SARS-CoV2 Projections for India including Vaccinations

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Contents: The document contains 3 sections.

1. Current Projections with variable Vaccination rate and discussions
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3. Appendix: State-wise analysis with increased vaccination rates

1 Current Projections with variable Vaccination rates

In this project we augment our model with variable vaccination rates and analyze it for estimated vaccination rates. Consistent with previous reports we assume that the vaccination rate is applied uniformly across Indian states to the susceptible population that is present in our compartment model (based on the SEIRH model) which has asymptomatic, hospitalized and death compartments and incorporates lockdown impacts (H compartment) for predictive modeling of virus spread in Indian states and an India aggregate model from individual states model. The current projections on the Sars-Cov2 crisis are based on data until September 8th 2021. As in the earlier reports, the analysis is based on the initial growth in population that were part of transmission dynamics in the early part of 2021 and that provides a baseline for rise in cases. After lockdown removal in June, a release of population that adopts the behaviour of the baseline is estimated. Using the baseline scenario we quantify the second release with respect to the susceptible population estimation that was computed during February-March 2021 when restrictions were removed in January.

Caveat: The current results are compromised by frequent periodic lockdown and release from lockdown in some states. With the current dynamic policies in play the frequent changes in policy will impact the accuracy of our model.

We consider two types of additional release from lockdown. Additional removal lockdown policies starts at 9/20/2021 and the population returns to the behavioral status in February/March in 30, 45 and 60 days. We compare the number of cases and deaths under projected vaccination rates.

Parameters

- Baseline established during February to March, 2021.

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- Average Vaccination rates: 3.0M (30 Lakhs)/day or approximately 0.225%/day till August 16th.

  Current rates averaged to 5M vaccinations/day.

  Projected vaccination for further releases from lockdown (20th Sptember, 2021) is averaged to 8M vaccinations/day.

- Additional lockdown removal date: September 20th, 2021 and Lockdown release rate:

  (a) 100% of baseline over 30 days

  (b) 100% of baseline over 45 days

  (c) 100% of baseline over 60 days

Discussion

The modeling shows projections (figure 1) that are less pessimistic outlook as compared to August 2021. However the situation is still somewhat alarming considering the mask and social distancing (mobility) measures. As illustrated in the figure (Fig. 2) there has been a reduction in usage of masks by at least 15% points as compared to the period under lockdown and increase in mobility causing addition to the susceptible population (which by our current estimate is 39.5%). **Sustained decrease in mask usage will impact the infection counts substantially.** Correlation between mask usage and social distancing with case load has been established in earlier reports.

There has been continued stagnation of cases and lack of decrease in infections since July 2021 resulting from a release in susceptible population in many states. Our model indicates the population that was released as a result of removal of lockdown in June 2021. **The overall release fraction is roughly 39.5%** which, when considering the speed of vaccination, results in stagnation or very slow increase in number of cases. This is a percentage fraction of the population released into the susceptible set during the removal of lockdown in January. Table 1 shows the release in various states corresponding to possible non-compliance with mask mandates that impact viral transmission, leading to a much slower reduction in total number of cases or increase in some states. This will impact the growth of infections in the next few months.

The two scenarios considered as in the previous report are:

Scenario 1 (pessimistic scenario): The first scenario is when the next release is estimated from only the established baseline scenario. This guides the possible susceptible population in the next few months. The population that has already become part of the susceptible pool after the relaxation from lockdown is ignored. This method has been used to create the projections in previous analysis and accounts for the total population of the state.

This method indicates a substantial rise in infections when rules regarding lockdown are relaxed. Our results project that with an increased pace of release of population there would be increasing high case loads during October, November and December months. It is critical that utmost care be taken to ensure social distancing and mask usage, reduced capacity of interior locations and marketplaces, especially in restaurants and bars. Due to the current vaccination rates the reduction in case loads will be substantial when the removal from lockdown is slow and continuous measures are taken to ensure social distancing. **We project substantial advantages in a slow and measured removal of lockdown especially due to increased vaccination rates.**

- Reduction of 63.9% in total cases and 63.75% in total deaths in the case of release over 45 days instead of 30 days. The reduction in total cases is 9.8M, and deaths is 119,687. The anticipated number of cases after release on September 20th, 2021 are 15.32M and 5.53M while deaths are 187,717 and 68,031 for the 30 and 45 day release.

- In the case of a period of release (60 days) the improvements in cases and deaths are 81.04% and 79.81, respectively, as compared to a 30 day release. The reduction in total number of cases is 12.42M and deaths are reduced by 149,809. The anticipated number of cases are 2.9M and deaths are 37,908 for the release over 60 days.

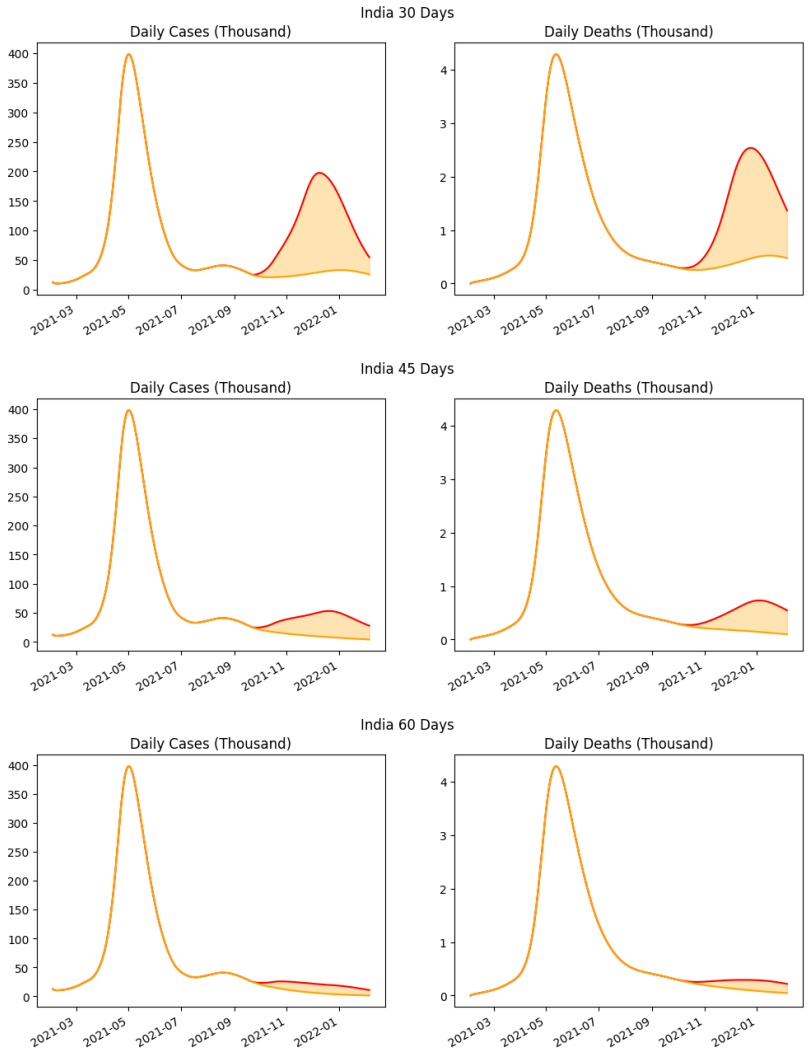


Figure 1: Comparison of three scenarios: releasing population from lockdown over 30, 45 and 60 days. Red indicates the worst case behavior (Scenario 1) and Orange indicate the optimistic Scenario 2. The shading in orange indicates a range of intermediate scenarios.

Further peaks can be progressively delayed and limited in size if social distancing measure are strictly followed as illustrated by the numbers above. Note that this does not account for any variants that can break-through the vaccine defense.

Scenario 2 (optimistic scenario): This scenario assumes that the susceptible that are added after relaxation of lockdown, but before the 14th August, were already exhibiting the baseline behaviour and are discounted from future release of population into the susceptible pool. This is an optimistic scenario.

The two scenarios are illustrated in Figure 1. The improvements due to slow and gradual removal of lockdown rules are substantial.

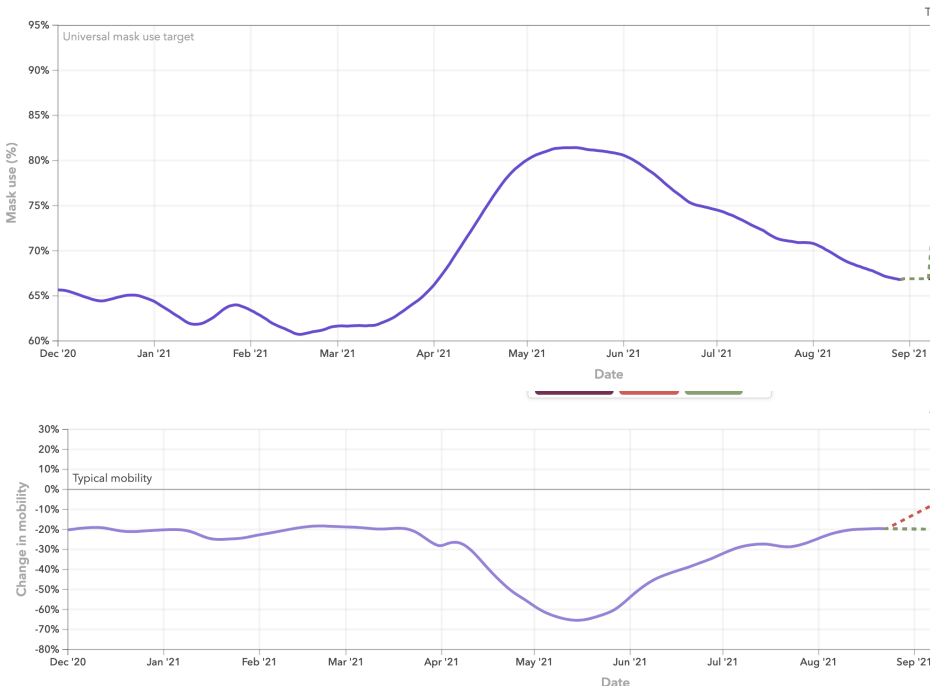


Figure 2: Mask Usage and mobility in India (source IHME). Mask usage has dropped by 15% points while social distancing has been almost fully reversed to pre-lockdown state.

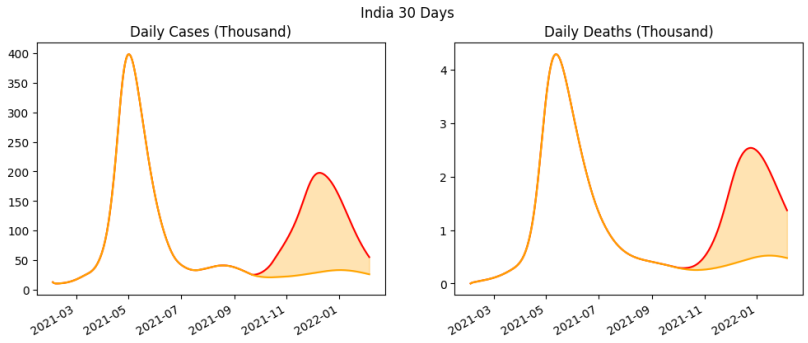
Comparison with previous projections

We emphasize that as compared with previous projections, the timing of the projected peak has shifted by almost a month. Figure 3 illustrates the shift in the number of cases for India when considering a 30 day quick release from lockdown.

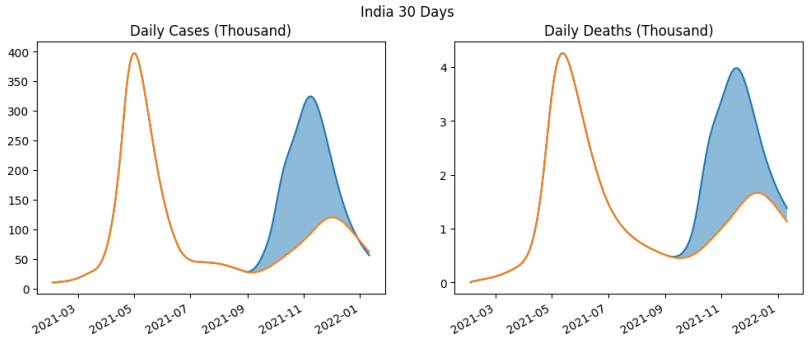
State wise changes in projections from August to September are illustrated in Figure 4. We illustrate changes for some of the populous or urbanized states and states that are undergoing high levels of infections currently. These include Delhi, Maharashtra, Uttar Pradesh, Kerala and Gujrat. In each of the cases there is a projected delay in the peak (for the case of 30 day release from lockdown) by about one month and importantly the number of cases at peak is reduced. **However, it is critical to note that a rise in cases is expected and should be guarded against.**

2 States with high estimates.

Our model as applied to the states indicated a number of high risk states. While these states are not immediately showing large cases, there are indications of growth in the number of infections. These include Chandigarh,Delhi, Gujarat, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Punjab,Tamil Nadu, Uttar Pradesh and Uttaranchal. The results are indicated in Figures 5,6,7.



(a) September Simulations



(b) August Simulations

Figure 3: Comparison of projections. The peak case load is now projected to be lower and delayed by almost a month

3 Appendix-1: State wise Analysis with increased vaccination rates

We present the improvements state-wise in the three scenarios, i.e. the release of population over 30, 45 and 60 days starting on September 20th, 2021. The tables illustrating the benefits follow (Table 2).

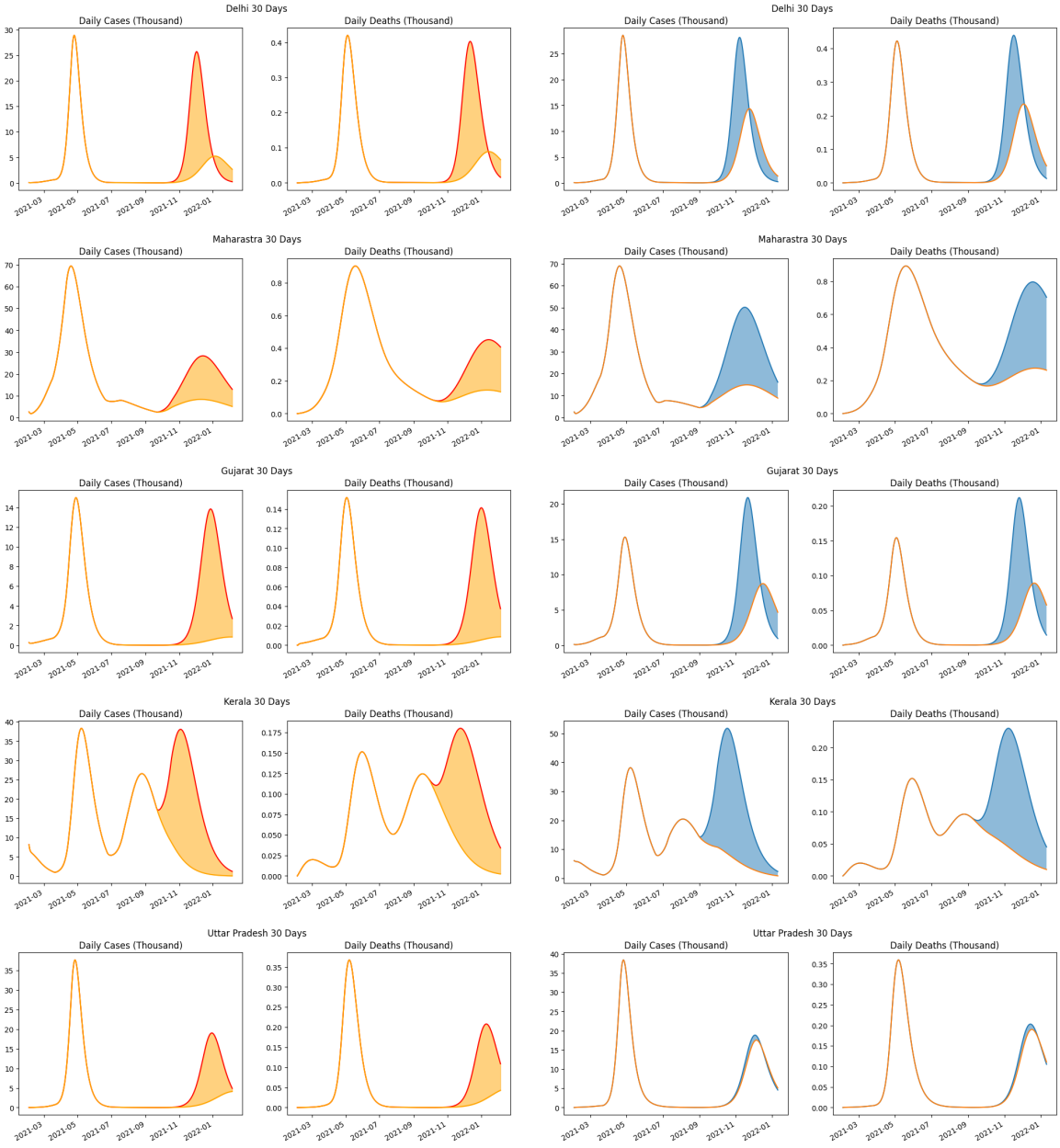


Figure 4: Comparison of projections: Peak of infections is delayed in September (orange) as compared to the August projections (blue) and is less in size (number of infections).

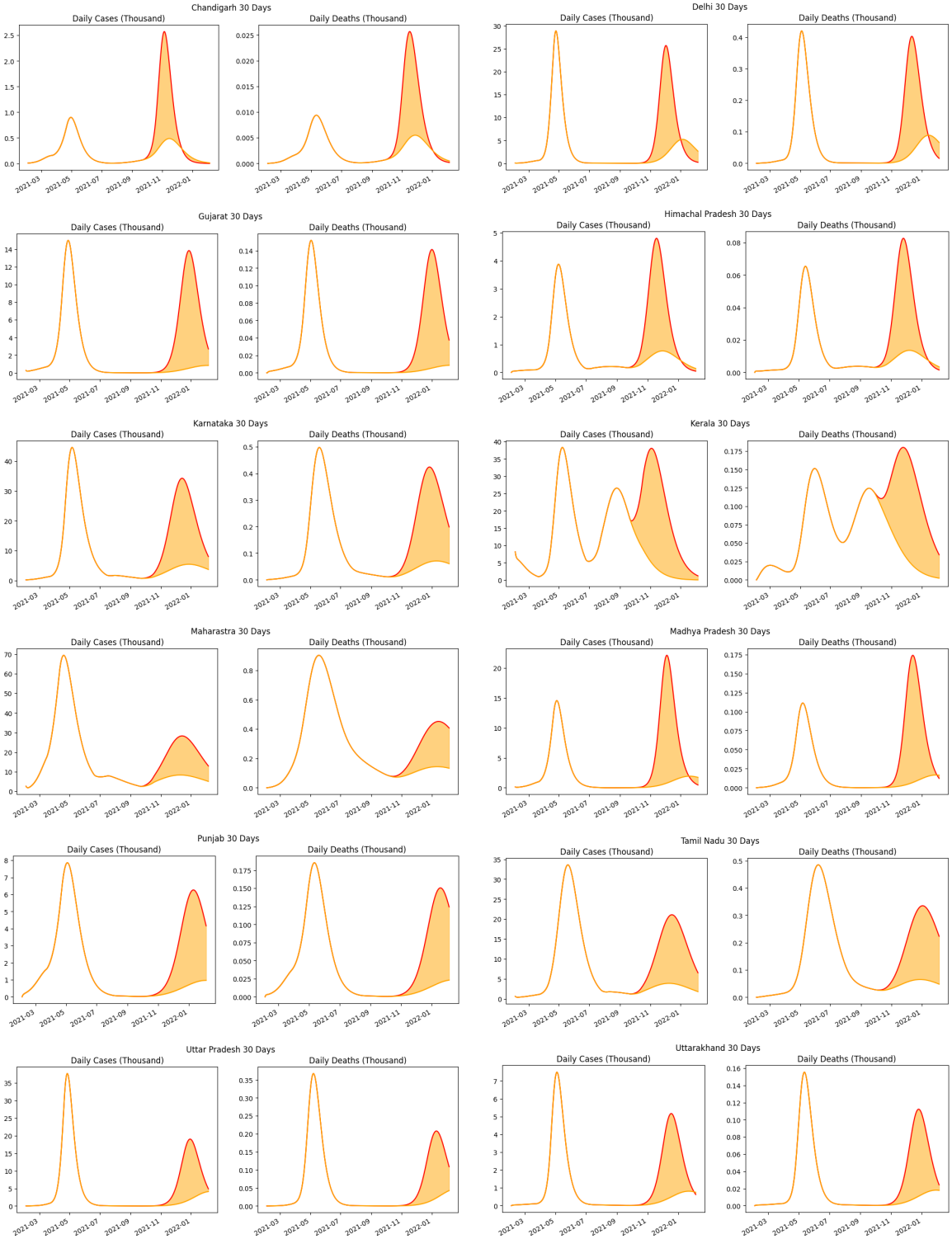


Figure 5: Projection with population release over 30 days

Figure 6: Projection with population release over 45 days

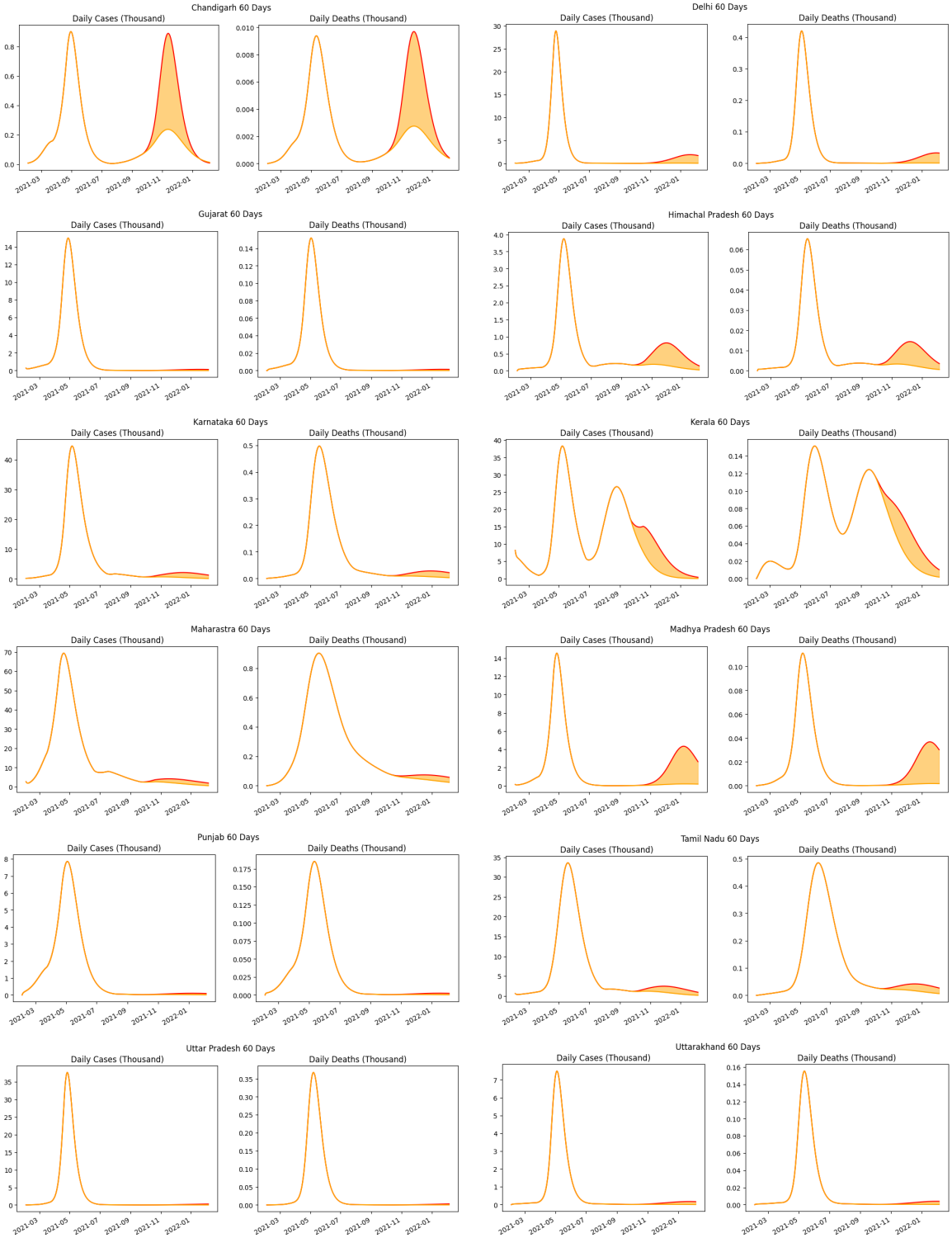


Figure 7: Projection with population release over 60 days

state	ratio	state	ratio
India	**39.35%**		
Andaman and Nicobar	68.62%	Lakshdweep	0.00%
Andhra Pradesh	38.57%	Madhya Pradesh	61.43%
Arunachal Pradesh	33.54%	Maharastra	32.89%
Assam	22.74%	Manipur	27.24%
Bihar	25.74%	Meghalaya	68.74%
Chandigarh	67.54%	Mizoram	117.78%
Chhattisgarh	24.82%	Nagaland	55.93%
Daman and Diu	0.00%	Odisha	9.05%
Delhi	39.23%	Puducherry	47.55%
Goa	41.86%	Punjab	29.83%
Gujarat	38.23%	Rajesthan	28.99%
Haryana	33.90%	Sikkim	17.56%
Himachal Pradesh	51.09%	Tamil Nadu	40.52%
Jammu and Kashmir	45.57%	Telangana	30.54%
Jharkhand	33.69%	Tripura	42.87%
Karnataka	37.54%	Uttar Pradesh	30.42%
Kerala	84.67%	Uttarakhand	36.51%
Ladakh	10.88%	West Bengal	44.76%

Table 1: Release ratios: Population release in second lockdown relaxation as a fraction of release in lockdown relaxation in February and March.

state	Improvement in Cases		Improvement in Deaths	
	45 Days	60 Days	45 Days	60 Days
India	**63.91%**	**81.04%**	**63.76%**	**79.81%**
Andaman and Nicobar	50.90%	67.91%	49.30%	64.99%
Andhra Pradesh	57.30%	70.48%	54.78%	67.55%
Arunachal Pradesh	29.68%	40.84%	28.05%	38.62%
Assam	42.24%	55.00%	39.83%	51.95%
Bihar	80.93%	89.19%	3.58%	4.05%
Chandigarh	32.97%	49.47%	32.92%	49.45%
Chhattisgarh	66.98%	77.85%	64.01%	74.61%
Daman and Diu	56.92%	70.82%	55.10%	68.73%
Delhi	56.48%	88.05%	59.87%	89.98%
Goa	59.01%	83.68%	59.88%	84.02%
Gujarat	88.20%	98.44%	89.04%	98.49%
Haryana	81.87%	96.97%	84.83%	97.27%
Himachal Pradesh	48.12%	70.85%	48.31%	70.94%
Jammu and Kashmir	56.89%	80.40%	57.84%	80.89%
Jharkhand	80.29%	89.52%	79.10%	88.48%
Karnataka	72.71%	90.12%	73.66%	89.65%
Kerala	43.45%	59.04%	35.12%	47.52%
Ladakh	90.69%	95.90%	75.64%	81.14%
Lakshdweep	42.83%	55.87%	31.11%	40.93%
Madhya Pradesh	45.11%	71.17%	48.10%	74.68%
Maharastra	64.25%	80.93%	57.41%	71.73%
Manipur	45.95%	60.60%	44.78%	59.09%
Meghalaya	74.76%	87.22%	73.48%	85.69%
Mizoram	15.20%	22.14%	8.19%	11.93%
Nagaland	60.22%	75.70%	57.28%	71.92%
Odisha	45.31%	58.81%	28.39%	37.23%
Puducherry	54.53%	77.18%	55.02%	77.38%
Punjab	88.52%	97.25%	88.78%	97.08%
Rajesthan	96.36%	99.50%	96.37%	99.43%
Sikkim	36.54%	49.40%	35.14%	47.55%
Tamil Nadu	67.30%	83.84%	65.62%	80.95%
Telangana	71.06%	86.76%	70.94%	86.36%
Tripura	73.44%	84.40%	68.90%	79.50%
Uttar Pradesh	87.08%	98.39%	89.63%	98.55%
Uttarakhand	75.70%	95.12%	78.14%	95.49%
West Bengal	60.40%	74.62%	58.43%	72.35%

Table 2: Improvement over 30-Day Release