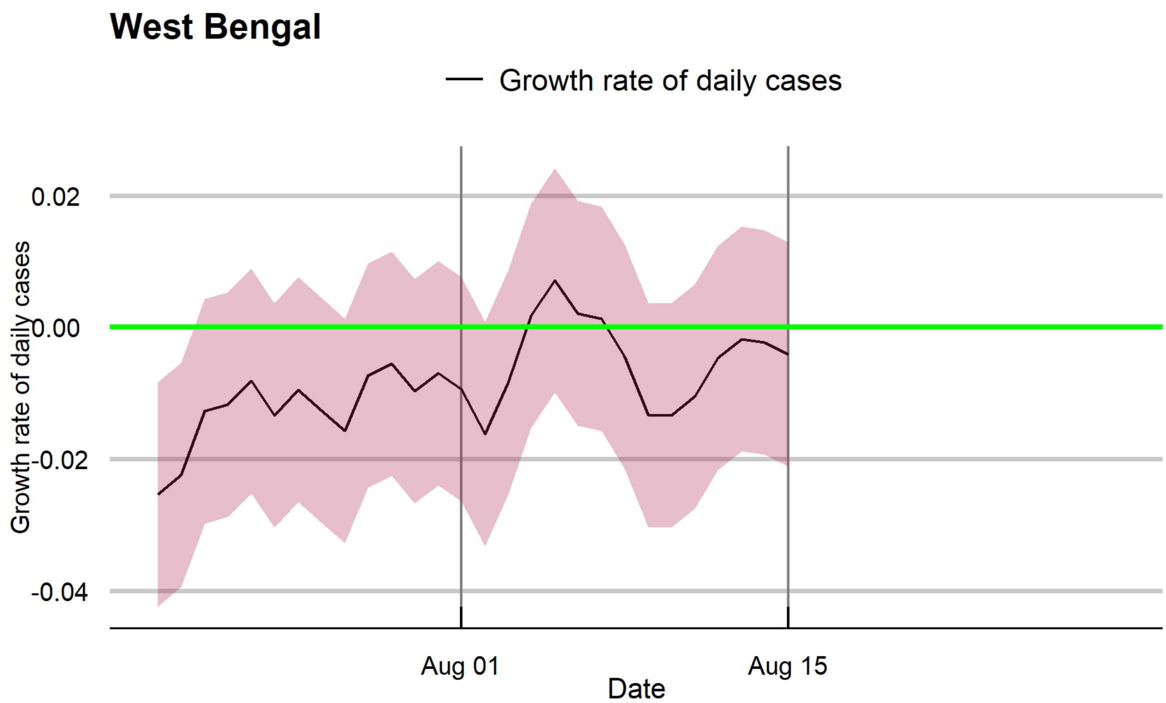

Uttarakhand
Data
Forecast New cases
Forecast Trend
120
90
60
30
0
New Cases
Aug 01
Aug 15
Date


Uttarakhand
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Date


Uttar Pradesh
Data
Forecast New cases
Forecast Trend
New Cases
75
50
25
Aug 01
Aug 15
Date

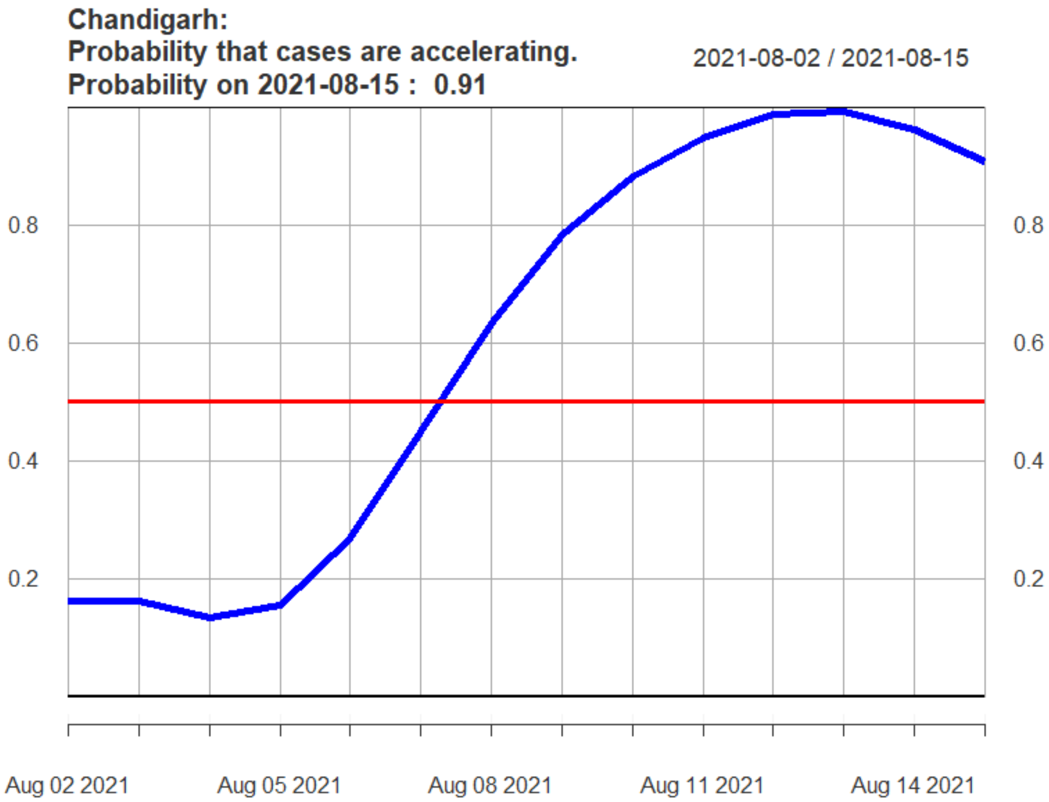

Uttar Pradesh
Growth rate of daily cases
Growth rate of daily cases
0.0
-0.1
Aug 01
Aug 15
Date

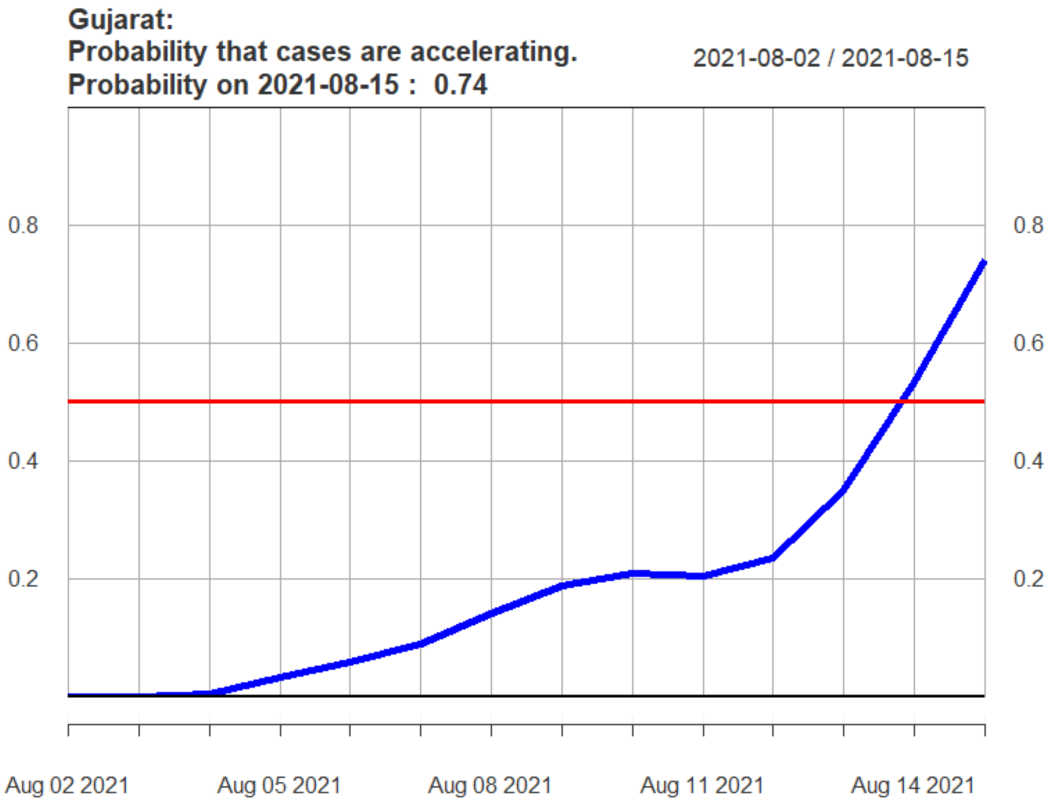

West Bengal
Data
Forecast New cases
Forecast Trend
900
800
700
600
500
New Cases
Aug 01
Aug 15
Date

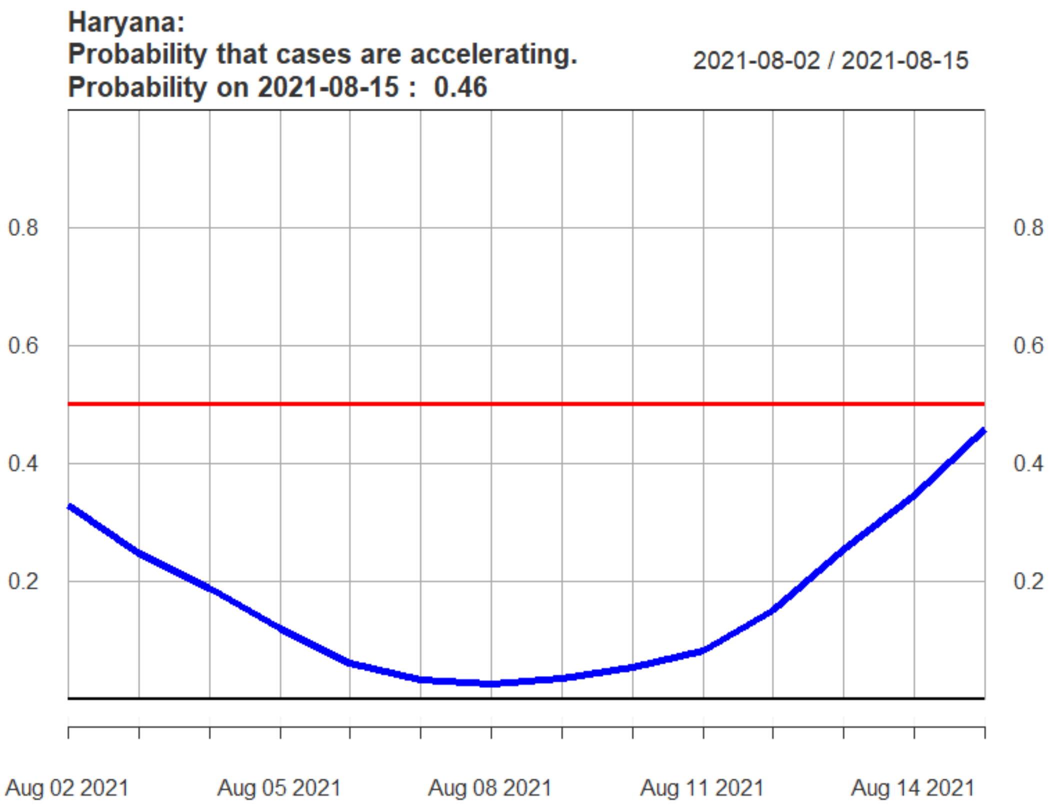

West Bengal
Growth rate of daily cases
0.02
0.00
-0.02
-0.04
Growth rate of daily cases
Aug 01
Aug 15
Date

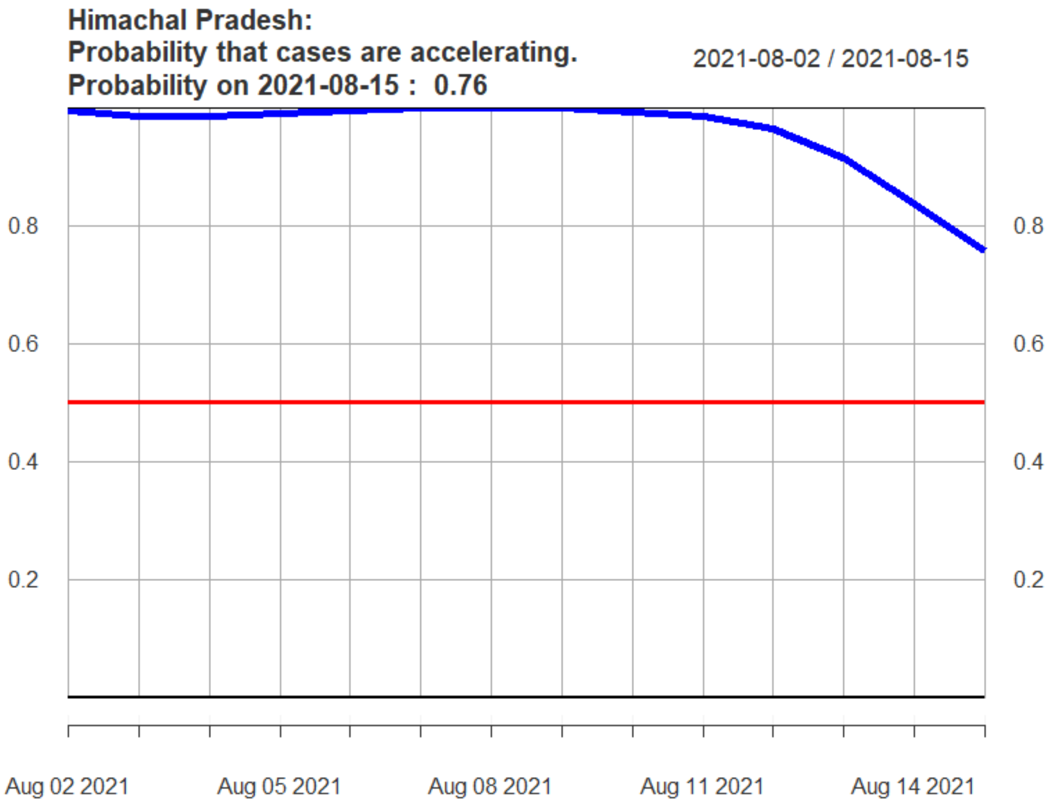
The nature of growth in new cases:

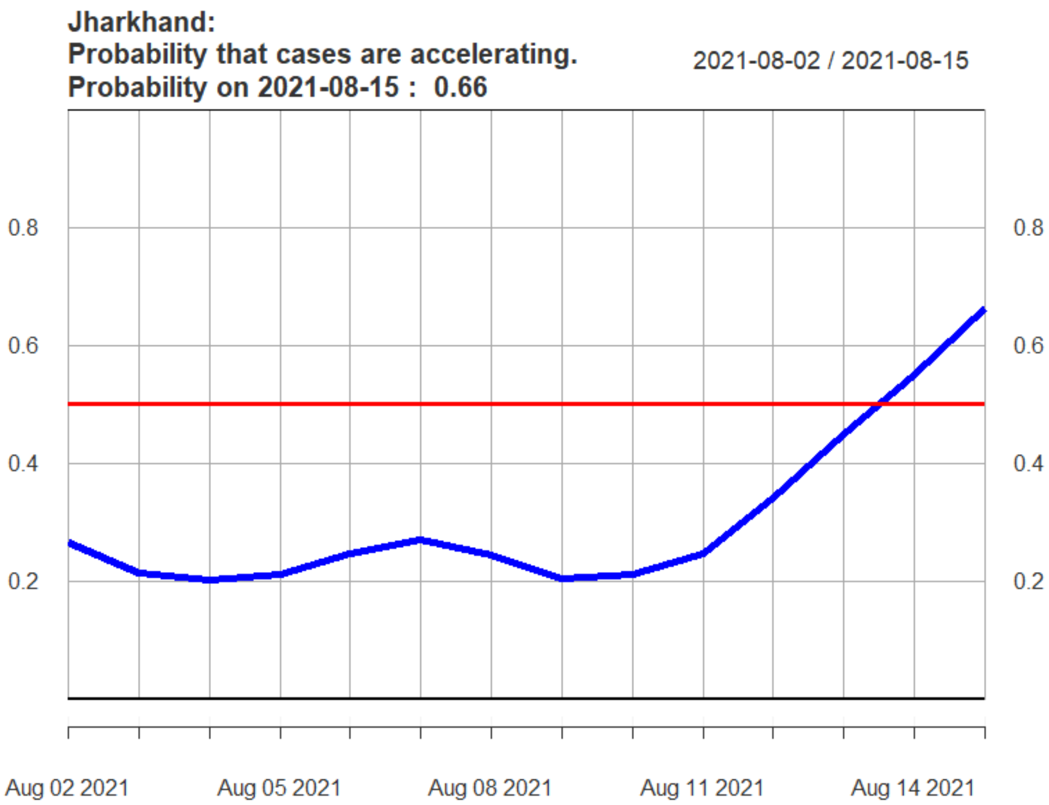
States/UTs with high odds that case numbers are currently accelerating

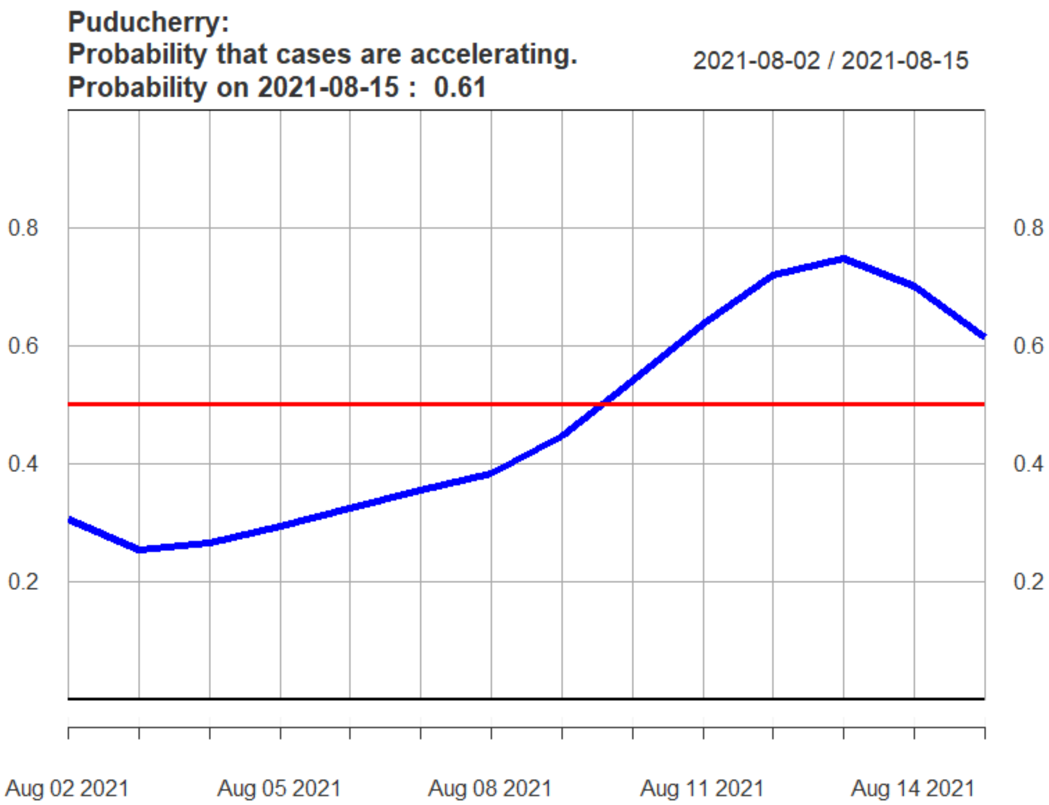


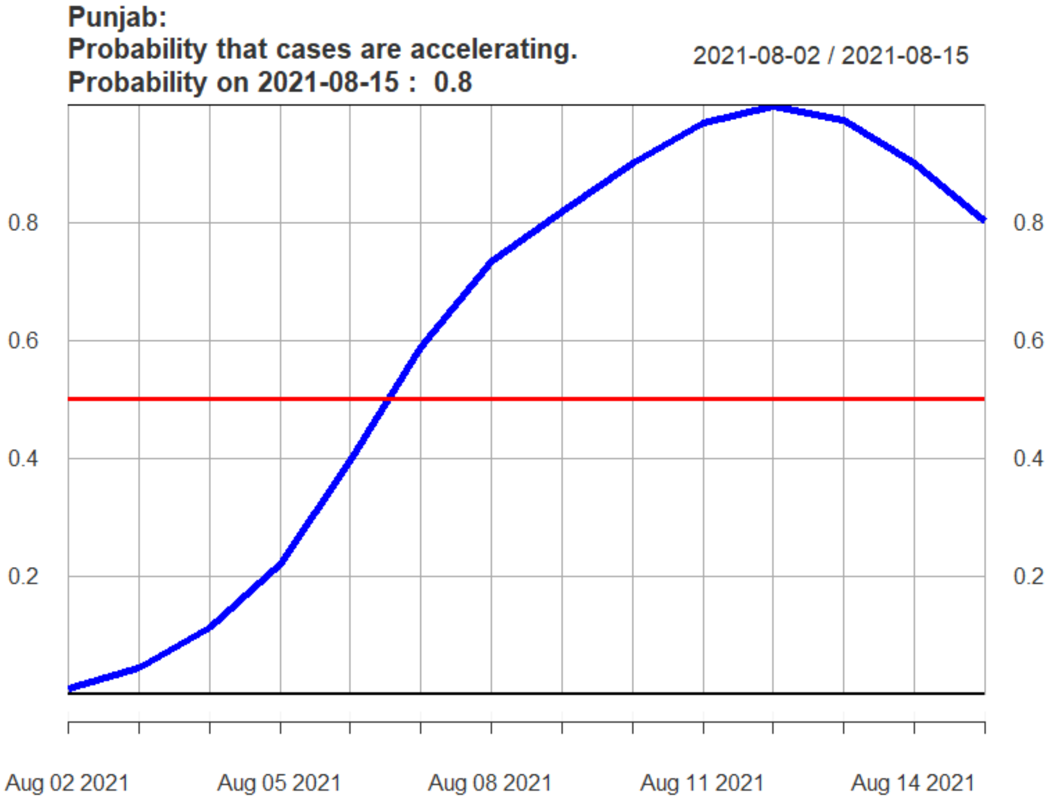


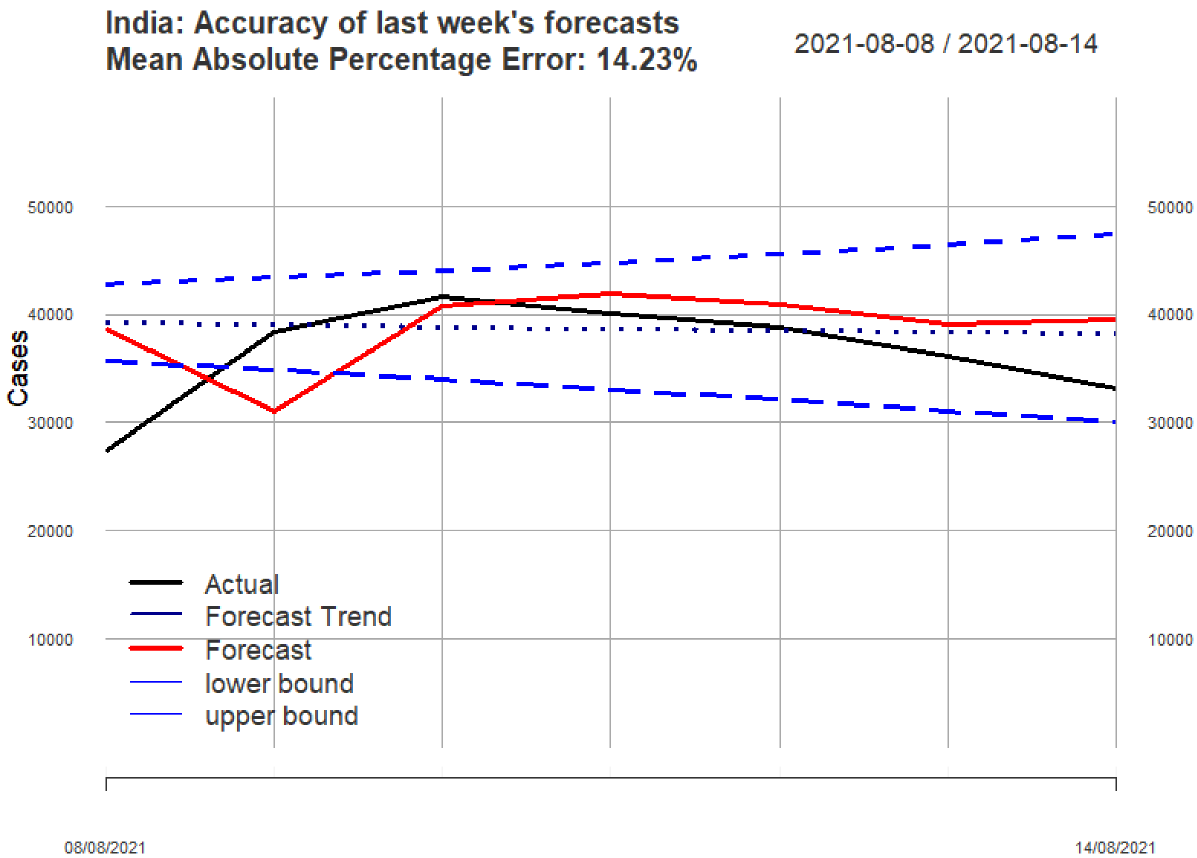

Haryana:
Probability that cases are accelerating.
Probability on 2021-08-15 : 0.46
2021-08-02 / 2021-08-15
0.8
0.6
0.4
0.2
Aug 02 2021
Aug 05 2021
Aug 08 2021
Aug 11 2021
Aug 14 2021


Himachal Pradesh:
Probability that cases are accelerating.
Probability on 2021-08-15 : 0.76
2021-08-02 / 2021-08-15
0.8
0.6
0.4
0.2
Aug 02 2021
Aug 05 2021
Aug 08 2021
Aug 11 2021
Aug 14 2021


Jharkhand:
Probability that cases are accelerating.
Probability on 2021-08-15 : 0.66
2021-08-02 / 2021-08-15
0.8
0.6
0.4
0.2
Aug 02 2021
Aug 05 2021
Aug 08 2021
Aug 11 2021
Aug 14 2021


Puducherry:
Probability that cases are accelerating.
Probability on 2021-08-15 : 0.61
2021-08-02 / 2021-08-15
0.8
0.6
0.4
0.2
Aug 02 2021
Aug 05 2021
Aug 08 2021
Aug 11 2021
Aug 14 2021


Punjab:
Probability that cases are accelerating.
Probability on 2021-08-15 : 0.8
2021-08-02 / 2021-08-15
0.8
0.6
0.4
0.2
Aug 02 2021
Aug 05 2021
Aug 08 2021
Aug 11 2021
Aug 14 2021


India: Accuracy of last week's forecasts
Mean Absolute Percentage Error: 14.23%
2021-08-08 / 2021-08-14
Cases
50000
40000
30000
20000
10000
Actual
Forecast Trend
Forecast
lower bound
upper bound
08/08/2021
14/08/2021

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: is assessed using mean absolute percentage error of the forecasts of cases over the past week. 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.

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