

## Spread of Covid-19 in India: The Second Report [31.3.20; 12AM]

Jyotsna Jalan & Arijit Sen\*

The cut-off time for our First Report was 3 pm on 29 March 2020. Our Second Report studies the stock of Novel Coronavirus infections in India starting from that point in time up to 12 midnight on 31 March. In this 57-hour window, 583 new cases of Covid-19 had been recorded all over India. Of these, a total 76 new cases were recorded in 28 new districts that did not have any disease load at 3 pm on 29 March.

The following table – Table 2 – presents information on the distribution of the new as well as the cumulated Covid infection stock across different districts in India. [The new Covid-infected districts are underlined in Table 2.] In the table, columns 2–5 record the number of total / primary / secondary / tertiary new cases in the 57-hour window. Then, column 6 presents the total stock of Covid-19 cases in India till 12am on March 31, and column 7 specifies how many cases in this total stock were “transmitted” cases (i.e., either secondary or tertiary cases). [For the definitions of primary, secondary, and tertiary cases, and our transmission index, please see our First Report.]

We then calculated the “updated” transmission index  $T(2)$  by measuring the following ratio: (stock of transmitted cases till March 31, 12 mid-night)/(stock of total cases till March 31, 12 mid-night), and report its district-wise information in column 8. In the final column, we calculate – for only those 170 districts that were “initially affected” (on March 29) – the change in the transmission index  $T$  as follows:  $\{T(2) \text{ on March 31} - T(1) \text{ on March 29}\}$ .

**Table 2**

<u>STATE / Affected District</u>	<u>Increase in Total Cases</u>	<u>Increase in Primary Cases</u>	<u>Increase in Secondary Cases</u>	<u>Increase in Tertiary Cases</u>	<u>Stock of Total Cases</u>	<u>Stock of Transmitted Cases</u>	<u><math>T(2)</math></u>	<u>Change in <math>T</math></u>
<b>ANDHRA PRADESH</b>	<b>26</b>	<b>1</b>		<b>25</b>	<b>45</b>	<b>32</b>		
<u>Anantpur</u>	2			2	2		0.00	
<u>Chittoor</u>					1		0.00	
East Godavari	3	1		2	4	2	0.50	+ 0.50
Kurnool					1		0.00	0.00
Nellore					1		0.00	0.00
Prakasam	8			8	11	10	0.91	+ 0.24
Guntur	5			5	9	8	0.89	+ 0.14
Krishna	1			1	5	1	0.20	+ 0.20
Visakhapatnam	7			7	11	9	0.82	+ 0.32
<b>ASSAM</b>	<b>1</b>	<b>1</b>			<b>1</b>			
<u>Cachar</u>	1	1			1		0.00	
<b>BIHAR</b>	<b>10</b>	<b>5</b>		<b>5</b>	<b>21</b>	<b>11</b>		
<u>Gopalganj</u>	1	1			1		0.00	
<u>Gaya</u>	1			1	1	1	1.00	

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<u>STATE / Affected District</u>	<u>Increase in Total Cases</u>	<u>Increase in Primary Cases</u>	<u>Increase in Secondary Cases</u>	<u>Increase in Tertiary Cases</u>	<u>Stock of Total Cases</u>	<u>Stock of Transmitted Cases</u>	<u>T(2)</u>	<u>Change in T</u>
Nalanda					1		0.00	0.00
Siwan	4	4			5		0.00	0.00
Bhagalpur	4			4	6	6	1.00	0.00
Munger					3	2	0.67	0.00
Patna					4	2	0.50	0.00
<b>CHATTISGARH</b>	<b>2</b>	<b>2</b>			<b>9</b>	<b>1</b>		
Korba	1	1			1			
Bilaspur					1		0.00	0.00
Durg					1		0.00	0.00
Rajnandgaon					1		0.00	0.00
Raipur	1	1			5	1	0.20	- 0.05
<b>GOA</b>	<b>2</b>	<b>1</b>		<b>1</b>	<b>5</b>	<b>1</b>		
Goa	2	1		1	5	1	0.20	+ 0.20
<b>GUJARAT</b>	<b>16</b>	<b>1</b>		<b>15</b>	<b>74</b>	<b>52</b>		
Porbandar	1			1	1	1	1.00	
Gir Somnath	2			2	2	2	1.00	
Bhavnagar	5			5	6	6	1.00	0.00
Kutch					1		0.00	0.00
Mehsana					1		0.00	0.00
Surat	4			4	9	7	0.78	+ 0.18
Rajkot	1			1	9	6	0.67	+ 0.04
Gandhinagar					9	7	0.78	0.00
Vadodara					9	5	0.56	0.00
Ahmedabad	3	1		2	23	14	0.61	+ 0.01
<b>HARYANA</b>	<b>8</b>		<b>2</b>	<b>6</b>	<b>43</b>	<b>22</b>		
Hissar	1			1	1	1	1.00	
Sirsa	3		2	1	3	3	1.00	
Ambala					1		0.00	0.00
Palwal					1		0.00	0.00
Panchkula	1			1	2	2	1.00	0.00
Sonipat					1		0.00	0.00
Faridabad	3			3	6	5	0.83	+ 0.17
Panipat					4	3	0.75	0.00
Gurgaon					24	8	0.33	0.00
<b>HIMACHAL PRADESH</b>					<b>3</b>			
Kangra					3		0.00	0.00
<b>JHARKHAND</b>	<b>1</b>	<b>1</b>			<b>1</b>			
Ranchi	1	1			1		0.00	

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<b>KARNATAKA</b>	<b>20</b>	<b>5</b>	<b>7</b>	<b>8</b>	<b>101</b>	<b>44</b>		
Bellary	3		3		3	3	1.00	
Chitradurga					1		0.00	0.00
Dharwad					1		0.00	0.00
Kodagu					1		0.00	0.00
Tumakuru	1		1		2	1	0.50	+ 0.50
Udupi	2	1	1		3	1	0.33	+ 0.33
Davanagere					2	1	0.50	0.00
Kalaburagi	1		1		4	3	0.75	+ 0.08
Dakshina Kannada	1	1			7	1	0.14	- 0.02
Mysuru	6			6	14	12	0.86	+ 0.11
Uttara Kannada	1	1			9	4	0.44	- 0.06
Chikkaballapur	1			1	10	6	0.60	+ 0.04
Bangalore	4	2	1	1	44	12	0.27	+ 0.02
<b>KERALA</b>	<b>59</b>	<b>17</b>		<b>42</b>	<b>241</b>	<b>85</b>		
Wayanad	2			2	3	2	0.67	+ 0.67
Alappuzha					2		0.00	0.00
Kollam	1			1	3	2	0.67	+ 0.17
Idukki	2			2	5	3	0.60	+ 0.27
Kottayam					3	3	1.00	0.00
Palakkad	1	1			5	1	0.20	- 0.05
Kozhikode					6	1	0.17	0.00
Thrissur	2			2	8	5	0.63	+ 0.13
Thiruvananthapuram	3			3	10	5	0.50	0.21
Malappuram	1	1			10	1	0.10	- 0.01
Pathanamthitta					12	6	0.50	0.00
Ernakulam	1			1	20	5	0.25	+ 0.04
Kannur	20	8		12	45	12	0.27	+ 0.27
Kasaragod	26	7		19	109	39	0.36	+ 0.12
<b>MADHYA PRADESH</b>	<b>28</b>			<b>28</b>	<b>67</b>	<b>55</b>		
Gwalior	1			1	2	1	0.50	+ 0.50
Shivpuri					2		0.00	0.00
Bhopal	2			2	5	4	0.80	+ 0.13
Ujjain	1			1	5	4	0.80	+ 0.05
Jabalpur					8	2	0.25	0.00
Indore	24			24	44	43	0.98	+ 0.03
<b>MAHARASHTRA</b>	<b>117</b>			<b>117</b>	<b>309</b>	<b>245</b>		
Nasik	1			1	1	1	1.00	
Buldana	4			4	4	4	1.00	
Aurangabad					1		0.00	0.00

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Gondia					1		0.00	0.00
Jalgaon					1		0.00	0.00
Kolhapur	1			1	2	1	0.50	+ 0.50
Raigad					1		0.00	0.00
Ratnagiri					1		0.00	0.00
Sindhudurg					1	1	1.00	0.00
Ahmednagar	7			7	9	7	0.78	+ 0.78
Palghar					2	2	1.00	0.00
Satara					2	1	0.50	0.00
Yavatmal					4		0.00	0.00
Nagpur	4			4	16	14	0.88	+ 0.04
Thane	21			21	37	35	0.95	+ 0.07
Sangli					25	21	0.84	0.00
Pune	12			12	49	34	0.69	+ 0.10
Mumbai	67			67	152	124	0.82	+ 0.15
<b>MANIPUR</b>					<b>1</b>			
Imphal West					1		0.00	0.00
<b>MIZORAM</b>					<b>1</b>			
Aizawl					1		0.00	0.00
<b>ODISHA</b>	<b>1</b>	<b>1</b>			<b>4</b>	<b>1</b>		
<u>Bhadrak</u>	1	1			1		0.00	
Khordha					3	1	0.33	0.00
<b>PUNJAB</b>	<b>3**</b>			<b>3**</b>	<b>42</b>	<b>33</b>		
Ludhiana					1		0.00	0.00
Amritsar					2		0.00	0.00
Jalandhar					5	4	0.80	0.00
Hoshiarpur					6	6	1.00	0.00
Ajit Singh Nagar	1			1	7	5	0.71	+ 0.05
Bhagat Singh Nagar					19	16	0.84	0.00
<b>RAJASTHAN</b>	<b>37</b>	<b>19</b>	<b>13</b>	<b>5</b>	<b>93</b>	<b>60</b>		
<u>Jaisalmer</u>	10	10			10		0.00	
<u>Alwar</u>	1	1			1		0.00	
Ajmer	4		3	1	5	4	0.80	+ 0.80
Churu					1	1	1.00	0.00
Pali					1	1	1.00	0.00
Sikar					1	1	1.00	0.00
Dungarpur	1			1	3	3	1.00	0.00
Pratapgarh					2	2	1.00	0.00
Jodhpur	8	7		1	14	5	0.36	- 0.31

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Jhunjhunu	1	1			8	2	0.25	- 0.04
Jaipur	11		10	1	21	15	0.71	+ 0.31
Bhilwara	1			1	26	26	1.00	0.00
<b>TAMIL NADU</b>	<b>82</b>	<b>1</b>	<b>5</b>	<b>76</b>	<b>124</b>	<b>97</b>		
<u>Viluppuram</u>	3			3	3	3	1.00	
<u>Thiruvannamalai</u>	1			1	1	1	1.00	
<u>Thoothukkudi</u>	1			1	1	1	1.00	
<u>Namakkal</u>	18			18	18	18	1.00	
<u>Karur</u>	1	1			1		0.00	
<u>Kanyakumari</u>	5			5	5	5	1.00	
Coimbatore	4			4	5	4	0.80	+ 0.80
Kanchipuram					1		0.00	0.00
Tirupur					1		0.00	0.00
Tiruchirappalli					1		0.00	0.00
Tirunelveli	22			22	23	22	0.96	+ 0.96
Thanjavur					1		0.00	0.00
Virudhunagar					1	1	1.00	0.00
Vellore					2		0.00	0.00
Madurai	3		1	2	6	5	0.83	+ 0.17
Erode	14			14	19	17	0.89	+ 0.29
Salem					6	2	0.33	0.00
Chennai	10		4	6	29	18	0.62	+ 0.20
<b>TELENGANA</b>	<b>25**</b>			<b>25**</b>	<b>92</b>	<b>46</b>		
Mahbubnagar					1	1	1.00	0.00
Warangal					1	1	1.00	0.00
Karimnagar					3	1	0.33	0.00
B. Kothagudem					4	3	0.75	0.00
Medchal-Malkajgiri					4	3	0.75	0.00
Ranga Reddy					7	5	0.71	0.00
Hyderabad	15			15	51	21	0.41	+ 0.25
<b>UTTAR PRADESH</b>	<b>39**</b>	<b>1</b>	<b>7</b>	<b>31**</b>	<b>104</b>	<b>84</b>		
<u>Bareilly</u>	6	1	5		6	5	0.83	
Bagpat					1		0.00	0.00
Jaunpur					1		0.00	0.00
Kanpur Nagar					1		0.00	0.00
Lakhimpur Kheri					1	1	1.00	+ 1.00
Moradabad					1		0.00	0.00
Muzaffarnagar					2	2	1.00	0.00
Pilibhit					2	1	0.50	0.00
Varanasi					2	1	0.50	0.00
Ghaziabad					5	3	0.60	0.00

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Meerut					5	4	0.80	0.00
Lucknow					8	4	0.50	0.00
Agra					10	10	1.00	0.00
Gautam Buddh Nagar	8		2	6	34	28	0.82	+ 0.05
<b>UTTARAKHAND</b>	<b>1</b>			<b>1</b>	<b>6</b>	<b>1</b>		
Pauri Garhwal					2		0.00	0.00
Dehradun	1			1	4	1	0.25	+ 0.25
<b>WEST BENGAL</b>	<b>9</b>	<b>4</b>		<b>5</b>	<b>27</b>	<b>15</b>		
South 24 Parganas	1	1			1		0.00	
Purba Medinipur	1	1			1		0.00	
Haowrah	1	1			1		0.00	
Hoogly	1	1			1		0.00	
Kalimpong					1		0.00	0.00
North 24 Parganas	3			3	4	3	0.75	+ 0.75
Paschim Medinipur					2	2	1.00	0.00
Nadia					5	5	1.00	0.00
Kolkata	2			2	11	5	0.45	+ 0.12
<b>ANDAMAN NICOBAR</b>	<b>1</b>			<b>1</b>	<b>10</b>	<b>8</b>		
N & M Andaman					1		0.00	0.00
South Andaman	1			1	9	8	0.89	+ 0.01
<b>CHANDIGARH</b>	<b>7</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>15</b>	<b>10</b>		
Chandigarh	7	2	3	2	15	10	0.67	+ 0.04
<b>JAMMU &amp; KASHMIR</b>	<b>17**</b>			<b>17**</b>	<b>55</b>	<b>47</b>		
Shopian	2			2	2	2	1.00	
Baramulla					1		0.00	0.00
Badgam	1			1	3	3	1.00	0.00
Udhampur					2	2	1.00	+ 1.00
Rajouri					3	3	1.00	0.00
Jammu	3			3	9	7	0.78	+ 0.11
Bandipora	2			2	11	10	0.91	+ 0.02
Srinagar	5			5	20	16	0.80	+ 0.07
<b>LADAKH</b>					<b>13</b>	<b>8</b>		
Kargil					2	1	0.50	0.00
Leh					11	7	0.64	0.00
<b>DELHI</b>	<b>71</b>			<b>71</b>	<b>120</b>	<b>105</b>		
Delhi	71			71	120	105	0.88	+ 0.18

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<b>PUDUCHERRY</b>					<b>1</b>			
Puducherry					1		0.00	0.00
** In Table 2, district data for following new cases could not be ascertained: 10 cases in Telangana, 4 cases in Jammu and Kashmir, 2 cases in Punjab, and 25 cases in Uttar Pradesh. These cases have all been considered to be tertiary cases.								

We now record some of the salient information that can be gleaned from Table 2.

[1] Fortunately for India, there had been no real explosion of new cases in the 57-hour time interval between March 29 (3 pm) and March 31 (12 am). The total number of cases have grown by 55.8%, and beyond the 170 districts that were already affected, 28 new districts (containing 7% of India’s population) have been additionally affected – these districts contain 13% of the new cases.

[2] Of the 583 new cases, 11% are primary cases, 6% are secondary cases, and 83% are tertiary cases, implying the natural preponderance of “transmitted” cases over primary cases as time progresses. However, as the *number* of new cases is not very large, even at mid-night on March 31, the set of primary infections (most of which involved travel from abroad) still predict the total number of cases in a district to a significant extent. Specifically, correlation between the total and primary cases across all affected districts has indeed gone down from 0.87, but it is still high at 0.75.

[3] It is, however, important to note that 24% of all the 443 new tertiary cases in the 57-hour window have arisen from a *single source* – the gathering of the “Tablighi Jamaat” at the Nizamuddin Dargah in Delhi on the 13<sup>th</sup> of March. Over the last few days, the transmission of Covid-19 from this source (as people dispersed from the gathering and travelled to many parts of India) is causing disease propagation in many diverse districts (predominantly in south India). Our data till the mid-night of March 31 captures some of this disease spread, but it is possible that in the near future we will see that this one event has contaminated many new districts in India. It is mainly for this reason that we would like to temper the optimistic view that Covid-spread in India is still quite controllable (for a guardedly optimistic view along these lines, see “Did India overreact?” by N. Devadasan in *Scroll.in* (1.4.20) written using data till March 31) till we ascertain the full import of the “Nizamuddin transmission”.

[4] As of March 31 mid-night, the “regional bias” in the spread of Covid-19 (as discussed at length in our First Report) still holds up. In general, the western and the southern states bear the brunt of the attack. In particular, Kerala, Maharashtra, and Tamil Nadu contain a lion’s share of the disease burden. Specifically, (i) a significant proportion of the new disease spread is contained in the region that satisfies the following geographical property: it is to the west of 77.5E longitude (which passes through the eastern suburbs of Delhi), or it is to the south of the Vindhyas, or both; and (ii) 44% of the new cases have risen in Kerala, Maharashtra, and Tamil Nadu (Tamil Nadu is showing the initial impact of the “Nizamuddin transmission”).

Of course, to view the spatial aspects of Covid-spread we will be better served by studying the nature of disease propagation at the district-level, and that is what we turn to next. Figure 2.1 (overleaf) simply updates Figure 1 in our First Report, by colour-coding the various affected districts of India on the basis of the “updated” district-level transmission index  $T(2)$ .

**Figure 2.1**     :=  $T=0$ ;     :=  $T \in (0, 0.5]$ ;     :=  $T \in (0.5, 0.75]$      :=  $T \in (0.75, 1]$

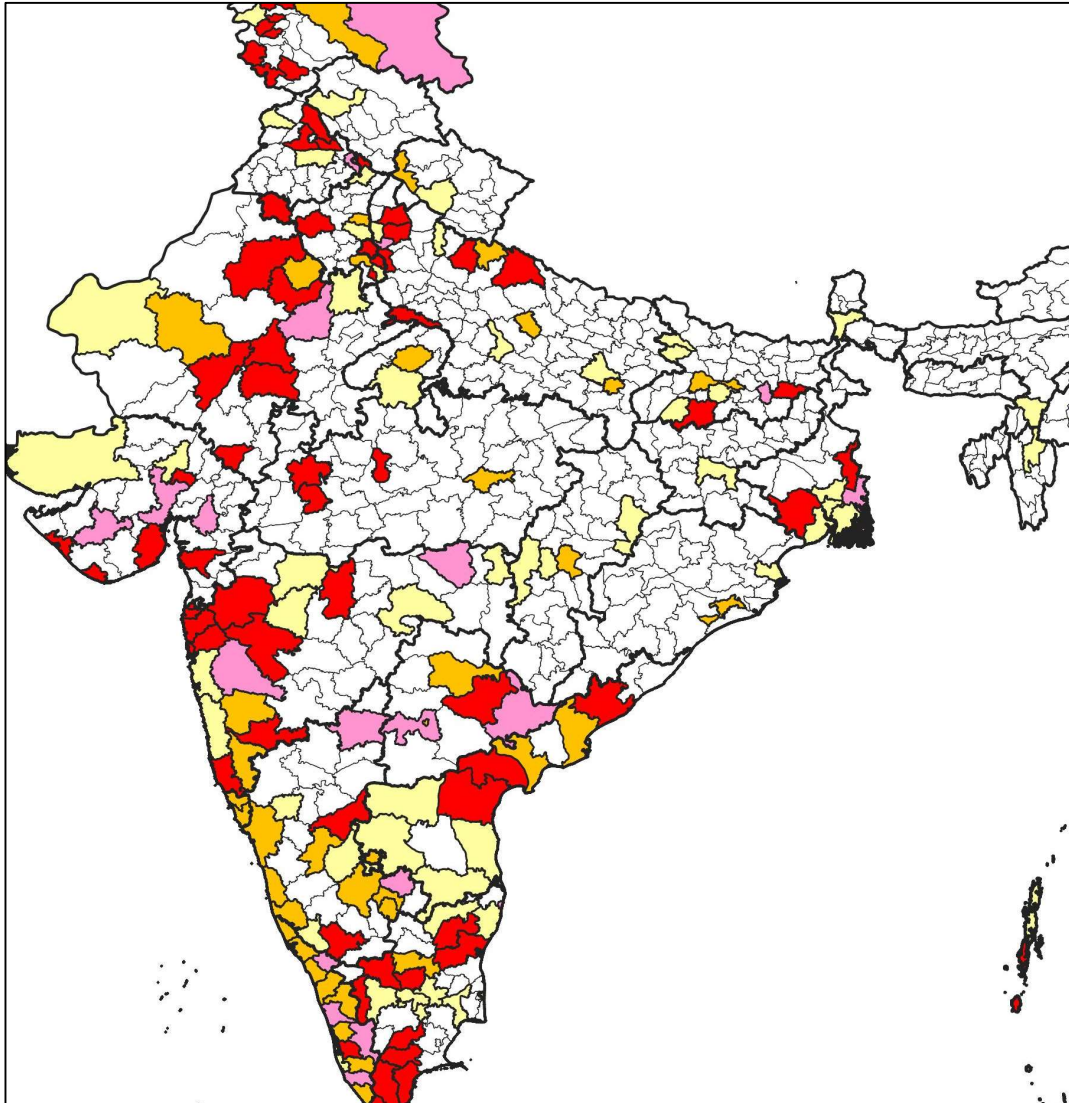


Figure 2.1 highlights the fact that disease-spread in the 57-hour period of our focus in this Second Report, the original disease clusters *have not been diluted* to any significant extent. In fact, the magnitudes of two correlation coefficients emphasize the persistence of the “affected district clusters”. Firstly, the district-level correlation between the “total stock of old cases” (as of 3pm on March 29) and the “total stock of new cases” (as on March 31, mid-night) is 0.73; this suggests that adverse initial conditions are indeed significantly associated with poor final conditions. Secondly, the district-level correlation between the “initial transmission index” (as of 3pm on March 29) and the “updated transmission index” (as on March 31, mid-night) is 0.87; this implies that greater initial local transmission of the disease persists in generating greater overall local transmission as determined at the final time-point of our current analysis.

Given these high district-level correlations, it is not surprising that the following features of local disease transmission continue to hold: (a) a large number of affected district clusters continue to exist in the western and southern parts of the country, and (b) districts containing/bordering the



large metropolitan areas of India are more significantly affected by Covid-19. [For context, please refer to our First Report.]

We also enquire into the “change” in the ratio of “transmitted cases” to “total cases” in every district over our 57-hour time horizon. This change is of course measured by the change ( $\Delta T$ ) in  $T$  (refer to the last column in Table 2). For all the districts in India that were initially affected (by 3pm on March 29), the following figure – Figure 2.2 – highlights the districts where the transmission ratio decreased ( $\Delta T$  was negative for 7 districts), districts where the transmission ratio remained unchanged ( $\Delta T$  was zero for 101 districts), districts where the transmission ratio decreased ( $\Delta T$  was greater than 0 and no greater than 0.5 for 40 districts), and districts where the transmission ratio increased significantly ( $\Delta T$  was greater than 0.5 for 22 districts).

**Figure 2.2** ■ :=  $\Delta T < 0$ ; ■ :=  $\Delta T = 0$ ; ■ :=  $\Delta T \in (0, 0.5]$  ■ :=  $\Delta T \in (0.5, 1]$

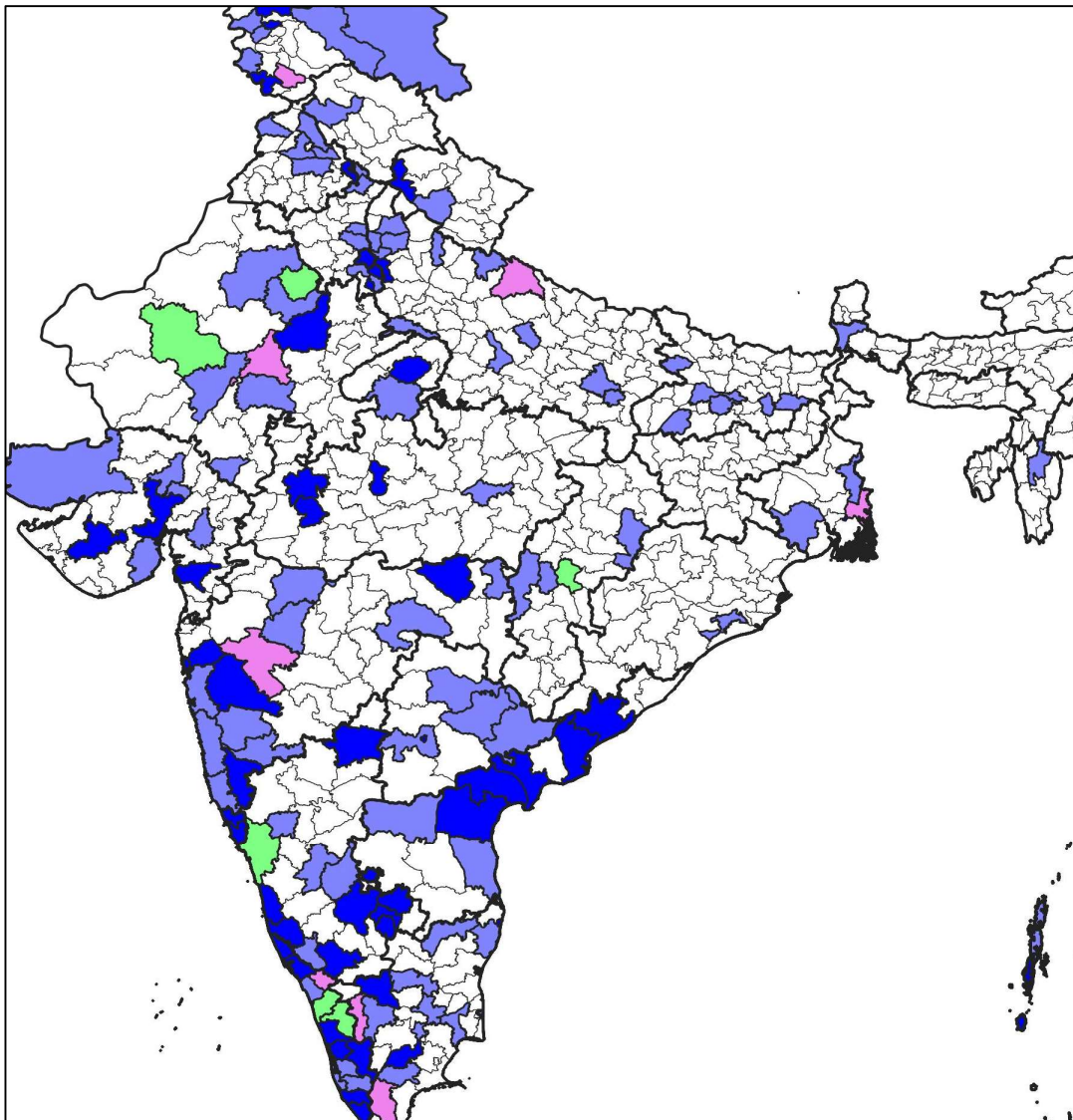


Table 2.2 lets us conclude the following: (i) In 83% of the initially affected districts, the disease transmission index either stayed unchanged or rose modestly in the 57-hour period under consideration; and (ii) in the top eleven metro-area district clusters of India (that we identified in our First Report) the transmission index necessarily increased, either modestly or significantly.

Summarizing our findings for the 57-hour period, we find that Covid-19 disease progression has not worsened alarmingly. Further, our completed analysis over two time instants do prod us to draw some tentative conclusions regarding appropriate public policy for disease control once the first sequence of country-wide lock-down is over on the 14<sup>th</sup> of April. In that respect, our thoughts are heavily influenced by the uneven-ness of Covid spread in India. Covid came to India on January 30, 2020, and at the end of the month of March the available data indicats that 538 districts of India – containing 57% of India’s population – remain Covid-free. Thus, as long as significant inter-district migration can be prevented, any public policy that considers further country-wide lock-down might justifiably be considered a “strategy of overkill”. Rather, lock-down of certain sets of districts for limited time-durations might make a lot of sense.

However, at this stage, we hold back on such policy advice for two important reasons. Firstly, the unanticipated disease-spread generated by the “Nizamuddin transmission” needs to play out, and we need to be assured that no other similar adverse event has taken place in India in the recent past. Secondly, we have to determine whether the movement of large numbers of migrant labour in India (consequent to the first lock-down announcement) does not generate its own disease-spread. We might be able to comment more concretely on each of these issues in our next report.

We conclude the current report by addressing an issue that is crucial to our entire exercise. How good/relaiable is the available data regarding the spread of Covid-19 in India? There are two aspects to this issue that need to be considered. The first is the obvious issue of errors in counting the number of people that have been tested and found to be Covid-positive. Here, the errors can be one of two types – non-counting of all the people who have tested positive, and/or multiple-counting of the people who have tested positive. Our careful anaysis of the raw data provided by [covid19india.org](http://covid19india.org) assures us that our errors in this regard will not be substantial (even though some will obviously exist).

But there is a second issue that is much more serious. *If not enough tests are being carried out in India*, then of course we are getting distorted information about the number of infected people in the different districts of India. To the extent that measuring disease-spread over time involves focusing more on the *changes in numbers rather than their absolute levels*, our within-state conclusions about disease propagation are likely to be reasonably robust as long as there is no systematic difference in testing strategies across districts in any particular state. But to the extent that our conclusion that 57% of Indians still reside in disease-free districts is one about *levels*, inadequate testing ceratinly becomes a significant issue. At this stage, we can only comment as follows regarding this issue: Covid-19 is expected to cause mild symptoms in about 80% of afflicted persons, and serious symptoms in about 20% of patients. If the Indian medical system is successful in indentifying almost all of the people who develop serious symptoms of the disease, then we can claim that our analysis is approximately valid for the “severely-infected Covid patients”. This, of course, is a disquieting topic that presents no easy resolution. We remain cognizant, and will return to discussing this issue in our subsequent reports.