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Burden of COVID-19 Pandemic in India: Perspectives from Health Infrastructure

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Abstract: The novel coronavirus (COVID-19) is spreading rapidly across the country but India's testing regime is far from the global standards. It is important to identify the states where testing needs expansion and the magnitudes of active COVID-19 cases are higher focusing on current health infrastructure to meet the pandemic. The data on COVID-19 was extracted from the Application Programming Interface. Test positive rate, test per confirmed case, recovery rate, case fatality rate were computed. The result revealed that, Maharashtra constitutes more than one-third positive cases in the country. More than a quarter of the active cases in India belonged to the Mumbai district of Maharashtra, followed by the Chennai district (9.4%) and Ahmedabad district (9.1%). Further, about 40 percent of the active cases in India belonged to the 11 districts of Maharashtra. The increased test positive rate in Maharashtra and Gujarat to almost double in last one month is a concern. In order to bring the states and the country in right track, the test positive rate need to be brought down to below 2 percent. The priority should be laid on expansion of more laboratories and hospitals, storage of PPE kit, testing kit, and indigenously developed vaccines.

Keywords: COVID-19, Recovery rate, Fatality rate, Health infrastructure, India.

Introduction

The novel coronavirus (COVID-19) is an infectious disease which is spreading rapidly, and scientists are endeavouring to discover drugs for its efficacious treatment in the world (Gao et al., 2020). The infected individual experiences symptoms varying from mild to moderate respiratory illness, high fever, sore throat, nasal congestion, malaise, headache, muscle pain etc. (Cascella et al., 2020). Older people, suffering from medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer, are more likely to develop severe illness (Remuzzi and Remuzzi, 2020; Singhal, 2020). Currently, there are no specific vaccines or drugs for COVID-19 (Singh et al., 2020). Studies suggest that isolating the infected individual is the best way to contain this pandemic (Cascella et al., 2020). Thus, countries are racing to reduce the spread of the virus by treating and testing patients, limiting travel, carrying out contact tracing, quarantining citizens, and cancelling large gatherings such as sporting events, concerts, and schools (United Nation Development Programme).

The first case of the COVID-19 disease was noted on December, 2019, linked to direct exposure to the Huanan seafood wholesale market of Wuhan, China (Velavan, and Meyer, 2020). On January 30, the World Health Organisation (WHO) declared COVID-19 situation as a Public Health Emergency of International Concern (Kannan et al. 2020). India

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has reported 95676 confirmed COVID-19 cases on May 17, 2020. India closed its international borders and had enforced an immediate lockdown on March 24, 2020, for 21 days initially which got further extended till May 31, 2020, which WHO praised as 'tough and timely'. The government demarcated 130 districts as red zones (Hotspot area), 284 districts as orange zones, and 319 districts as green zones, on May 1, 2020. The list identifies all 11 regions of Delhi as red zones. Other metropolitan cities, including Mumbai, Bengaluru, Hyderabad, Chennai, and Kolkata have also been designated as red zones (Nair, 2020).

As the number of COVID-19 positive case is increasing day by day, the study on test rate is important. If a country has fewer cases than expected, it could be either because the country did a good job to combat against the virus or the country is not testing for the virus well enough. The testing facility is not the same across the states and union territories. Rajasthan, the largest state in terms of the area, has the same number (eight) of testing labs at the city of Chennai, and that is just double in India's most densely populated state of Bihar. Maharashtra has the highest testing centres and the maximum number of COVID-19 cases, on the other, Nagaland has no testing centre and no reported case (Banerjee, 2020). West Bengal experienced the highest death rate from COVID-19, along with the lower testing than major states in India (Basu, 2020b). The reported cases (confirmed, active, recovery and death) differ across the states because of the wide variation in the testing centres. The number of testing indicates, some states are farther behind in getting a sense of the outbreak than others (Chauhan and Kawoosa, 2020). India's testing regime is far from the global standards (Basu, 2020a).

The state governments began taking more swab samples, without realizing the limited capacity of laboratories in the states. Many states have sent samples to laboratories outside the state to get faster test results (Thakur et al., 2020). That is why there is a need to study the current trend in the testing, recovery rates, and fatality rates. Study on active case is important as they really need access to health care. Because of geographical and socio-economic diversity in the country, there is a wide variation in health infrastructure. Preparedness and response to COVID-19 is not same at the state level. Health inequalities, widening economic and social disparities, and distinct cultural values in India, present unique challenges. In India, however, the public health system already overburdened with various Communicable and Non-communicable diseases. The implementation of the public health measures to handle the pandemic is difficult in places with inadequate hygiene and sanitation and overcrowded living conditions. Thus the study on current health infrastructure is important to meet the pandemic. With this background, the specific objectives of the study are as follows:

1. To identify the states where the testing need to be expanded.
2. To study the change in recovery and fatality rate and to identify the areas where the magnitude of active COVID-19 cases are higher.
3. To link the availability of health infrastructure with COVID-19 positive cases.

Data and Methods

The COVID-19 related information is taken from the Application Programming Interface (API, https://api.Covid19india.org/csv/) a data-sharing portal that provides the most updated information on the daily and total confirmed cases, active cases, recovered cases, and deaths for each affected states/Union Territories. The data on number of government hospital and hospital beds are obtained from National Health Profile (2019). The estimated number of private hospital, private hospital beds and intensive care unit (ICU) beds and ventilators are taken from a report of The Center for Disease Dynamics, Economics and Policy (Kapoor et

al., 2020). The projected population of 2020 data is obtained from the Report of the Technical Group on Population Projection (RGI, 2019).

The analysis in the study is performed upto the end of Lockdown 3, i.e., 17th May, 2020. The phases were upto the end of 1st Lockdown i.e., 14th April 2020; upto the 2nd Lockdown (3rd May 2020); and finally upto the 3rd Lockdown (17th May, 2020). The test positivity rate is defined as the proportion positive cases per 100 persons tested. Test per confirmed case is defined as the number of tests performed per positive case. Tests per million population are also calculated. Further, recovery rate, case fatality rate, active rate and percent distribution of active cases of COVID-19 in different phases are also computed. Recovery rate is the number of number of recovered cases per 100 positive cases while Case fatality rate is the number of deaths per 100 infected cases. Active rate is defined as the number of currently active cases per 100 positive cases. The hotspot zones of confirmed positive cases in the districts are identified using the GIS software. Availability of hospitals, hospital beds, intensive care unit (ICU) beds and ventilators per lakh population is also computed by public, private and total.

Results

COVID-19 Testing in India and states:

Table 1 presents the scenario of COVID-19 testing till 17th May, 2020, for states of India. Results show that, till 17th May, a total of 2457651 individuals were tested for COVID-19 in India, out of which 95676 individuals were tested positive. The total number of active cases as on 17th May was reported as 55868. Tamil Nadu followed by Andhra Pradesh, Maharashtra, Rajasthan and Uttar Pradesh recorded the highest number of individuals tested for COVID-19 with Maharashtra having the highest number of positive cases followed by Gujarat and Tamil Nadu. It is clear that, in India, about 1824 individuals were tested per million populations varying from 377 individuals in Bihar to 6725 in Delhi. Further, Maharashtra, followed by Tamil Nadu, Gujarat, Delhi, and Madhya Pradesh, were the states with the highest number of active cases as on 17th May. The test positivity rate in India was 3.9 percent, and it varied largely across the states of India, varying from 12.1 percent in Maharashtra to 0.7 percent in Jharkhand. The test positivity rate was higher than the national average in six states, namely Maharashtra (12.1%), Gujarat (7.9%), Delhi (7.2%), Chandigarh (6.8%), Telangana (6.6%) and Madhya Pradesh (4.8%). The test per confirmed cases in India was estimated as 26, and wide variation was observed across the states varying from 8 in Maharashtra to 149 in Jharkhand. While the test per confirmed cases in most of the states was higher than the national average, it was lower in six states namely Maharashtra (8), Gujarat (14), Delhi (13), Chandigarh (15), Telangana (15) and Madhya Pradesh (21). Thus looking at the testing and positive cases, states, namely Kerala, Karnataka, Andhra Pradesh, Odisha, Jharkhand, and Haryana, are doing better than the other states in terms of testing COVID-19. On the other hand, states which have a higher proportion of positive cases, i.e., Maharashtra, Gujarat, Delhi, and Madhya Pradesh, testing seems to be much lower. Maharashtra constitutes more than one-third positive cases in the country, but the test per confirmed cases (8) is much lower than the other states. Similarly, Gujarat and Delhi each constitute little more than 10 percent of positive cases in the country, but the test per confirmed cases is 13 and 14, respectively. Thus it clearly indicates that there is an urgent need to increase the COVID-19 testing centers in these states.

Table 1: Test Positive Rate, Tests per confirmed case, Tests per million population by State, India as on May 17, 2020

State	Projected Population (in 000) as on March 31 2020	Total Tested	Total Positive Cases	Recovered Cases	Deceased Cases	Active Cases	Test positivity rate	Tests Per Confirmed Case	Tests per million population
Maharashtra	123295	274040	33053	7688	1197	24168	12.1	8	2223
Tamil Nadu	76049	326720	11224	4172	79	6973	3.4	29	4296
Gujarat	68862	143600	11380	4499	659	6222	7.9	13	2085
Delhi	20193	135791	9755	4202	148	5405	7.2	14	6725
Madhya Pradesh	83374	103898	4977	2403	249	2325	4.8	21	1246
Rajasthan	78273	231946	5202	3045	131	2026	2.2	45	2963
Uttar Pradesh	227943	172219	4464	2636	112	1716	2.6	39	756
West Bengal	97516	85956	2677	959	238	1480	3.1	32	881
Andhra Pradesh	52504	238998	2362	1456	50	856	1.0	101	4552
Bihar	121302	45729	1320	473	8	839	2.9	35	377
Odisha	43852	91223	828	220	4	604	0.9	110	2080
Karnataka	66322	145398	1147	509	37	601	0.8	127	2192
Jammu and Kashmir	13305	80934	1183	575	13	595	1.5	68	6083
Punjab	30099	51812	1964	1366	35	563	3.8	26	1721
Telangana	37473	23388	1551	992	34	525	6.6	15	624
Haryana	29077	78029	910	561	14	335	1.2	86	2684
Chandigarh	1193	2812	191	51	3	137	6.8	15	2357
Jharkhand	37937	33220	223	113	3	107	0.7	149	876
Kerala	35307	45027	602	497	4	101	1.3	75	1275
Tripura	4032	13750	164	85	0	79	1.2	84	3410
Rest of India	99826	133161	500	283	6	211	0.4	266	1334
India	**1347734**	**2457651**	**95676**	**36785**	**3023**	**55868**	**3.9**	**26**	**1824**

Figure 1: Change in the Test Positive rate of COVID-19

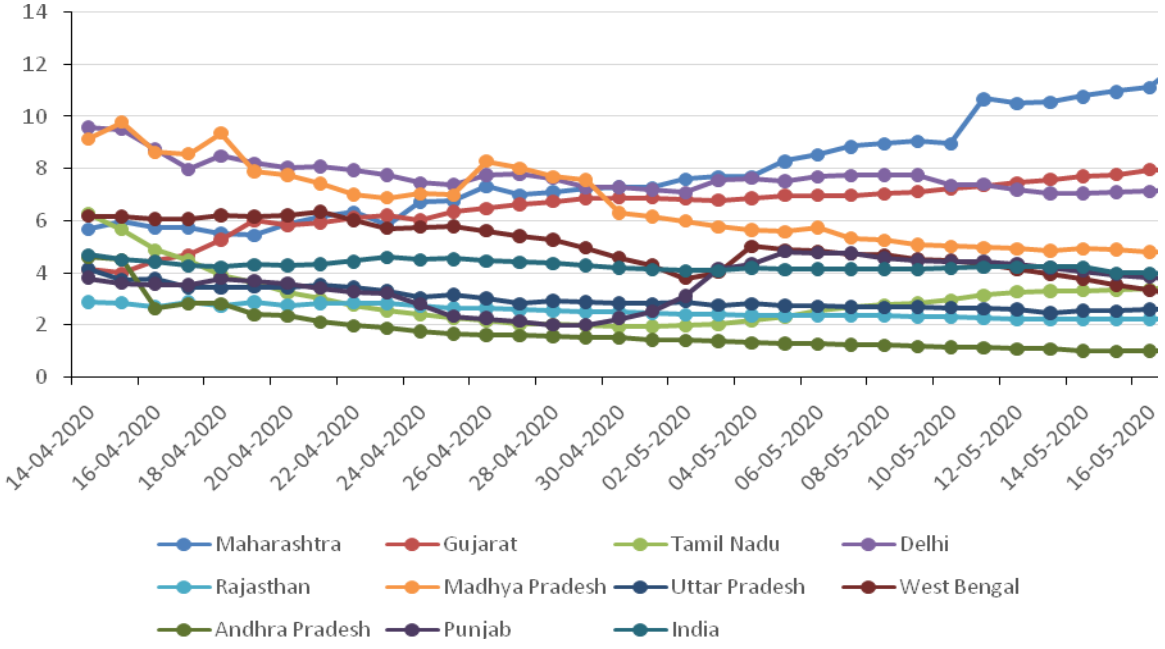
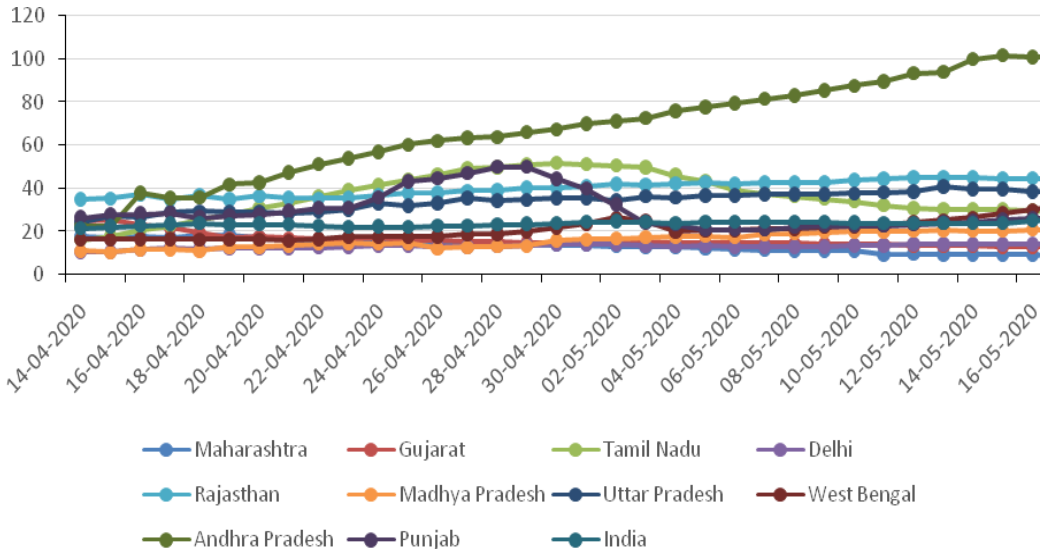


Figure 2: Change in Tests per Confirmed Case of COVID-19



The test positivity rate in India varied from 4.7 percent on April 14 to 3.9 percent on May 17 (Figure 1). A large variation in test positivity rate was observed across the selected states of India. While the test positivity rate has increased in the states of Maharashtra, Gujarat, and Punjab during this period, the rate declined in case of remaining states. The increase in test positivity rate was highest in Maharashtra (6.4%) followed by Gujarat (3.8%) whereas the decline was highest in Madhya Pradesh (4.3%) followed by Andhra Pradesh (3.5%), West Bengal (3.1%) and Tamil Nadu (2.9%). The decline in test positivity rate remained low in case Uttar Pradesh (0.7%), Rajasthan (0.6%), and Delhi (0.6%). In India, the test per confirmed cases increased by five individuals from 21 on April 14 to 26 on May 17 (Figure 2). The test per confirmed cases declined in the case of Maharashtra and Gujarat while it remained the same in the case of Punjab. While the test per confirmed cases declined by seven individuals in Maharashtra and four individuals in Gujarat, it increased by 75 individuals in Andhra Pradesh, 15 individuals in West Bengal, 13 individuals in Tami Nadu, ten individuals in Madhya Pradesh and Rajasthan, six individuals in Uttar Pradesh and four individuals in Delhi.

Change in recovery, fatality rate, and the hotspot areas

The recovery rate in India has increased substantially by 26.5 percent point from 11.9 percent on April 14 to 38.4 percent on May 17 (Figure 3). All the selected states exhibited an increase in recovery rate during this period; however, wide variation across states was observed. Andhra Pradesh, Punjab, and Uttar Pradesh showed a change in recovery rate of more than fifty percent. The change in recovery rate was highest in Andhra Pradesh (58.3%), followed by Punjab (54.9%), Tripura (51.8%), Uttar Pradesh (51.5%), Rajasthan (43.9%), Delhi (41.1%) and Madhya Pradesh (39.6%) while the changes were lowest in case Maharashtra (12.2%) followed by West Bengal (16.9%), Gujarat (30 %) and Tamil Nadu (30.5%).

The case fatality rate of COVID-19 in India has declined by 0.2 percent from 3.4 percent on April 14 to 3.2 percent on May 17 in India (Figure 4). While the change in case fatality rate was negative in the state of Punjab, Maharashtra, Tamil Nadu, Madhya Pradesh, Andhra Pradesh, and Delhi, it was positive in case of West Bengal, Rajasthan, Gujarat, and Uttar Pradesh. The negative change in case fatality rate highest in the case of Punjab (5.3%),

followed by Maharashtra (3.9%) and Madhya Pradesh (2.3%). In contrast, the positive change in case fatality rate was highest in West Bengal (5.2%) followed by Rajasthan (1.4%), Gujarat (1.3%) and Uttar Pradesh (1.3%).

Figure 3: Change in recovery rate of COVID-19 by most affected states of India

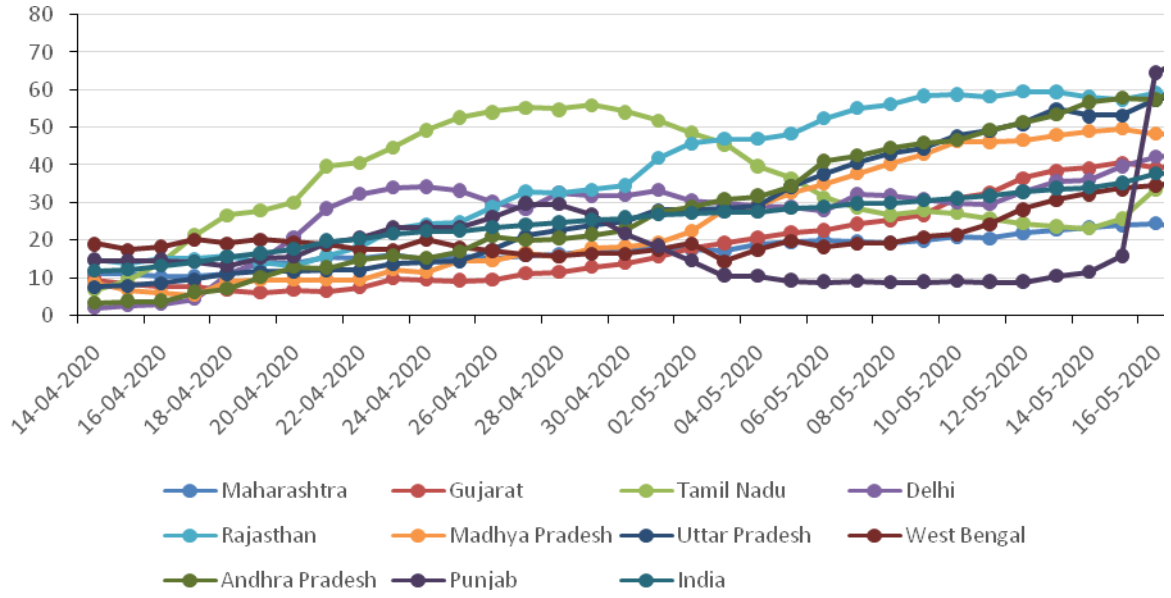
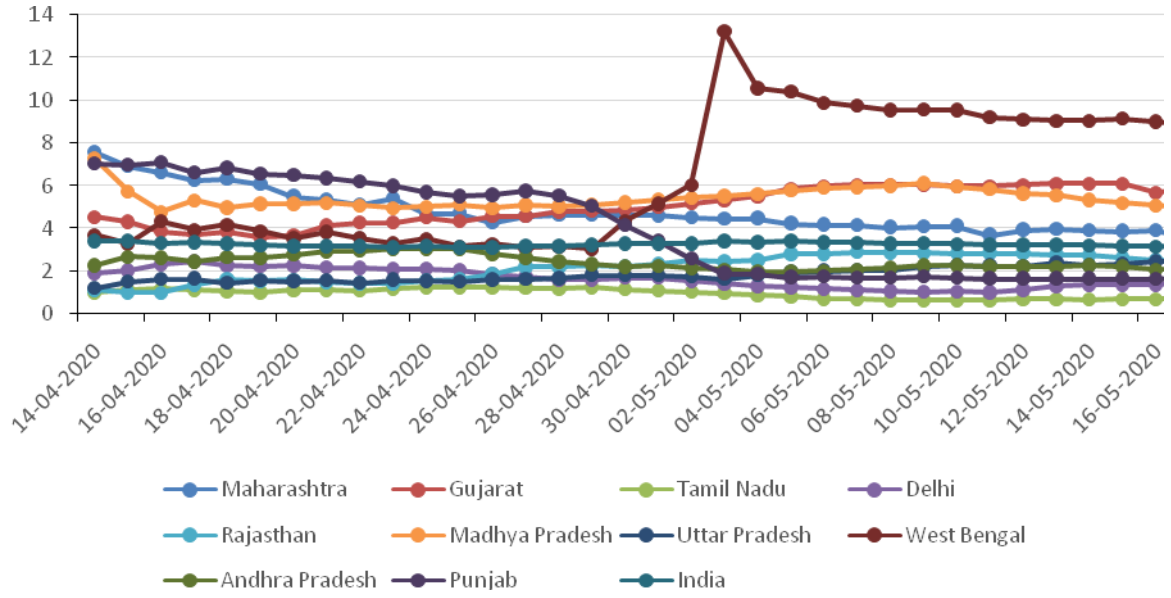


Figure 4: Change in fatality rate of COVID-19 by most affected states of India



The recovery rate of COVID-19 in India was 38.4, while the case fatality rate was 3.2 percent and exhibited wide variation across selected states (Table 2). The recovery rate was highest in Kerala (82.6%), followed by Punjab, Telangana, Andhra Pradesh, and Haryana, while it was more than fifty percent in the states of Uttar Pradesh, Rajasthan, Tripura, and Jharkhand. Further, the recovery rate was lowest in Maharashtra (23.1%), followed by Odisha, Chandigarh. The case fatality of COVID-19 was highest in West Bengal (8.9%), followed by Gujarat (5.8%) and Madhya Pradesh (5%) while it was lowest in Tripura, Odisha, Bihar, Tamil Nadu, and Kerala. More than three-quarters of the active cases

belonged to the state of Maharashtra (4.3.3%), Tamil Nadu (12.5%), Gujarat (11.1), and Delhi (9.7%).

Table 2: Change in the Recovery Rate, Case Fatality Rate and Active Rate by State, India

States	Recovery Rate			Case Fatality Rate			Active Rate			Percent Distribution of Active Cases		
	14th April	3rd May	17th May	14th April	3rd May	17th May	14th April	3rd May	17th May	14th April	3rd May	17th May
Maharashtra	11.1	16.3	23.3	7.6	4.2	3.6	83.7	79.5	73.1	23.1	34.9	43.3
Tamil Nadu	6.7	45.6	37.2	1	1	0.7	92.3	53.4	62.1	11.4	5.5	12.5
Gujarat	9.6	19.2	39.5	4.5	5.3	5.8	86.6	75.5	54.7	5.8	13.9	11.1
Delhi	2	29.9	43.1	1.9	1.4	1.5	96.1	68.7	55.4	15.4	10.6	9.7
Madhya Pradesh	8.6	28.1	48.3	7.3	5.5	5	84.1	66.3	46.7	6.4	6.4	4.2
Rajasthan	14.6	47	58.5	1.1	2.5	2.5	84.3	50.6	38.9	8.7	4.9	3.6
Uttar Pradesh	7.6	28.5	59.1	1.2	1.6	2.5	91.2	69.9	38.4	6.2	6.3	3.1
West Bengal	18.9	11	35.8	3.7	10.2	8.9	77.4	78.8	55.3	1.5	3.2	2.6
Andhra Pradesh	3.3	30.8	61.6	2.3	2.1	2.1	94.4	67.1	36.2	4.7	3.6	1.5
Bihar	46.8	24	35.8	1.6	0.8	0.6	54.5	75.2	63.6	0.4	1.3	1.5
Odisha	32.1	37	26.6	1.8	0.6	0.5	68.3	62.3	72.9	0.4	0.3	1.1
Karnataka	27.3	47.7	44.4	3.8	4.1	3.2	68.8	48.2	52.4	1.8	1.0	1.1
Jammu and Kashmir	10.8	40.9	48.6	1.4	1.1	1.1	87.8	57.9	50.3	2.5	1.4	1.1
Punjab	14.7	10.6	69.6	7.1	1.9	1.8	78.3	87.5	28.7	1.5	3.3	1.0
Telangana	12.8	50.4	64	2.1	2.7	2.2	80.1	47	33.8	5.3	1.7	0.9
Haryana	29.3	55.2	61.6	1.5	1.1	1.5	71.2	43.7	36.8	1.5	0.7	0.6
Chandigarh	33.3	19.6	26.8	0	1	1.6	66.7	79.4	71.6	0.1	0.3	0.2
Jharkhand	0	23.5	50.7	7.4	2.6	1.3	92.6	73.9	48	0.3	0.3	0.2
Kerala	54.5	80.2	82.6	0.8	0.8	0.7	44.7	19	16.8	1.8	0.3	0.2
Tripura	0	12.5	51.8	0	0	0	100	87.5	48.2	0.0	0.0	0.1
Rest of India	35.5	71	56.6	1.6	1.6	1.2	62.8	27.4	42.2	1.2	0.3	0.4
India	**11.9**	**27.5**	**38.4**	**3.4**	**3.4**	**3.2**	**84.7**	**69.1**	**58.4**	**100.0**	**100.0**	**100.0**

The recovery rate in India by the end of 1st lockdown was 11.9 percent, which increased to 27.5 percent at the end of 2nd lockdown and 38.4 percent by the end of 3rd lockdown showing a positive change of 15.6 percent during 2nd lockdown phase and 10.9 percent during 3rd lockdown phase. On the contrary, the case fatality rate showed no change during the 2nd lockdown phase while negative change of 0.2 percent point by the end of 3rd lockdown phase. Similarly, the proportion of active cases has declined by 15.6 percent and 10.9 percent by the end of second and third lockdown, respectively. The recovery rate was highest in Tamil Nadu (38.9%), followed by Telangana (35.5%) and Rajasthan (33.3%), while it was lowest in Maharashtra (6.6%) followed by Odisha (7.0%) and Gujarat (10.1%) during the 2nd lockdown phase. Further, negative growth in recovery rate was observed in Bihar (19.9%), Chandigarh (13.7%), West Bengal (7.9%) and Punjab (4.1%). By the end of the 3rd phase of lockdown, Punjab (59%) followed by Tripura (39.3%) and Andhra Pradesh (30.8%) recorded the higher recovery rate while Kerala (2.4%) followed by Haryana (6.4%) and Maharashtra (7%) had the lower recovery rate. During a similar phase, negative growth in recovery rate was observed in Odisha (10.4%), Tamil Nadu (8.4%) and Karnataka (3.3%). In case of case fatality rate, during 2nd lockdown phase, West Bengal (6.5%) followed by Rajasthan (1.4%), Gujarat (1%), Chandigarh (1%), Uttar Pradesh (0.4%) and Karnataka (0.3%) had positive case fatality rate while negative or no growth was observed in remaining states. Punjab (5.2%) recorded the highest decline in case fatality rate followed by Jharkhand (4.8%) and Maharashtra (2.4%). During 3rd phase of lockdown, while the state of Uttar Pradesh (0.9%), Chandigarh (0.6%), Gujarat (0.5%), Haryana (0.4%) and Delhi (0.1%) recorded positive growth in case fatality rate, negative or no growth was observed in the remaining states with Jharkhand (1.3%) followed by West Bengal (1.3%) and Maharashtra

(0.9%) recording the highest negative growth. During 2nd phase of lockdown, the active number of cases increased by 20.7 percent in Bihar followed by Chandigarh (12.7%), Punjab (9.2%) and West Bengal (1.4%), negative growth was observed in remaining states with the highest decline in active cases observed in Tamil Nadu (38.9%) followed by Rajasthan (33.7%) and Telangana (33.1%). During the 3rd phase, while Odisha, Tamil Nadu, and Karnataka observed a surge in the active number of cases, remaining states observed a decline in active cases. The decline in active rate was highest in Punjab (58.8%), followed by Tripura (39.3%) and Uttar Pradesh (31.5%).

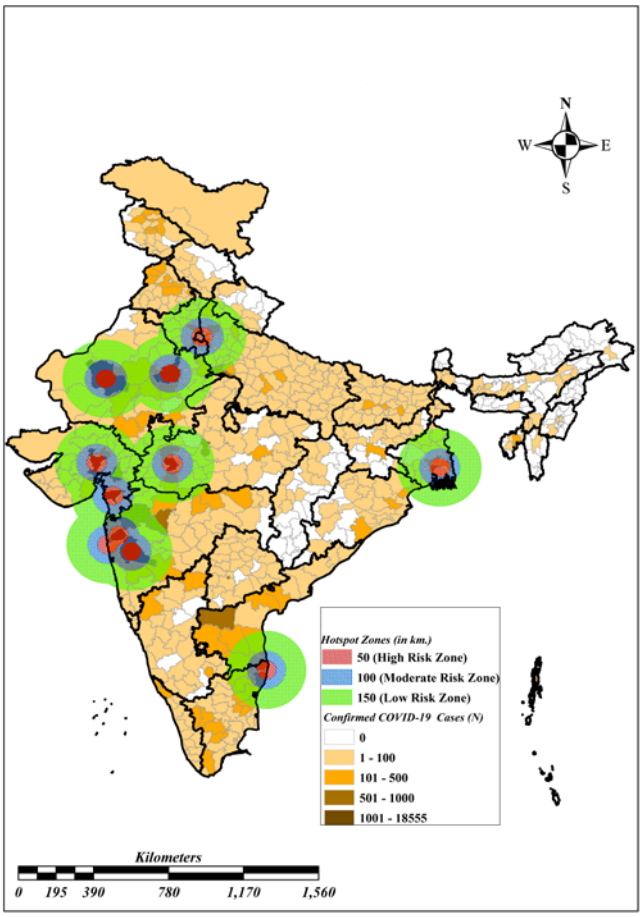
Table 3: High Focused districts (Top 40 districts) in active cases as on May 17, 2020

Sl. No.	District	State	Confirmed Cases	Recovered Cases	Deceased Cases	Active Cases	Recovery Rate	Case Fatality Rate	Percent Active Cases within State	Percent Active Cases within India
1	Mumbai	Maharashtra	18555	3260	696	1459	17.6	3.8	64.9	26.13
2	Chennai	Tamil Nadu	6761	1476	54	5231	21.8	0.8	75.2	9.36
3	Ahmedabad	Gujarat	8144	2545	493	5106	31.3	6.1	84.3	9.14
4	Thane	Maharashtra	3834	766	47	3021	20.0	1.2	13.4	5.41
5	Pune	Maharashtra	3647	1452	188	2007	39.8	5.2	8.9	3.59
6	Indore	Madhya Pradesh	2470	1119	100	1251	45.3	4.0	53.8	2.24
7	Kolkata	West Bengal	1311	478	160	673	36.5	12.2	46.0	1.20
8	Hyderabad	Telangana	981	305	23	653	31.1	2.3	74.6	1.17
9	Aurangabad	Maharashtra	873	260	25	588	29.8	2.9	2.6	1.05
10	Jaipur	Rajasthan	1553	901	66	586	58.0	4.2	29.9	1.05
11	Nashik	Maharashtra	835	265	35	535	31.7	4.2	2.4	0.96
12	Bhopal	Madhya Pradesh	992	564	38	390	56.9	3.8	16.8	0.70
13	Udaipur	Rajasthan	379	12	0	367	3.2	0.0	18.7	0.66
14	Howrah	West Bengal	571	173	32	366	30.3	5.6	25.0	0.66
15	Thiruvallur	Tamil Nadu	544	178	5	361	32.7	0.9	5.2	0.65
16	Surat	Gujarat	1049	687	49	313	65.5	4.7	5.2	0.56
17	Raigad	Maharashtra	414	99	12	303	23.9	2.9	1.3	0.54
18	Chengalpattu	Tamil Nadu	491	187	3	301	38.1	0.6	4.3	0.54
19	Agra	Uttar Pradesh	806	501	27	278	62.2	3.3	16.2	0.50
20	Jodhpur	Rajasthan	1004	722	16	266	71.9	1.6	13.6	0.48
21	Palghar	Maharashtra	390	136	13	241	34.9	3.3	1.1	0.43
22	Ganjam	Odisha	292	49	2	241	16.8	0.7	39.9	0.43
23	Solapur	Maharashtra	371	109	22	240	29.4	5.9	1.1	0.43
24	Vadodara	Gujarat	639	384	32	223	60.1	5.0	3.7	0.40
25	Meerut	Uttar Pradesh	322	95	18	209	29.5	5.6	12.2	0.37
26	Nagpur	Maharashtra	352	159	2	191	45.2	0.6	0.8	0.34
27	North 24 Parganas	West Bengal	355	133	32	190	37.5	9.0	13.0	0.34
28	Kurnool	Andhra Pradesh	611	405	19	187	66.3	3.1	25.0	0.33
29	Central Delhi	Delhi	184	0	0	184	0.0	0.0	23.4	0.33
30	Jalgaon	Maharashtra	250	52	30	168	20.8	12.0	0.7	0.30
31	Cuddalore	Tamil Nadu	417	259	1	157	62.1	0.2	2.3	0.28
32	Akola	Maharashtra	236	71	14	151	30.1	5.9	0.7	0.27
33	Anantnag	Jammu and	177	35	1	141	19.8	0.6	23.7	0.25
34	Kulgam	Jammu andKashmir	147	9	0	138	6.1	0.0	23.2	0.25
35	Chandigarh	Chandigarh	191	51	3	137	26.7	1.6	100.0	0.25
36	Guntur	Andhra Pradesh	417	275	8	134	65.9	1.9	17.9	0.24
37	Ujjain	Madhya Pradesh	329	148	47	134	45.0	14.3	5.8	0.24
38	South East Delhi	Delhi	130	0	0	130	0.0	0.0	16.5	0.23
39	Tirunelveli	Tamil Nadu	195	65	1	129	33.3	0.5	1.9	0.23
40	Burhanpur	Madhya Pradesh	149	14	10	125	9.4	6.7	5.4	0.22
		Total	**61368**	**1839**	**2324**	**4064**	**30.0**	**3.8**	**-**	**72.75**

In case of percent distribution of active cases, during 2nd phase of lockdown in India, Maharashtra followed by Gujarat, Punjab, West Bengal, Bihar, Chandigarh, and Uttar

Pradesh recorded a positive change in the distribution of active cases whereas negative or no growth was observed in the distribution of active cases in the remaining states. The decline in the distribution of active cases was highest in Tamil Nadu (6%), followed by Delhi (4.9%) and Rajasthan (3.8%). Similarly, during 3rd phase of lockdown, the change in the distribution of active cases was positive in Maharashtra, followed by Tamil Nadu, Odisha, Bihar, Tripura, and Karnataka, while negative or zero change in the distribution of active cases was observed in the remaining states. The decline in the distribution of active cases was highest in Uttar Pradesh (3.2%), followed by Gujarat (2.7%) and Punjab (2.3).

Map 1: Covid-19 Hotspot zones of India



High Focused Districts in India

Table 3 presents the scenario of recovery rate and case fatality rate of the top 40 high focused district of India based on active cases of COVID-19 till May 17, 2020. The top 40 districts accounted for 64.1 percent of the total confirmed cases in India, 76.9 percent of the total deceased cases, and 72.8 percent of the total active cases. The average recovery rate of these forty districts was estimated as 30 percent, while the case fatality rate was 3.8 percent, and wide variation was observed across the districts. Of the top 40 districts, 11 districts belonged to Maharashtra, five districts from Tamil Nadu, four districts from Madhya Pradesh, three districts each from Gujarat, Rajasthan and West Bengal, two districts each from Delhi, Uttar Pradesh, Andhra Pradesh and Jammu and Kashmir and one district each from Odisha, Telangana, and Chandigarh (Map 1). The recovery rate was highest in the Jodhpur district (71.9%) of Rajasthan followed by Kurnool (66.3%) and Guntur district (65.9%) of Andhra Pradesh and Surat district (65.5%) of Gujarat while it was lowest in South East (0.0%) and Central district (0.0%) of Delhi followed by Udaipur district (3.2%) of

Rajasthan and Kulgam district (6.1%) of Jammu and Kashmir. The case fatality rate was highest in Ujjain district (14.3%) of Madhya Pradesh followed by Kolkata (12.2%) and North 24 Parganas districts of West Bengal and Burhanpur district of Madhya Pradesh while it was lowest in Kulgam district (0%) of Jammu and Kashmir, Udaipur district (0%) of Rajasthan, South East (0%) and Central district (0%) of Delhi. Ahmedabad district of Gujarat accounted for 84.3 percent of the active cases in Gujarat, while the Chennai district (75.2%) of Tamil Nadu accounted for three-quarters of the active cases in the states. About 65 percent of active cases in the state of Maharashtra belonged to the Mumbai district, whereas Indore district (53.8%) of Madhya Pradesh accounted for more than half of the active cases in the state. More than a quarter of the active cases in India belonged to the Mumbai district (26.1%) of Maharashtra, followed by the Chennai district (9.4%) of Tamil Nadu and Ahmedabad district (9.1%) of Gujarat. Further, about 40 percent of the active cases in India belonged to the 11 districts of Maharashtra.

Health infrastructure

Table 4 represents the availability of health infrastructure in India. There are only 5.1 hospitals per one lakh population in India. The number of government hospitals is less (1.9) compared to the private (3.2) hospitals in the country. India has 140 hospital beds (53 in govt. and 87.9 in private), 7.0 ICU beds (2.6 in govt. and in 4.4 private), and 3.5 ventilators (1.3 in govt. and 2.2 in private) per lakh population. India has not been a great spender on health; it spends only 1.28% of its GDP as public expenditure on health (NHP, 2019). India has just one bed per 1844 patients in government hospitals, and the doctor-patient ratio is 1:1445, far from the WHO recommended one doctor per 1000 patients (Sharma, 2020). Among the states, only a few states have adequate health infrastructure. Karnataka has the highest number of the hospital (16 per lakh population) followed by Telangana, whereas Delhi has recorded the lowest number of hospitals (0.9 per lakh population) followed by Chandigarh, Madhya Pradesh, Jammu and Kashmir, and Andhra Pradesh.

Despite fewer hospitals, the number of hospital beds, ICU beds, and ventilators in Chandigarh is higher than the other States and UTs of India. However, the state like Bihar, Odisha, Jammu and Kashmir, Jharkhand, Madhya Pradesh, and Gujarat face a severe deficiency in health facilities. The Union health ministry reported on May 10, 2020; there are 7,740 dedicated COVID-19 facilities in 483 districts in the country including all states and central government facilities, to fight against the pandemic. Also, there are 6,56,769 isolation beds, 3,05,567 beds for confirmed cases, 3,51,204 beds for suspected cases, 99,492 oxygen supported beds, 1,696 facilities with oxygen manifolds, and 34,076 ICU beds (IANS, 2020). Though there are several quarantine centres have been created, many lack necessary infrastructure. The patients complained that there were only three washrooms and five large bedrooms for more than 40 people when they were quarantined in Delhi (Thacker 2020).

At present, Maharashtra (highest COVID-19 burden) has only 2.6 hospital, 188 hospital beds, 9.4 ICU beds, and 4.7 ventilators per lakh population. In Mumbai, about 30% of COVID-19 cases who are admitted as symptomatic, including 3% in need of critical care (Barnagarwala, 2020). Though this percentage is small, the city is still lacking hospital beds for these critical patients. The available facilities are divided into three layers, i.e., Dedicated Covid Hospitals (DCH), Dedicated Covid Health Centres (DCHCs), and Dedicated Covid Care Centre (DCCC). The DCH admits only critically ill patients who require ICU or ventilator support or patients who are gasping for breath whereas DCHCs admits moderately sick (cough, cold, and continued fever) COVID-19 patients and DCCC quarantine people who are high-risk suspects, slum-dwellers who cannot practice social distancing at home and

asymptomatic positive cases, or cases with mild symptoms. However, there is plenty of space to admit people in DCHCs and DCCC, and the beds are limited for the infected COVID-19 patients in DCHs.

Table 4: Availability of health infrastructure per lakh population in India

States	Number of hospital			Hospital Beds			ICU Beds			Ventilators		
	Govt.	Private	Total	Govt.	Private	Total	Govt.	Private	Total	Govt.	Private	Total
Maharashtra	0.6	2.0	2.6	41.7	146.2	188.0	2.1	7.3	9.4	1.0	3.7	4.7
Tamil Nadu	1.6	1.6	3.2	102.0	102.4	204.3	5.1	5.1	10.2	2.5	2.6	5.1
Gujarat	0.6	1.4	2.0	29.3	64.9	94.2	1.5	3.2	4.7	0.7	1.6	2.4
Delhi	0.5	0.3	0.9	120.7	74.6	195.4	6.0	3.7	9.8	3.0	1.9	4.9
Madhya Pradesh	0.6	0.6	1.2	37.3	40.6	77.9	1.9	2.0	3.9	0.9	1.0	1.9
Rajasthan	3.6	3.6	7.2	60.1	58.9	119.0	3.0	2.9	6.0	1.5	1.5	3.0
Uttar Pradesh	2.0	5.5	7.5	33.5	90.0	123.5	1.7	4.5	6.2	0.8	2.3	3.1
West Bengal	1.6	0.7	2.3	80.6	35.9	116.4	4.0	1.8	5.8	2.0	0.9	2.9
Andhra Pradesh	0.5	1.3	1.8	44.1	114.5	158.5	2.2	5.7	7.9	1.1	2.9	4.0
Bihar	0.9	1.6	2.5	9.6	15.8	25.4	0.5	0.8	1.3	0.2	0.4	0.6
Odisha	4.1	1.6	5.7	42.2	16.3	58.5	2.1	0.8	2.9	1.1	0.4	1.5
Karnataka	4.3	11.8	16.1	105.1	290.1	395.2	5.3	14.5	19.8	2.6	7.3	9.9
Jammu and Kashmir	1.1	0.1	1.2	54.8	5.3	60.1	2.7	0.3	3.0	1.4	0.1	1.5
Punjab	2.3	5.4	7.7	59.6	143.1	202.7	3.0	7.2	10.1	1.5	3.6	5.1
Telangana	2.3	8.7	11.0	56.0	210.6	266.6	2.8	10.5	13.3	1.4	5.3	6.7
Haryana	2.3	5.1	7.4	38.7	85.6	124.3	1.9	4.3	6.2	1.0	2.1	3.1
Chandigarh	0.8	0.3	1.1	314.8	157.2	472.0	15.8	7.9	23.6	7.9	3.9	11.8
Jharkhand	1.5	2.1	3.6	28.4	41.4	69.8	1.4	2.1	3.5	0.7	1.0	1.7
Kerala	3.6	5.8	9.5	107.6	173.4	281.0	5.4	8.7	14.1	2.7	4.3	7.0
Tripura	3.9	0.2	4.1	109.8	5.9	115.7	5.5	0.3	5.8	2.8	0.1	2.9
Rest of India	3.4	1.9	5.3	70.6	42.2	112.8	3.5	2.1	5.6	1.8	1.1	2.8
India	**1.9**	**3.2**	**5.1**	**53.0**	**87.9**	**140.9**	**2.6**	**4.4**	**7.0**	**1.3**	**2.2**	**3.5**

In this section, we focused on the availability of government hospital beds in other COVID-19 affected states. Using the data from National Health Profile-2019, it is observed that there are 20,172 government hospital beds in Gujarat (29.3 per one lakh population), 24,383 in Delhi (120.7 per one lakh population), 77,532 in Tamil Nadu (102 per one lakh population), and 47,054 in Rajasthan (60.1 per lakh population). The capacity of ICU beds is not sufficient in these states (Gujarat 1009; Delhi 1219; Tamil Nadu 3877; and Rajasthan 2353). An estimated 5-10% of total patients will require critical care in the form of ventilator support (Singh, Ravi and Chakraborty, 2020; Joshi, 2020). With the estimated number of 47,481 ventilators available in the country will be deficit in near future to cater to a growing number of active COVID-19 patients and the burden of other communicable and non-communicable diseases. Clearly, the growing demand for ventilators is going to outstrip the limited supply really soon.

Besides this, the health workers are instructed to wear the mandatory Personal Protective Equipment (PPE) to protect themselves from harmful biological agents or contaminated surfaces. Apart from this, the shortage of PPE for doctors, nurses, and other health workers are now becoming a global issue. India also lacks much needed PPE kit for those who screen, test, and treat COVID-19 patients. The nurses and health care workers were forced to use raincoats, scarves, motorcycle helmets to cover their faces in the absence of masks (Sarda, 2020). Apart from PPE kit, the government faced challenges with COVID-19 testing laboratories. Currently, India has only 569 testing laboratories (396 govt. and 173 private) against its 1.35 billion population (ICMR, 2020). The procurement of more Cobas 6800 testing machine, with the capacity to test around 1200 samples per day is essential.

Discussion

This study presents the status of COVID-19 testing, recovery rate, fatality rate, and hotspot areas as on 17th May 2020. It also provide the current health infrastructure and available testing facility in the country till the study period. At the national level, a total of 2457651 individuals were tested till 17th May out of which 95,676 individual were tested positive. Tamil Nadu recorded the maximum number of COVID-19 test while the prevalence was highest in state of Maharashtra. The test positivity rate varied from 12.1 percent in Maharashtra to 0.7 percent in Jharkhand. The recovery rate in India has increased from 11.9 percent to 38.4 percent during the study period. At state level, wide variation in recovery rate was observed varying from 58.3 percent in Andhra Pradesh to 12.2 percent in Maharashtra. At the same time, a decline in the case fatality rate from 3.4 percent to 3.2 percent was also observed. This study also indicates that the recovery rate increased during the first three phases of lockdown while in case of case fatality rate, there was no change was observed till the 2nd lockdown phase. The number of active cases was highest in Maharashtra during all the phases of lockdown and the change in the positive cases was also high in Maharashtra. The top 40 districts accounted for 64.1 percent of confirmed, 76.9 percent of deceased and 72.8 percent of actives cases in India.

Testing to detect the cases is one of the important strategies to deal with COVID-19 pandemic. To minimize the spread of the infection, it is vital to find out the detected cases, trace their contacts and quarantine infected persons. The number of tests per million populations may not provide accurate information about the adequacy of the tests rather the test positive rate provides a better measure. If we say that the country or the state is in right direction, then the test positive rate should be low and it should decrease. States such as Maharashtra and Gujarat shows the test positive rate is increasing; it has almost doubled since last one month which is a matter of concern. Therefore, the testing is grossly inadequate in these states. The test positive rate in India is almost stabilized around 4 percent since last one month. However, to bring the states and the country in right track, the test positive rate has to be curtailed to below 2 percent as observed in case of Kerala. During the lockdown, the curve of COVID-19 pandemic was flattered at somewhat desired level but the critical component of this post-lockdown strategy is adequate testing (Lancet, 2020). The immediate challenge is to keep infections at manageable levels and to test, trace contacts, isolate patients, and implement COVID-19 care plans. Higher emphasis should be laid on the health sector and recognize the importance of having strong public sector capacity, especially in primary care and at the district level.

Conclusion

The health infrastructure of India made enormous progress over the past decades. The life expectancy has crossed 67 years, infant and under-five mortality rates are declining as is the rate of disease incidence. The diseases, such as polio, yaws, and guinea worm disease, etc. have been eradicated. In spite of the progress, communicable diseases are expected to continue, and the non-communicable diseases are now leading cause of death due to the absence of adequate health facilitates at the primary, secondary, and tertiary levels (Narain, 2016). At present, India faces the triple burden of diseases- the infectious diseases, the challenge of non-communicable diseases (NCDs), and the emerging of COVID-19 pandemics. The uncertainty around the novel coronavirus with no vaccine available until today sparks several concerns to the country's public health systems (Dwivedi et al., 2020).

The existing health infrastructure in India is already over-stretched and needs to be strengthening to face these challenges in the twenty-first century. The lockdown was the preliminary measure to create required health infrastructure to combat against COVID-19. The life after COVID-19 will not be the same. The current disaster reiterated the fact that healthcare and life sciences are the biggest opportunities for our country. According to Global health experts, India does not have the proper infrastructure or financial capability to deal with a massive public health disaster (Changoiwala, 2020). Further, there are also severe shortages of trained medical staff and supplies throughout India. This pandemic is a lesson and wake-up call for the governments worldwide to change their priorities in GDP and needs to be prepared to deal with the same crisis in the future. There is a need to increase the public health spending in India at least upto the global average of 6 percent, which should focus both preventive and curative care. In the current situation, there is an urgent need to make a sizeable allocation to the annual health financing in India. The priority should be the development of more laboratories and hospitals, PPE and testing kits, and indigenously developing vaccines. Besides, spending on research and training is another priority area. The government needs to address the gap in medical advancements (i.e., latest technology, medical knowledge) and research to provide better care giving at all levels. Looking at the severity of COVID-19, there is a need to scale-up public health services, the number of beds and physicians, medical equipment, medicines, and care packages for public health emergencies. Public-private partnership is another priority area, especially when the country is in a public health emergency. The government needs to strengthen medical infrastructure through the public-private partnership to make India not only the 'Pharmacy of the World' but also the 'Laboratory of the World'.

The findings of the study may be subjected to few limitations. First, the validity of the analysis depends on the data available on testing, confirmed, recovery and deceased cases but the real situation might be different as the testing is not rampant in the country, hence the findings cannot be generalized to overall pandemic situation of the country. Second, though all states have added large number of facilities to combat COVID-19 but the complied data are not available at one place.

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