Tracking COVID-19 burden in India: A review using SMAART RAPID tracker

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Abstract

Objective: India has seen a rapid rise in COVID-19 cases. Examine spatiotemporal variation of COVID-19 burden Tracker across Indian states and union territories using SMAART RAPID Tracker.

Method: We used SMAART RAPID Tracker to visually display COVID-19 spread in space and time across various states and UTs of India. Data gathered from publicly available government information sources. Data analysis on COVID-19 conducted from March 1 2020 to October 1 2020. Variables recorded include COVID-19 cases and fatality, 7-day average change, recovery rate, labs and tests. Spatial and temporal trends of COVID-19 spread across Indian states and UTs is presented.

Result: The total number of COVID-19 cases were 63, 12,584 and total fatality was 86,821 (October 1 2020). More than 85,000 new cases of COVID-19 were reported. There were 1,867 total COVID-19 labs throughout India. More than half of them were Government labs. The total number of COVID-19 tests was 76,717,728 and total recovered COVID-19 cases was 5,273,201. Results show an overall decline in the 7-day average change of new COVID-19 cases and new COVID-19 fatality. States such as Maharashtra, Chandigarh, Puducherry, Goa, Karnataka and Andhra Pradesh continue to have high COVID-19 infectivity rate.

Discussion: Findings highlight need for both national guidelines combined with state specific recommendations to help manage the spread of COVD-19.

Conclusion: The heterogeneity represented in India in terms of its geography and various population groups highlight the need of state specific approach to monitor and combat the ongoing pandemic. This would further facilitate the tailored approach for each state to mitigate and contain the spread of the disease.

Keywords: COVID-19, India, spatiotemporal, Infectivity rate, Rate of change

Abbreviations: Union Territories (UT)

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DOI: 10.5210/ojphi.v13i1.11456

Introduction

The recently discovered SARS-CoV-2 originated in the month of December 2019 in Wuhan, China, and has since caused catastrophic damages globally after being declared as a pandemic. It has spread rapidly and globally since its advent via direct or indirect contact with infected surfaces or people [1]. The infection can be asymptomatic or can primarily cause fever, dry cough and tiredness along with difficulty in breathing, body aches, diarrhoea and loss of taste or smell [2]. As of 1st October 2020, the worldwide total number of COVID-19 cases stand at a staggering 33,842, 281 with USA (total cases - 3741406, fatality - 208433), India (total cases - 6685082, fatality - 103569) and Brazil (total cases - 4915289, fatality - 146352) among the top three countries with the COVID-19 infection [3]. Since no vaccine or pharmaceutical drugs are available to combat COVID-19, therefore, to control infections, prevent spread of the virus and reduce mortality, the governments across the globe issued various advisories, and policies and various non-pharmaceutical interventions. These interventions included home isolation, voluntary quarantine, and closure of educational institutions, lockdowns, and guidance on hygiene [4].

However, the cases continued to surge, especially in low- and middle-income countries (LMICs), where the population is already at risk due to inequitable access to the health services in resource-poor settings [5]. India is the second most populated country with a population of around 1.38 billion and more than half of its population residing in rural areas [6]. The country is categorised into six zones namely – North, North-East, Central, East, West and South. There are total 28 states and 8 union territories in India (Figure 1) [7]. All these states and union territories have official abbreviations consisting of two letters and these abbreviations have been used in this study to present the data in a simpler form [8]. India reported its first case on 30 January 2020, the same day when WHO declared COVID-19 as Public Health Emergency of International Concern. The case was linked, to an Indian medical student who returned to Kerala from Wuhan. The state reported 2 more cases within a few days and the first death due to coronavirus in India was reported on 12 March 2020 in Karnataka. By the time the situation was declared a pandemic by WHO on 11 March 2020, around 11 states and union territories of India had been affected by the novel coronavirus. Although the government took swift actions to curb and contain the spread of the virus, but, despite of the early precautionary steps by the government, India had a growing outbreak with more than 6.3 million cases (as of 1st October, 2020) across its states and union territories [9]. As of 1st October 2020, the total reported deaths due to COVID-19 in India were 102,685 [9,10].

With the alarming rise of COVID-19 cases, the government of India imposed a nation-wide lockdown under the Disaster Management Act 2005, on 24 March 2020 for 21 days, and subsequently implemented 3 more lockdowns till the end of May with increasing relaxations in each. India's immediate response to the surge of cases has been one of the strictest measures as compared to other countries [11] and was also lauded by WHO.

The non-pharmaceutical interventions (NPIs) in these lockdowns included travel ban for both inter-district and inter-state movements, functioning of only essential services, closing of all educational institutes, ban on public gatherings, guidance and advisories on voluntary quarantine, and home isolation. However, these NPI's also posed serious repercussions, not

only on the economy but, also social well-being and health of the people. The downwardly spiralling economy and unemployment has further triggered the pattern of the biggest reverse migration in the Indian History. In a country like India, where the wage labourers were dependent on daily incomes, they suddenly found themselves with no job prospects which led to this migration stream. Whether the lockdown was successful is a debatable issue but, it has certainly helped in slowing down the spread of infection [12].

Currently where there are no recommended drugs and vaccines available to control the transmission of COVID-19, mathematical estimation can help in predicting its control [13]. A study reported that the aggressive containment measures to control transmission, might have helped in reducing the Ro (reproduction number), but a proper and rapid surveillance system is necessary, along with increased testing and devising strategies to control the asymptomatic cases [14]. Results of one of the previous studies showed that if the lockdown was implemented seamlessly, then it may possibly have helped the containment of the spread of cases and would have been the perfect time for the central and state governments to strengthen their pandemic responsiveness and disease surveillance system [15]. The rise in the number of reported cases in India can also be attributed to increased COVID-19 testing by the government. Initially, there was only 1 lab in Pune which has now increased to a total of 1869 labs, with over 58% (1101) owned by the government (as of 1 October, 2020) [16]. The variety of diagnostic tests have also been made available with RT-PCR, True Nat, CBNAAT, Rapid Antigen testing and Rapid Antibody Testing [17].

The objective of this study was to track spatiotemporal variations in the spread of COVD-19 across different regions of India using an internet enabled, interactive population health informatics platform SMAART RAPID Tracker. The tracker generates COVID-19 trends and insights to inform stakeholders about the spread of COVID-19 virus across space and time.

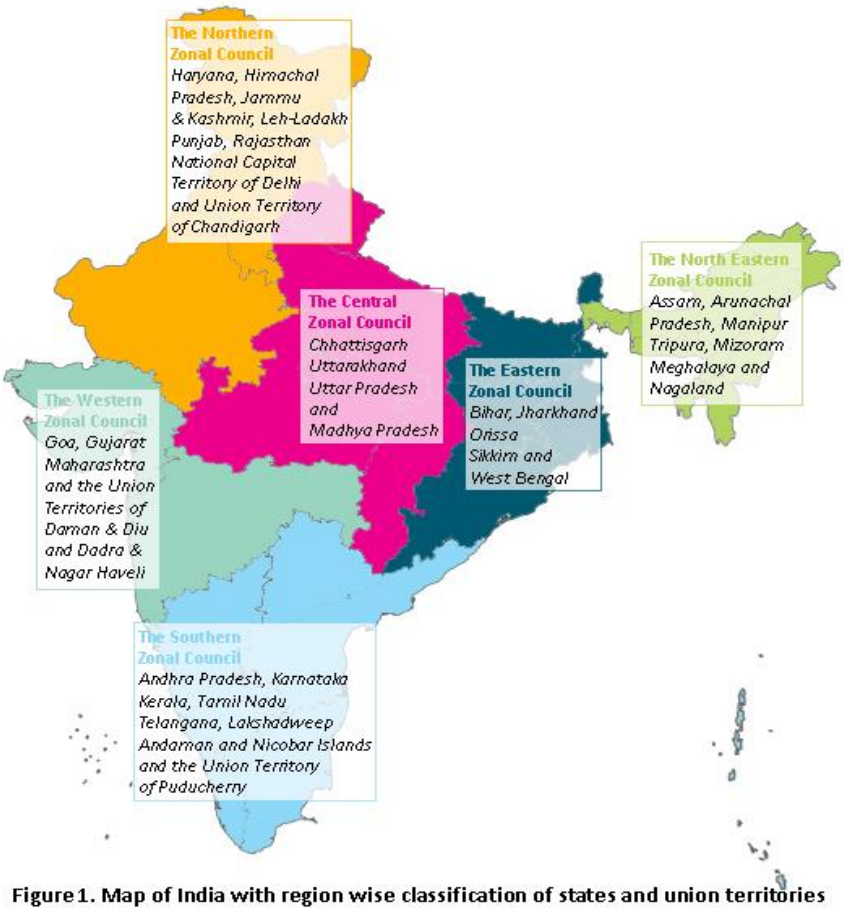

Figure 1. Map of India with region wise classification of states and union territories

Map source: https://mea.gov.in/india-at-glance.htm [18] (Accessed on February 17, 2021)
Zonal classification source: http://interstatecouncil.nic.in/composition-2/ [19] (Accessed on February 17, 2021)

SMAART RAPID Tracker

Visualization empowers laypeople and professionals to better track global pandemic. Comparing disease's spatiotemporal variation across different regions of India is of great interest as different states have responded differently to the COVID-19 pandemic. SMAART RAPIDTRACKER, a Research enabled Action oriented Policy Interventions driven by Data, is an innovative policy informatics tool, aimed to track geospatial spread of COVID-19 outbreak and policy actions globally. The dashboard aggregates publicly available but verified information on the burden of COVID-19. There are four key modules of SMAART RAPID Tracker including data module, policy module, digital resource and insights module. Data module aims to aggregate COVID-19 data and provides users an opportunity to explore, compare, sort, and rank COVID-19 related data across different geographic settings (Figure2). Variables recorded in SMAART RAPID Tracker include COVID-19 total and new cases, total and new fatality, recovered cases, availability of lab centres and number of COVID-19 tests data. Information on recovery cases of COVID-19 is also gathered.

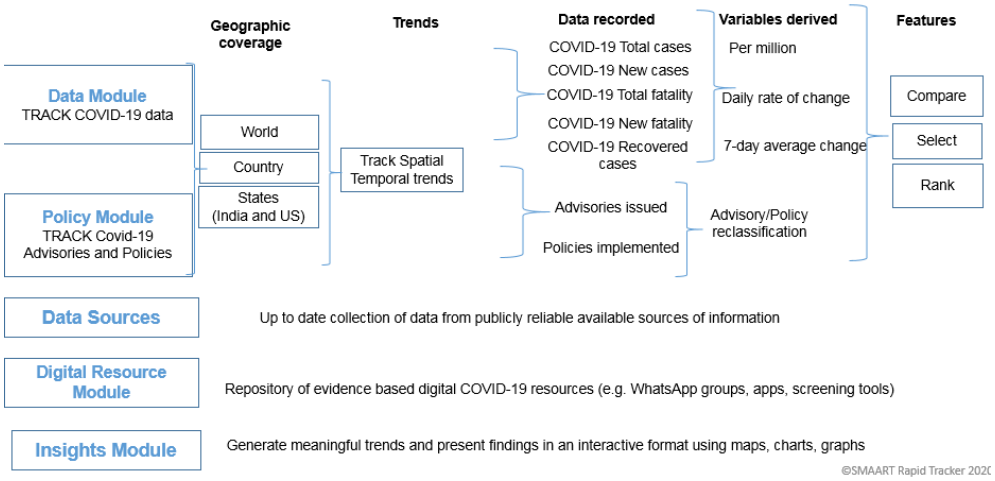

Figure2. SMAART RAPID Tracker modules

Data sources module indicates the sources of data from where information if gathered. Digital resource module is a repository of evidence based digital COVID-19 resources such as digital apps aimed to address the burden of COVID-19 and insights module generates meaningful trends and present findings in an interactive format using maps, chart and graphs. SMAART RAPID Tracker is designed and developed using SMAART informatics framework that gathers multi-faceted, multi-level, and multi-dimensional data and analyses that data into meaningful information that is contextually relevant. New knowledge generated through use of interactive visualizations in the form of maps, charts and graphs can be leveraged to guide data driven, evidence-based decision making.

Methodology

The SMAART RAPID Tracker dashboard aggregates globally publicly available but verified information on the burden of COVID-19. In this study, we analyse COVID-19 data collected for all the Indian states and Union territories. This includes the total and new cases of COVID-19, and total and new cases of COVID-19 per million, total and new fatality, and total and new fatality cases of COVID-19 per million, daily and 7 day change of COVID-19. Further data was recorded on the COVID-19 lab facilities and its testing data across each state and UT of India. The total lab facilities - specified as COVID-19 testing facility centres, were first categorized according to the geographical location in the state/union territory and then further categorized as per the district's distribution within those states/ union territories. The proportion of lab facilities conducting COVID-19 detection in each location, helps us realize the testing capacity in each area of the country. Information was also recorded on when the first COVID-19 case and fatality was reported. We also assessed infectivity rate by calculating:

Infectivity rate = Total covid-19 cases/Total reported COVID-19 tests*100 [20].

Each region's infectivity rate was calculated and compared across different regions of India.

We calculated time lapse between the first case and first death due to COVID-19. It is the time period or the duration between the first reported COVID-19 case and the first death due to COVID-19. For each state and union territory, this duration was calculated and expressed in the form of total number of days. We assess the date of the index case and then count all the days till the date of the first COVID-19 specific death.

Time lapse (number of days) = First reported COVID-19 case- First reported COVID-19 fatality

Time lapse would help inform the distribution pattern of the COVID-19 across different regions of India. To understand the transmission dynamics of COVID-19, the total confirmed cases and deaths due to COVID-19 were collected for each month, starting from March 2020 to September 2020 for all the states and union territories. All the data was obtained from publicly available domains of the Ministry of Health and Family Welfare, Indian Council of Medical Research, state and union territory's health department, and the SMAART RAPID Tracker website mainly (smaartrapidtracker.org). All data has been analysed till October1 2020.

Statistical analysis:

We used SMAART RAPID Tracker (smaartrapidtracker.org) to visually display the descriptive analysis of total number of cases, and fatality, cases and fatality per million, number of COVID-19 tests conducted, and the number of labs available in each states. Descriptive analysis was also performed to report infectivity rate across different regions of India. States and UTs were stratified based on infectivity rate of COVID-19. SMAART RAPID Tracker was used to display 7-day average change of new COVID-19 cases across different states and UTs of India.

Results

India, 7th largest country in the world consists of 28 states and 8 union territories. According to the provisional results of the 2011 census, the literacy rate in the country stands at 74%. As per Census 2011, while 28.5% population of India lies between 0-14 age group, only 8.3% are above the age of 60 years in the country. As of Oct1 2020, the total number of COVID-19 cases reported were 63, 12,584, and 5,216 cases per million (Figure3). More than 85,000 new cases of COVID-19 were reported and 72 new cases per million as of Oct1 2020. As of Oct1 2020, the total fatality reported in India was 86, 821. There were 1,867 total COVID-19 labs throughout India. More than half of them were Government labs (59%; n=1101). The total number of COVID-19 tests reported as of Oct 1 2020 was 76,717,728 and total recovered COVID-19 cases was 5,273,201 (Figure3).

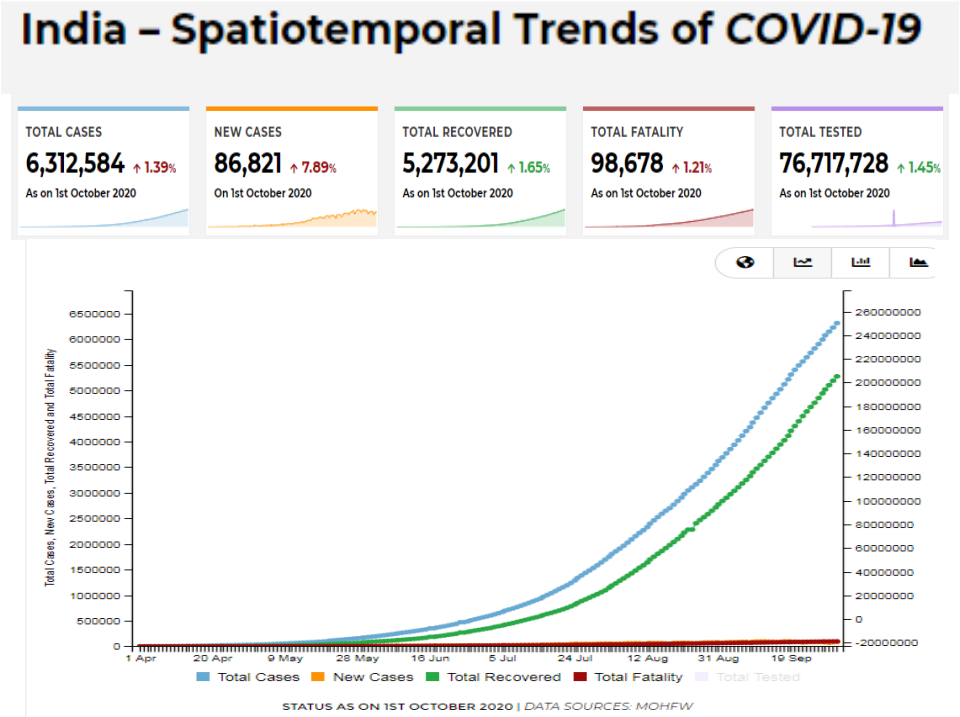

Figure3. Status of COVID-19 in India (as of Oct 1 2020).

Source: smaartrapidtracker.org (Last accessed Oct 22 2020)

Results show an overall decline in the 7-day average change of new COVID-19 cases and new COVID-19 fatality in India as of October 1 2020. (Figure4a and 4b). As of October 1 2020, 7-day average change of new COVID-19 cases was 0.89% as compared to 4.13% on Sep1 2020 (Figure4a). Similarly, the 7-day average change of new COVID-19 fatality was 3.51% on Oct1 2020 as compared to -22.66% on Sep1 2020 (Figure4b). Number of COVID-19 recovered cases per million has increased more than 50% as of Oct 1 2020 (n=4357/million) compared to Sep1 2020 (n=2347 per million).

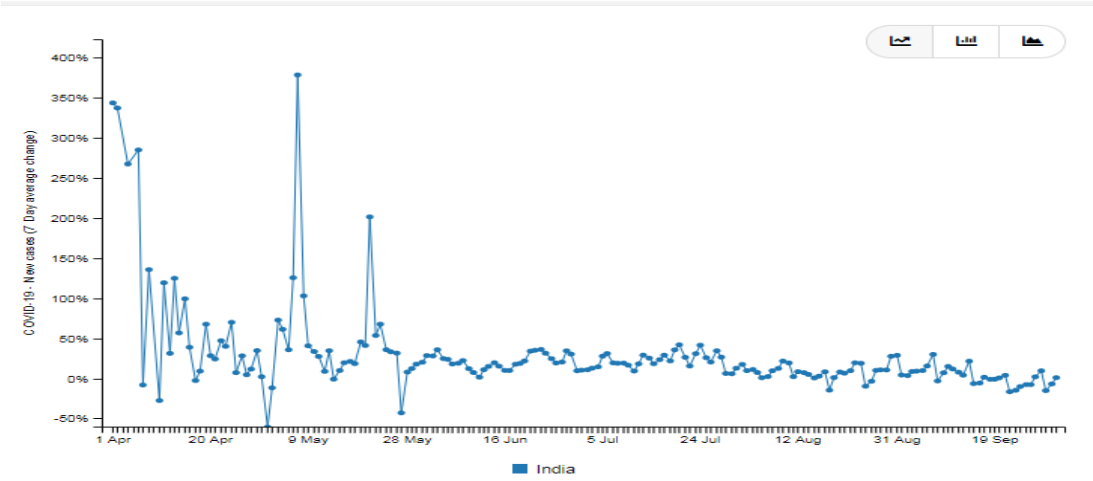

Figure4a. 7-day average change of new COVID-19 cases (April1 2020-Oct1 2020)

Source: smaartrapidtracker.org (Last accessed Oct 22 2020)

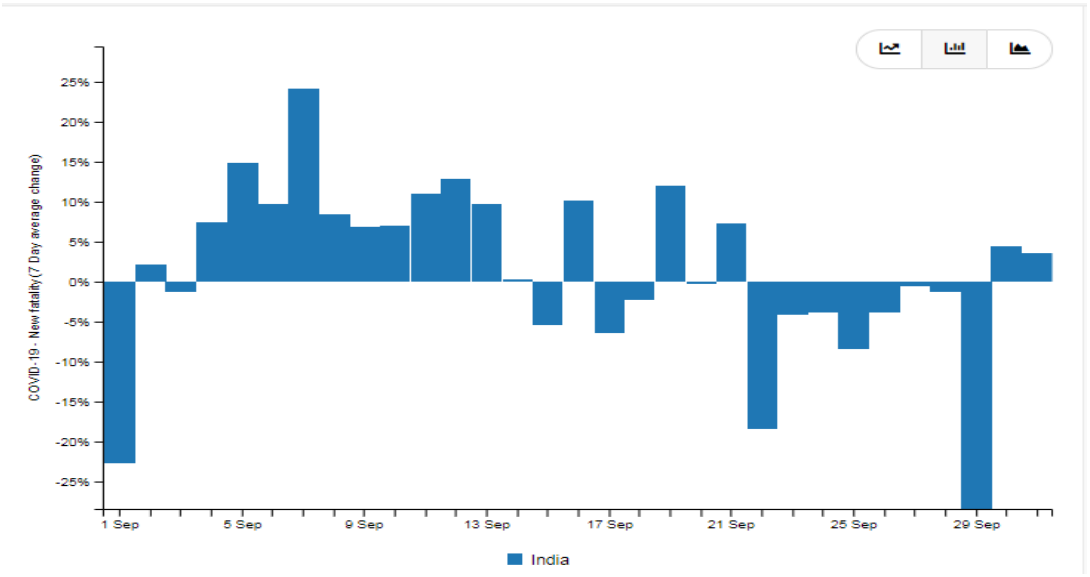

Figure4b. 7-day average change of new COVID-19 fatality (Sep1 2020-Oct1 2020)

Source: smaartrapidtracker.org (Last accessed Oct 22 2020)

In India, Kerala was the first state to report COVID-19 case, whereas Karnataka was the first state to report COVID-19 related fatality. Mizoram and Lakshadweep Islands have not reported any COVID-19 fatality. However, states and UTs that have reported COVID-19 fatality within days of a reported COVID-19 case included North eastern state of Meghalaya (n=2days), southern state of Karnataka (n=4 days), and an eastern state Bihar (n=7 days). Similarly, the Southern UT Andaman & Nicobar Islands (n=123 days) and North Eastern state Manipur (n=127 days) reported their first fatality after 3 months of their first reported case of COVID-19. Results showed that by the end of the March 2020, nearly all of India (28 states and 8 union territories) had been affected by COVID-19 cases (Figure5).

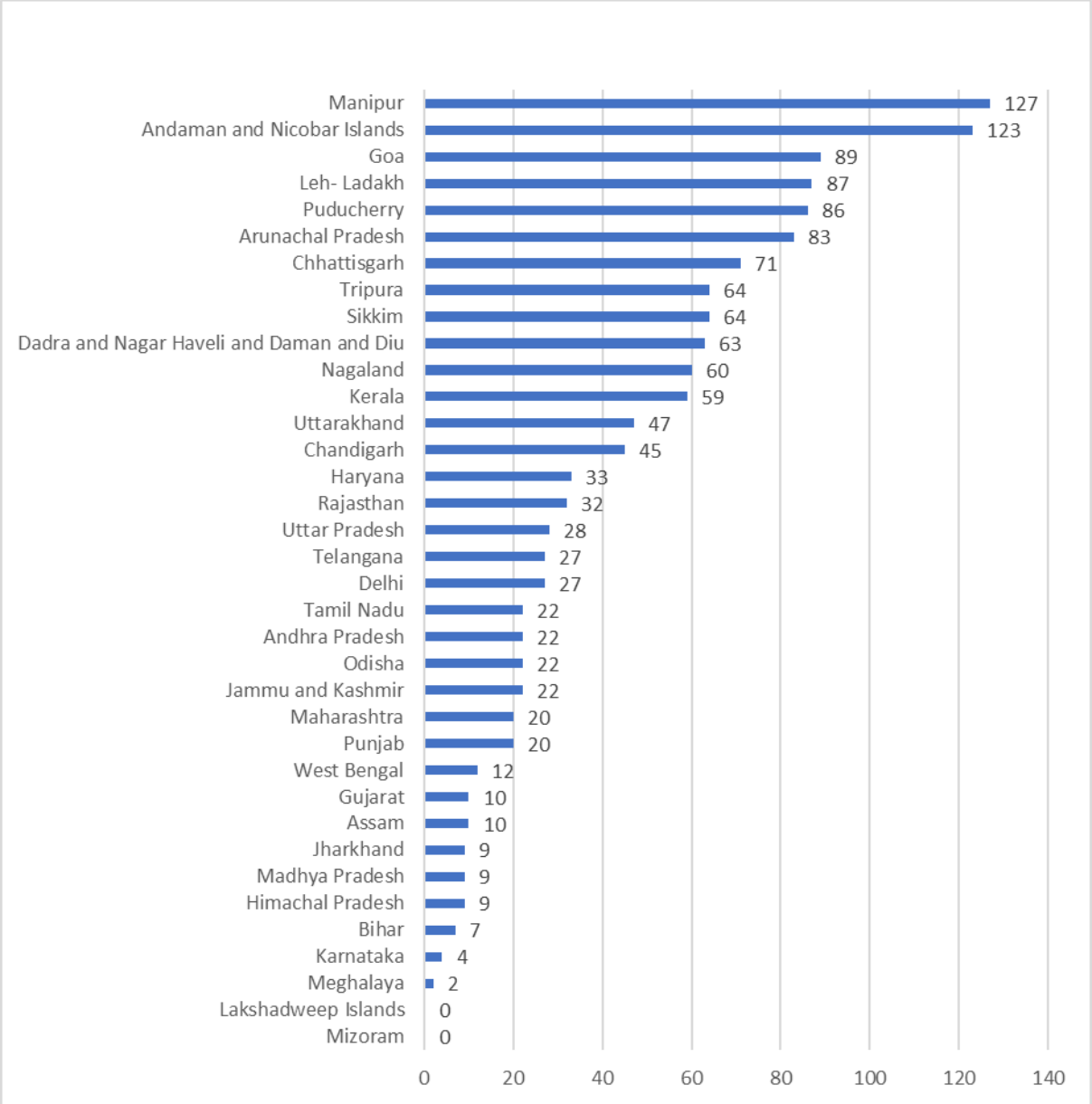

Figure5. Number of day's difference between first reported COVID-19 fatality and first case.

- **Overall COVID-19 case and fatality across India**

Total COVID-19 cases in South India were highest (n=2,281, 754) as of October 1 2020 (Table2). This attributed nearly 37% of the total number of COVID-19 cases in India, followed by West zone (27%) and North zone (17%) However, the total number of cases per million was highest in North India (n=82,965 per million) followed by South (n=63,438 per million) and West (44,008 per million) (Table1). Central zone showed the lowest number of total COVID-19 cases per million (n=6069 per million). Highest total COVID-19 fatality was seen in West zone (N=41512) while Northeast zone (N=1137 showed the lowest COVID-19 fatality (Table1). Highest fatality per million was seen in North India (n=1282 per million) compared to Central India (n=67 per million). (Table1).

Table1. Total COVID-19 cases, cases per million, fatality and fatality per million comparison across different regions of India. (October 1 2020)

Indicators	Regions of India					
	North	**North-East**	**Central**	**East**	**West**	**South**
Total cases	1063427	239680	236698	733269	1670899	**2281754**
Total fatality	17904	1137	3197	7321	**41512**	26426
Total COVID-19 tests	20015123	4813757	3185406	16244588	14816225	**24606962**
Total COVID-19 labs	466	107	137	249	297	**611**
Infectivity rate	5.31	4.98	7.43	4.51	11.28	9.27
Total cases per million	82965	35099	6069	12170	44008	63438
Total fatality per million	1282	216	67	104	690	919

Source: SMAART RAPID Tracker (www.smaaartrapidtracker.org)

- **COVID-19 labs and testing data**

Highest number of COVID-19 labs were reported from South India, followed by North and West. Number of COVID-19 government labs were higher across all regions of India except South where private labs were greater in number compared to government labs. (Figure6).

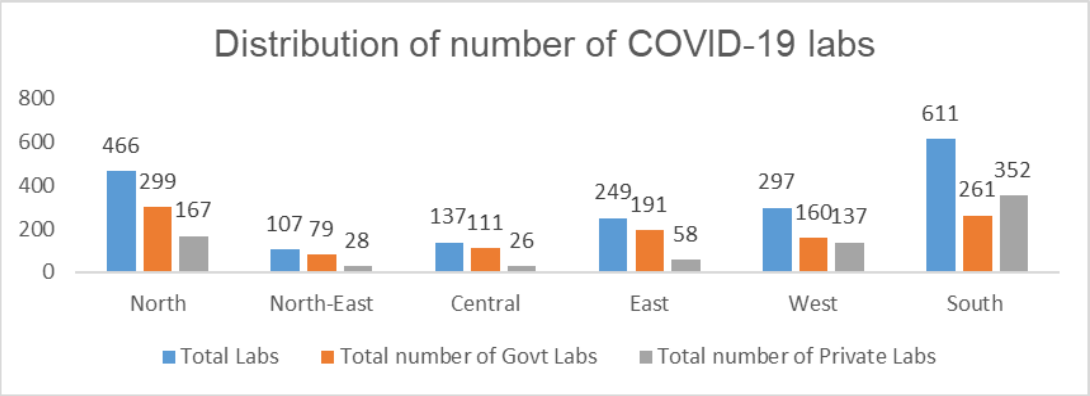

Figure6. Number of COVID-19 labs across different zones

Of the total CVOID-19 tests conducted in India (n=83682061), South (29%; n=24606962) and North (24%; n=20015123) regions of India attributed to the highest number of COVID-19 tests. The Central region of India had the lowest COVID-test (3.81%; n=3185406), followed by North-East (5.75%; n=4813757) and East Zone (19.41%; n=16244588). As of October 1 2020, in India infectivity rate was about 7.4% with nearly 6,22,5727 cases of COVID-19 of the 83682061 reported COVID-19 tests.

COVID-19 analysis By Zone: The total COVID-19 cases and fatality varied across different states within each zone. Similar geographic variations were seen for COVID-19 labs, tests and infectivity rate due to COVID-19.

a. COVID-19 Burden North Zone

- **Total COVID-19 cases and fatality burden:** Total COVID-19 cases were highest in the state of Uttar Pradesh (n=394,856). Similarly, Uttar Pradesh also had the highest CVID-19 fatality (n=5,715) followed by Delhi (n=5320). Lowest total COVID-19 fatality was seen in Leh-Ladakh (n=58), and Himachal Pradesh (n=183). Majority of the states and UT have in the North India have shown decline in 7-day average change of new cases of COVID-19 except Leh-Ladakh and Uttarakhand (Figure7b). Results show that Uttar Pradesh surpassed Delhi in total COVID-19 cases around August 17 2020 (Figure7a) and around Sep 20 2020 for total COVID-19 fatality (Figure 7c). Punjab is another state showing increase in total COVID-19 fatality.
- **COVID-19 Labs and testing data**: The state of Uttar Pradesh had highest number of COVID-19 labs in the North zone (n=197). Nearly 41% (n=122) of them were government labs. Highest COVID-19 tests were reported from the state of Uttar Pradesh (n=10,263, 709) attributing more than half of the total tests (51%) conducted in the entire North zone.
- **COVID-19 Infectivity rate**: Overall COVID-19 infectivity rate (number of positive cases of COVID-19/Number of total tests reported) was 5.31% (as of Oct 1 2020). Chandigarh seemed to have highest COVID-19 infectivity rate (15%), followed by Delhi (8.81%), Leh-Ladakh (7.8%), Uttarakhand (6.66%), Haryana (6.5%) and Punjab (n=6%). Uttar Pradesh had the lowest infectivity rate of 3.85% among the states in the North India.

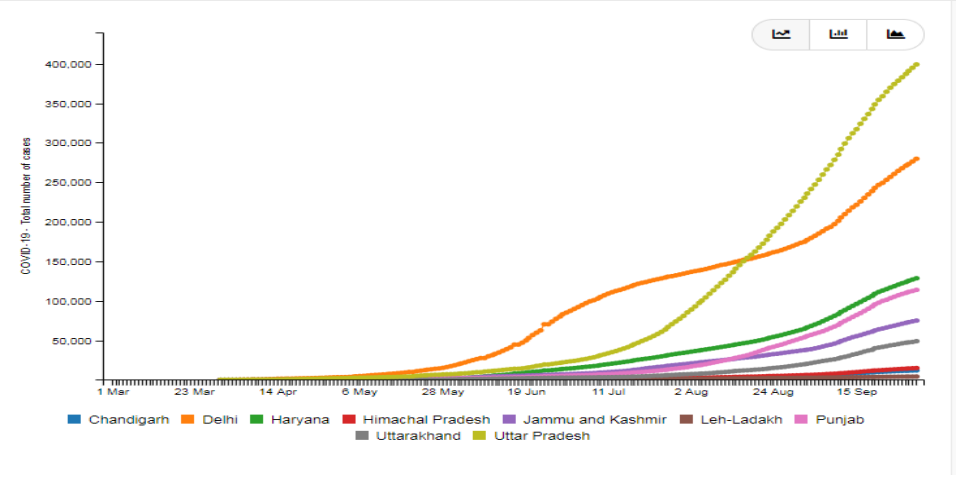

Figure7a. COVID-19 Total number of cases North India

Source: smaartrapidtracker.org (October 1 2020).

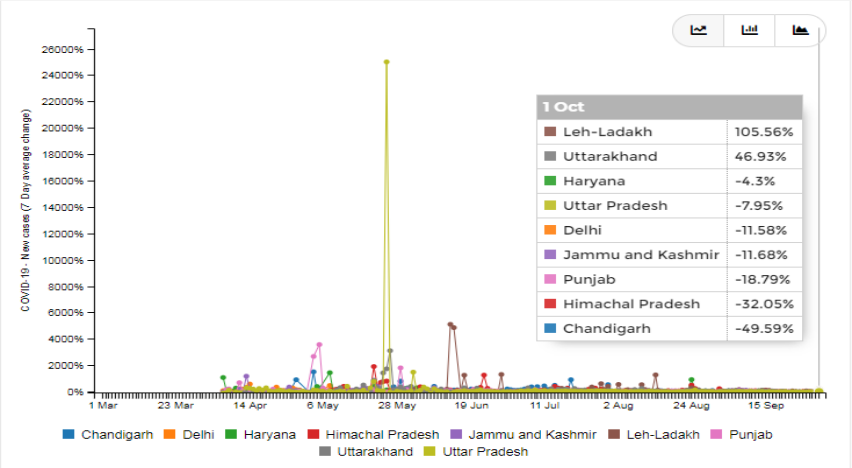

Figure7b. 7- Day average change of new COVID-19 cases North India

Source: smaartrapidtracker.org (October 1 2020).

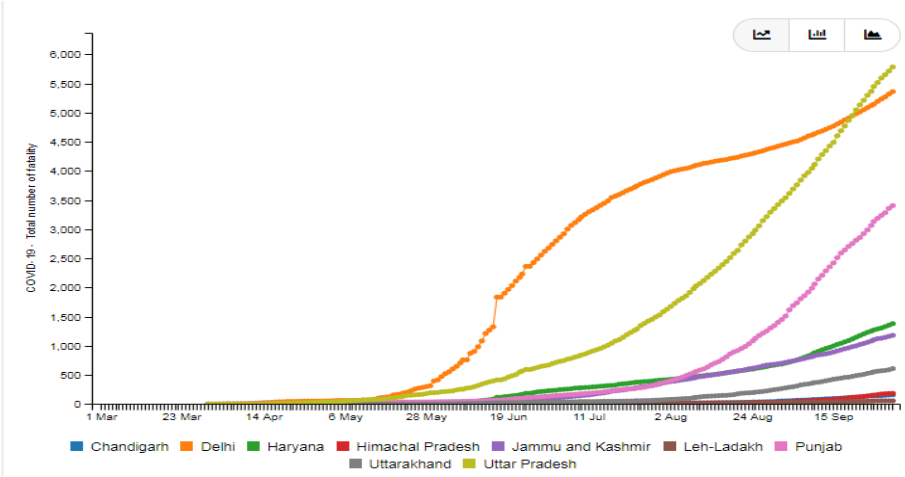

Figure7c. COVID-19 Total number of fatality North India

Source: smaartrapidtracker.org (October 1 2020)

b. COVID-19 burden South Zone

- **Total COVID-19 cases and fatality**: Results showed the highest number of total COVID-19 cases in the state of Andhra Pradesh (n=687351), Karnataka (n=592911) and Tamil Nadu (n=591943) (Figue8a). More than half of the total cases of COVID-19 in the South zone were attributed to the cases in the states of Andhra Pradesh (30%) and Karnataka (26%). Andaman and Nicobar Islands (n=3821) reported the lowest total COVID-19 cases while Lakshadweep islands reported no COVID-19 case. Results showed decline in 7 day average change of new COVID-19 cases across majority of the states in South India except Kerala (39.63%) and Karnataka (14.86%) that showed an increase (Figure8b). However, highest total COVID-19 fatality was seen in Tamil Nadu (n=9,453) and Karnataka (n=8,777). Both of these states attributed more than 69% of the total COVID-9 deaths in the South zone (Figure8c).
- **COVID-19 Tests and Lab centres**: The number of COVID-19 labs was highest in Tamil Nadu (n=188) followed by Karnataka (n=144). Andhra

Pradesh (n=96) had the highest COVID-19 government labs (n=77) as compared to the states of Karnataka (n= 53) and Tamil Nadu (n=66). The number of COVID19 tests was highest in the state of Tamil Nadu (n=744, 1697).

- **COVID-19 Infectivity rate:** States such as Puducherry (13.9%), Karnataka (11.86%) and Andhra Pradesh (11.69%) were the 3 southern states reporting highest infectivity rate. States such as Kerala (6.27%) and Telangana (6.27%) reported the lowest infectivity rate among the southern states of India.

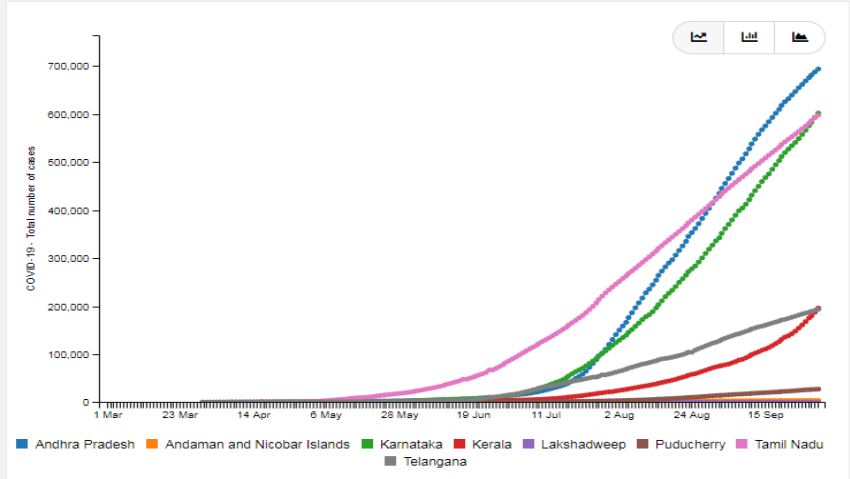

Figure8a. COVID-19 Total number of cases South India

Source: smaartrapidtracker.org (October 1 2020).

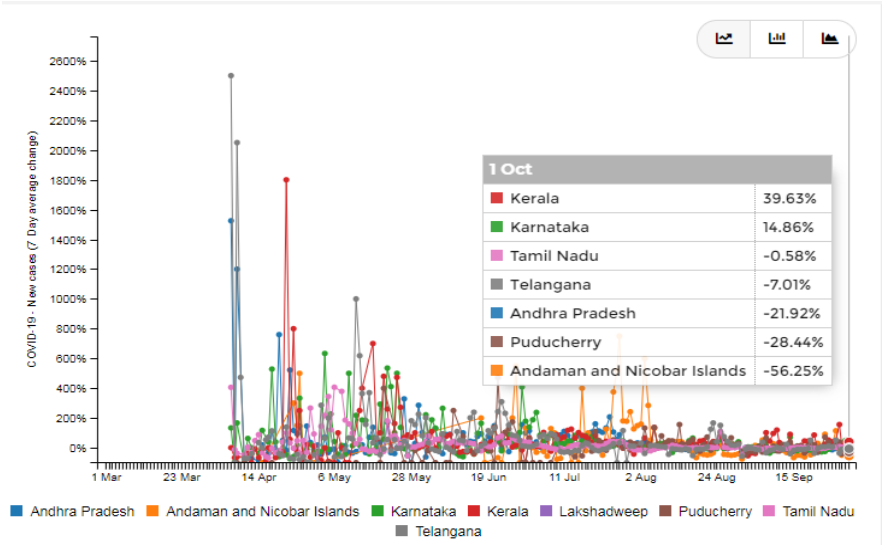

Figure8b. 7- Day average change of new COVID-19 cases South India

Source: smaartrapidtracker.org (October 1 2020).

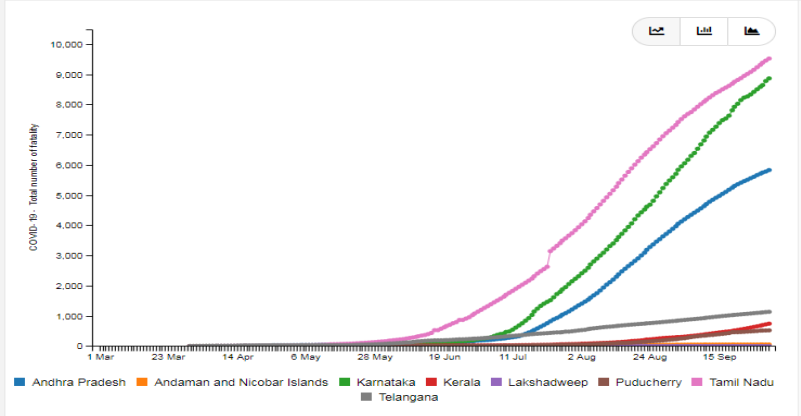

Figure8c. COVID-19 Total number of fatality South India

Source: smaartrapidtracker.org (October 1 2020)

COVID-19 burden East Zone

- **Total COVID-19 case and fatality**: Results showed highest number of total COVID-19 cases in the state of West Bengal (n=253, 768), followed by Odisha (n=215676) and Bihar (n=181285). Jharkhand (n=82540) had reported the lowest total COVID-19 cases (Figure9a). An increase in the 7-day average change of new COVID-19 cases was seen in Bihar (18.57%) and West Bengal (2.66%) (Figure9b). More than half of the fatality in the East zone was attributed to West Bengal (67%; n=4899). Lowest fatality was reported in the state of Jharkhand (9.6%) (Figure9c).
- **COVID-19 Tests and Lab centres**: Though the highest COVID-19 cases and fatality was in West Bengal and Odisha, COVID-19 testing was highest in the state of Bihar (n=7,386, 521) followed by Odisha (n=3, 300, 644) and West Bengal (n=3271316). Of the total COVID-19 labs in the East zone, 41% (n=101) of them were in the state of West Bengal of which majority of them were the government labs.
- **COVID-19 Infectivity rate:** Infectivity was lowest in Bihar (2.45%) while West Bengal had highest infectivity (7.76%), followed by Odisha (6.5%) and Jharkhand (3.61%).

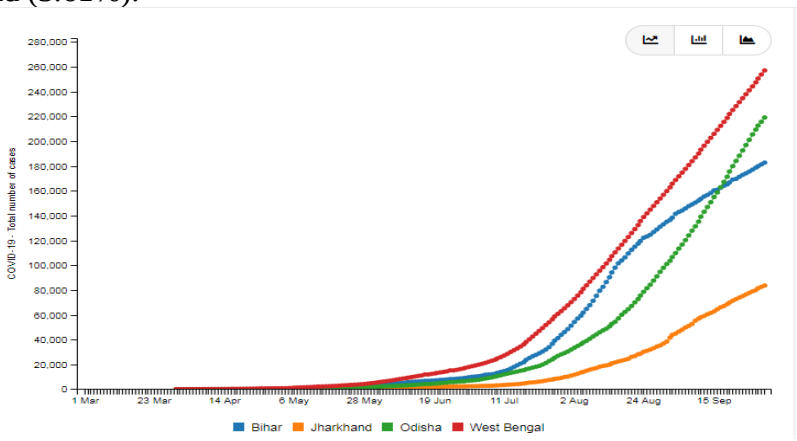

Figure9a. COVID-19 Total number of COVID-19 cases East India

Source: smaartrapidtracker.org (October 1 2020)

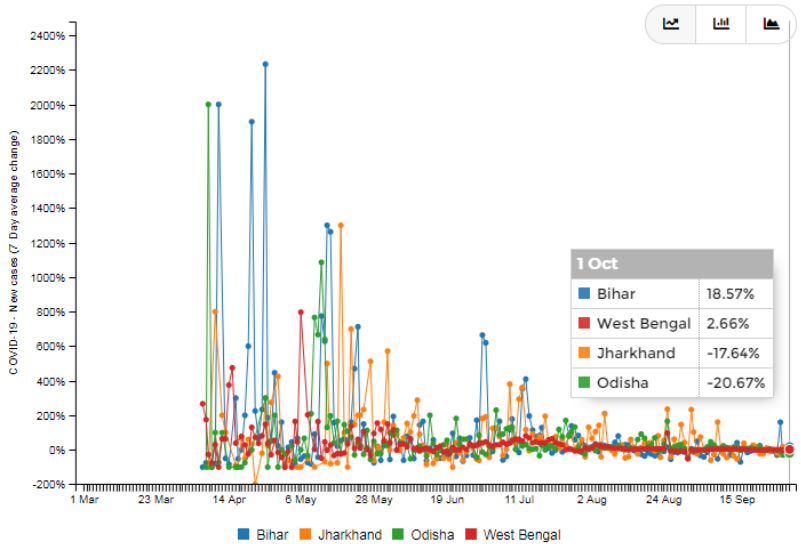

Figure9b. 7 day average change of new COVID-19 cases South India

Source: smaartrapidtracker.org (October 1 2020)

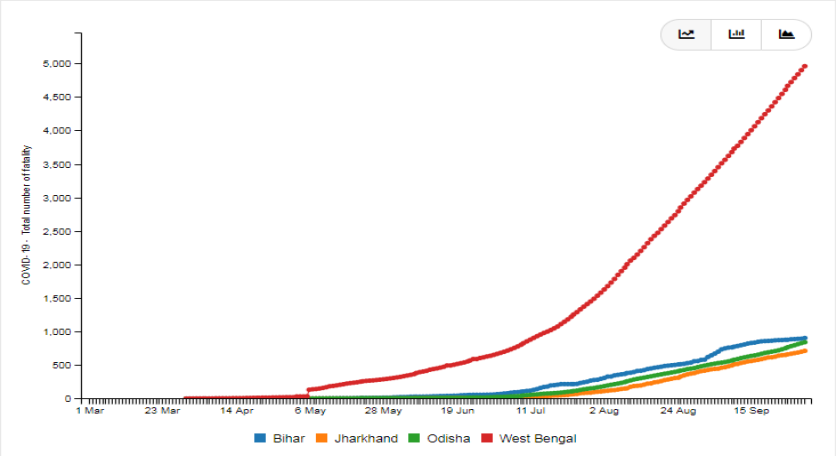

Figure9c. COVID-19 Total number of fatality East India

Source: smaartrapidtracker.org (October 1 2020)

COVID-19 burden Central Zone

- **Total COVID-19 case and fatality**: Total COVID-19 cases in the state of Madhya Pradesh (n=126043) were higher compared to the state of Chhattisgarh (n=110,655) (Figure10a). However, as of Oct 1 2020, there was a 30% increase in the 7-day average change of new COVID-19 cases in the state of Chhattisgarh as compared to Madhya Pradesh that showed a decline of 13% (Figure10b). Similarly, COVID-19 fatality was higher in the state of Madhya Pradesh (n=2281) compared to Chhattisgarh (n=916). Madhya Pradesh attributed nearly 71% of the COVID-19 fatality in the Central zone. (Figure10c).
- **COVID-19 Tests and Lab centres**: COVID-19 testing was higher in the state of Madhya Pradesh (n=2063765) compared to Chhattisgarh (n=1,121, 641). The total number of COVID-19 labs was higher in the state of Madhya Pradesh

(n=97) compared to Chhattisgarh (n=40) and majority of these states had government COVID-19 labs.

- **COVID-19 Infectivity rate:** Chhattisgarh had a greater infectivity rate (9.87%) compared to Madhya Pradesh (6.11%).

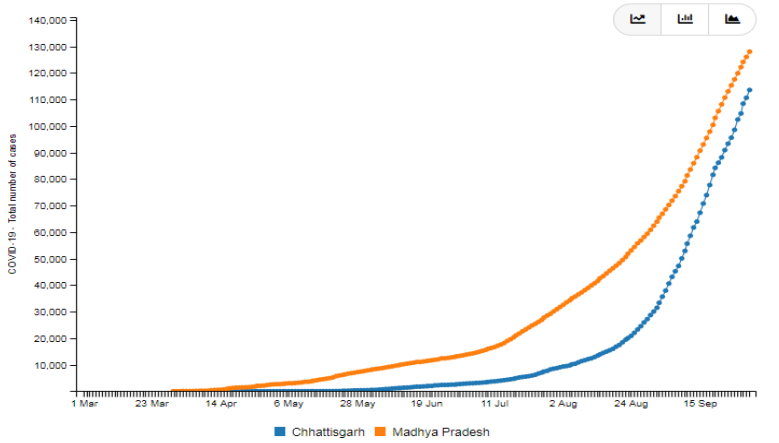

Figure10a. COVID-19 Total number of COVID-19 cases Central India

Source: smaartrapidtracker.org (October 1 2020)

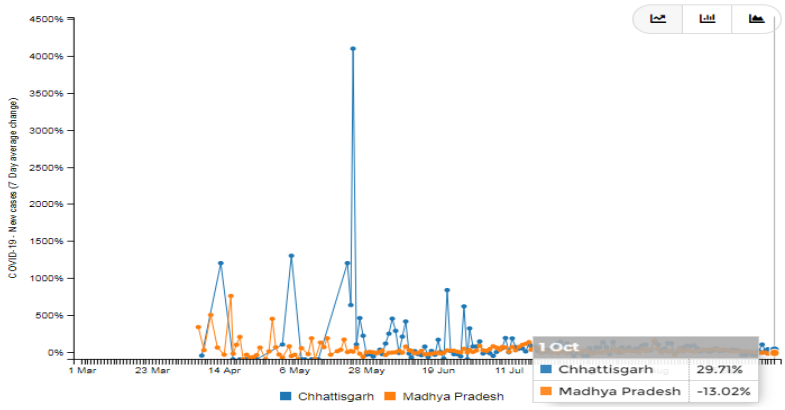

Figure10b. 7-day average change of new COVID-19 cases Central India

Source: smaartrapidtracker.org (October 1 2020)

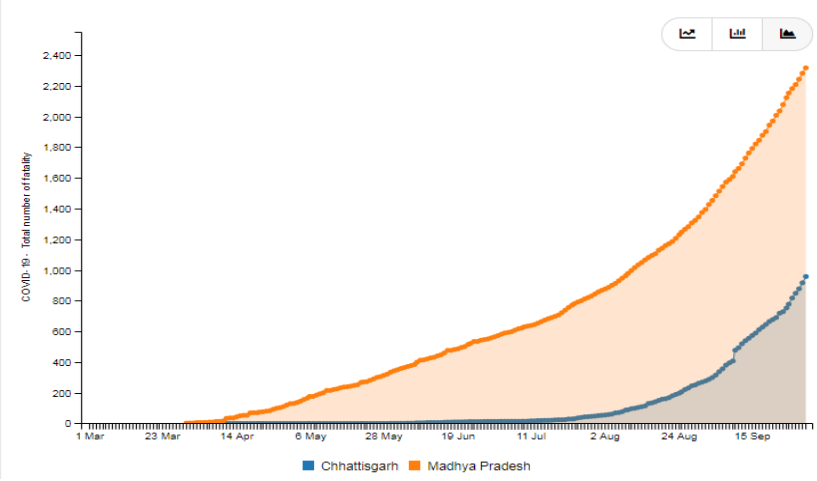

Figure10c. COVID-19 Total number of fatality Central India

Source: smaartrapidtracker.org (October 1 2020)

COVID-19 burden West Zone

- **Total COVID-19 case and fatality:** Total COVID-19 cases in the state of Maharashtra (n=1366129) were highest compared to the total number of COVID-19 cases in the state of Gujarat (n=135842) and Rajasthan (n=133119). Lowest cases were seen in Goa and Dadra and Nagar Haveli and Daman and Diu (Figure11a). The 7-day average change of new COVID-19 cases showed an increase in COVID-19 cases only in Rajasthan while all other states showed decline (Figure11b). COVID-19 fatality was reported highest in the state of Maharashtra (n=36181) contributing 87% to the total fatality occurring in the west zone of India. Goa (1%) and Rajasthan (4%) had the lowest COVID-19 fatality (Figure11c).
- **COVID-19 Tests and Lab centres**: COVID-19 testing was highest in the state of Maharashtra (n=6, 87, 5451) followed by Gujarat (n=4, 47, 4766) and Rajasthan (n=3, 14, 3572). Similarly, the number of total COVID-19 labs was also highest in the state of Maharashtra (n=172) followed by Gujarat (n=72) and Rajasthan (n=45). Fifty percent of the labs in Maharashtra were government labs.
- **COVID-19 infectivity rate:** Goa with lowest number of total cases and fatality showed higher COVID-19 infectivity (12.76%) compared to Gujarat (3.04%) and Rajasthan (4.23%) as of October 1 2020. However, Maharashtra had the highest infectivity rate (20%) compared to all other states in India.

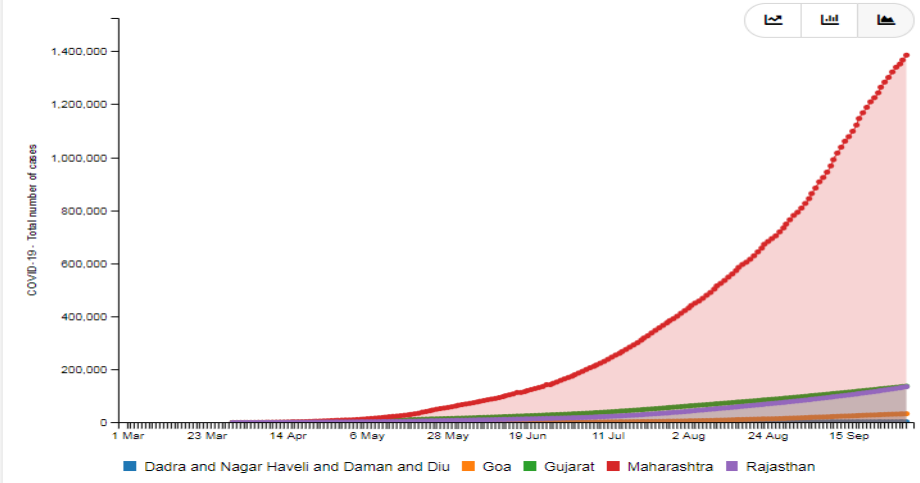

Figure11a. COVID-19 Total number of cases West India

Source: smaartrapidtracker.org (October 1 2020)

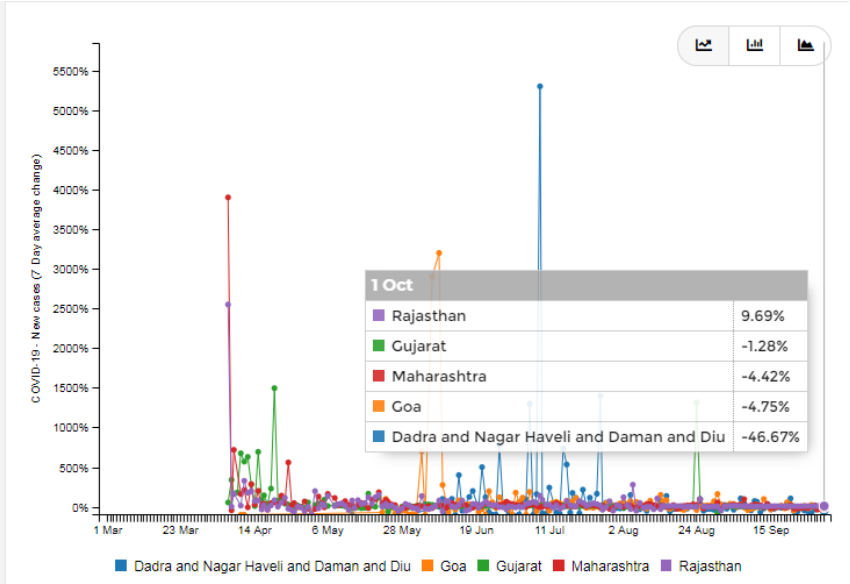

Figure11b. 7-day average change of new COVID-19 cases West India

Source: smaartrapidtracker.org (October 1 2020)

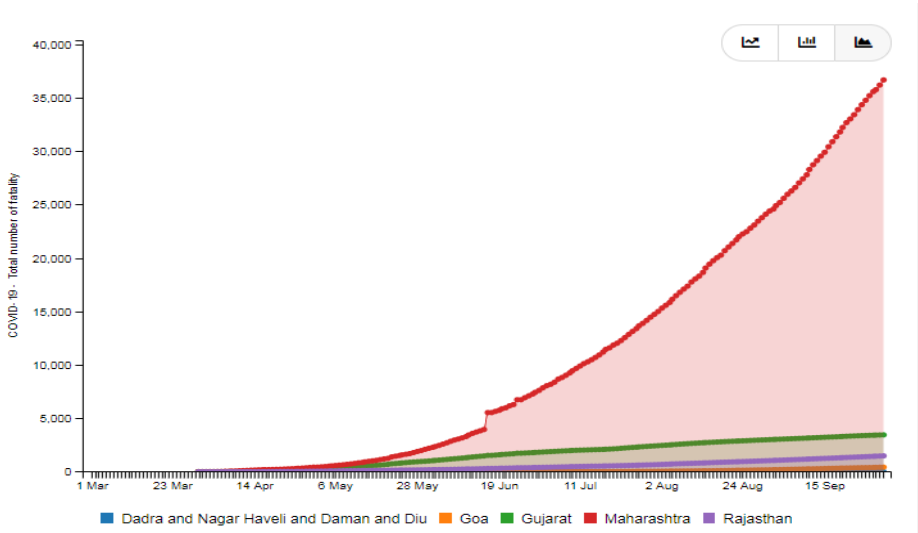

Figure11c. COVID-19 Total number of fatality West India

Source: smaartrapidtracker.org (October 1 2020)

COVID-19 burden North East Zone

- **Total COVID-19 case and fatality**: Results show highest COVID-19 cases in the state of Assam (n=177221) compared to other North Eastern States (Figure12a). Assam (73.94%) and Tripura (10.74%) contributed towards greater burden of COVID-19 cases in North East India. (Figure12a) 7-day average change of new cases of COVID-19 showed decline in these cases only in 3 of the North-eastern states including Tripura, Arunachal and Mizoram (Figure12b). Nagaland, Assam and Meghalaya showed the highest increase in the 7-day average change of new COVI-9 cases. More than half of the COVID-19 fatality was in Assam (59%; n=680) followed by Tripura (24%; n=277), Manipur (5.7%; n=65) and

Meghalaya (4.13%; n=47). No COVID-19 fatality has been reported in Mizoram as of October 1 2020 (Figure12c).

- **COVID-19 Tests and Lab centres**: COVID-19 testing was highest in the state of Assam (n=3563210) compared to Tripura (n=391684), Manipur (n=243870) and Meghalaya (n=153177). Number of total COVID-19 labs was highest in the state of Assam (n=35) with more than half of them being the private labs (57%; n=20).
- **COVID-19 infectivity:** Nagaland (7.51%), Tripura (6.57%) and Sikkim (5.8%) are some of the common North-eastern states with high COVID-19 infectivity rate as of Oct1 2020. Mizoram (2.49%), Meghalaya (3.57%) and Arunachal Pradesh (3.81%) reported lowest COVID-19 infectivity rate. Though Assam had the highest number of COVID-19 cases and fatality, the infectivity rate was 4.9%.

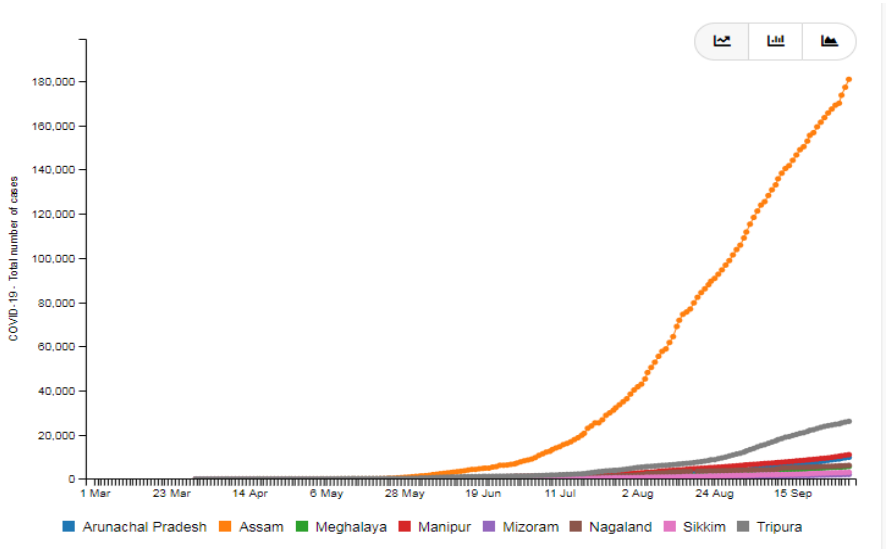

Figure12a. COVID-19 Total number of cases North East India

Source: smaartrapidtracker.org (October 1 2020)

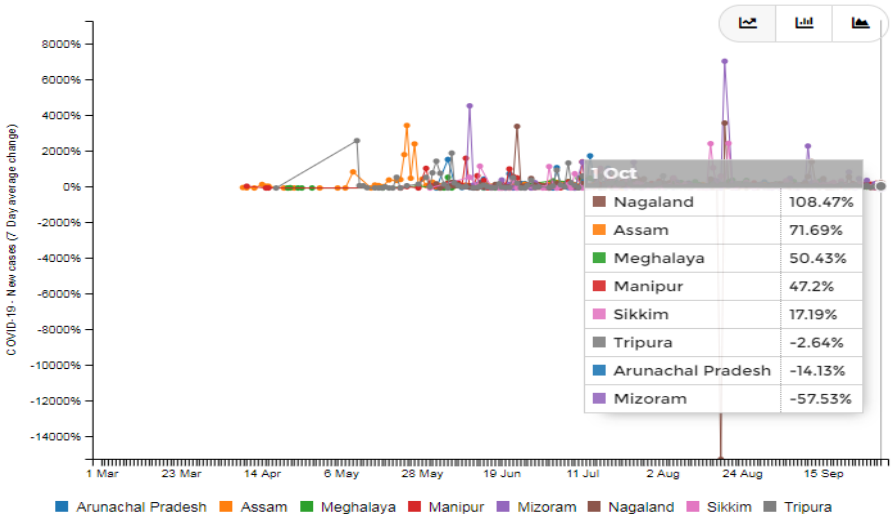

Figure12b. 7 days average change of new COVID-19 cases North Eastern India

Source: smaartrapidtracker.org (October 1 2020)

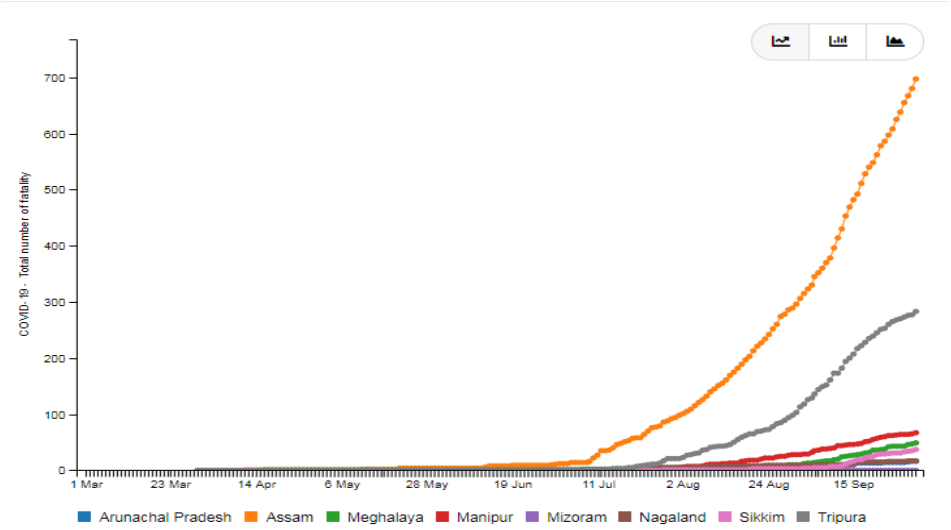

Figure12c. COVID-19 Total number of fatality North Eastern India

Source: smaartrapidtracker.org (October 1 2020)

Sub-Analysis

We stratified the states/UTs by COVID-19 infectivity rate into three categories including: Group1 having an Infectivity Rate <=5.99%; Group2 having an Infectivity Rate between 6.00% to ≤10.00% and Group 3 having an infectivity rate greater than 10% (Table2). Forty percent of the states/UTs were in Group1with an infectivity rate <=5.99%. More than half of the states (64%; n=9) were from North-east and West parts of India followed by 21% (n=3) from North India and 14% (n=2) from East India. None of the states /UTs were from either South or Central parts of India. Highest Infectivity Rate was seen in West India including Maharashtra (IR=19.87%), followed by North Indian state of Chandigarh (15.07%). Lakshadweep Island was one of the only UT in South India that had zero infectivity rate due to COVID-19. Forty three percent (n=15) of the Indian states and UTs were in Group 2 with an infectivity rate of 6.00% to ≤10.00%. More than half of the states/UTs in Group2 were from North (33%) and South (26%), while 13% of them were states/UTs from East, Central and North-east parts of India. None of the states from West India were in Group2. Seventeen percent of the states and UTs were in Group3 with highest infectivity rate of greater than 10%. Fifty percent of these states were from South India including Andhra Pradesh (11.69%), Karnataka (11.86%) and Puducherry (12.76%).

Table2. States/UTs stratified by Infectivity rates into 3 groups (As of October 1 2020)

States/UTs of India (n=36)		
Group1 ***Infectivity rate <=5.99%.***	**Group2** ***Infectivity Rate between 6.00% - ≤10.00%***	**Group3** ***Infectivity rate > 10%***
Bihar (East)	Punjab (North)	Andhra Pradesh (South)
Mizoram (North Eastern)	Madhya Pradesh (Central)	Karnataka (South)
Gujarat (West)	Kerala (South)	Goa (West)
Meghalaya (North Eastern)	Telangana (South)	Puducherry (South)
Jharkhand (East)	Andaman and Nicobar Islands (South)	Chandigarh (North)
Arunachal Pradesh (North Eastern)	Haryana (North)	Maharashtra (West)
Uttar Pradesh (North)	Odisha (East)	
Rajasthan (West)	Tripura (North Eastern)	
Manipur (North-Eastern)	Uttarakhand (North)	
Jammu and Kashmir (North)	Nagaland (North Eastern)	
Dadra and Nagar Haveli and Daman and Diu (West)	West Bengal (East)	
Himachal Pradesh (north)	Leh- Ladakh (North)	

Results of the study show spatiotemporal COVID-19 trends across different parts of India that help us inform data driven, evidence-based policy making. The geographic variation in the COVID-19 cases and fatality will help us explore factors that are influencing the spread of the virus and help respond accordingly. High infective rates across different Southern states of India have been observed. Monitoring spread of the COVID-19 virus will help policy makers take comprehensive and necessary measures sufficient to take control of the disease.

Discussion

India has the second highest population after China which makes it more vulnerable to COVID-19. The first case of COVID 19 was reported in India on January 29 when a Kerala student returned from Wuhan, China. The first 100 COVID-19 cases were reached by March15 2020 and the first 1000 COVID-19 cases by March 31 2020. As of October 1 2020, India had a total of 6225763 COVID-19 cases and fatality of 98,678. Our study outlines spatiotemporal COVID-19 trends to examine the extent of states affected due to COVID-19. As of October 1 2020, the states/union territory with the highest number of total COVID-19 cases was Maharashtra (n=1366129) and with a total of 36181 COVID-19 specific deaths. The state had recorded the highest fatality in India. Results show an overall decline in the 7-day average change of new COVID-19 cases and new COVID-19 fatality in India as of October 1 2020.

Results show greater total COVID-19 cases in South India, but total fatality was higher in West India attributed primarily to the state of Maharashtra. Higher infectivity rate across several states such as Maharashtra (19.87%), Chandigarh (15.07%), Puducherry (13.7%), and Goa (12.76%) highlight need of measures such as social distancing, wearing masks, and hand washing. Further it also highlights the importance to prepare healthcare facilities with essential medical and other equipment supplies. The circumstances in COVID19 is highly uncertain, and hence it becomes challenging to envisage the course of the novel coronavirus.

India is a vast country, and most of the Indian states are quite large in the geographic area and population. Analysing coronavirus infection data, considering entire India to be on the same page, may not provide us the right picture. This is so because the total cases, new infection-rate, progression over time, and preventive measures taken by state governments and the common public for each state are different. Each state needs to be tackled differently and will enable the government to utilize the limited available resources in an effective manner.

SMAART RAPID Tracker displays visual trends in infection rates and can provide us whether the COVID-19 is under control or not in a specific state. There are many states like Maharashtra, Chandigarh, Puducherry, Goa, Karnataka, and Andhra Pradesh with very high infectivity rates are already at high risk. Similarly, other states such as Chhattisgarh, Delhi, Tamil Nadu and West Bengal are the states that may see a huge jump in confirmed COVID-19 cases if preventive measures are not implemented properly.

We examine COVID-19 infection in each state and union territory as of October 1 2020. Total cases and fatality per million are also represented for better comparison purposes. Results visualize the snapshot of the pandemic on 1st October throughout the country and also presents the total number of COVID-19 tests conducted for each state and the total lab facilities as on 1st October 2020.

We also examined the onset of first COVID-19 fatality after first reported case of COVID-19. Results showed variation in the number of days when first fatality due to COVID-19 was reported after first reported case of COVID-19. States and UTs such as Meghalaya (n=2days), Karnataka (n=4 days), and Bihar (n=7 days) showed earlier onset of COVID-19 fatality. However, other states and UTs such as Andaman & Nicobar Islands (n=123 days) and Manipur (n=127 days) reported their first fatality nearly after 3 months of their first reported case of COVID-19. The approaches to addressing the states must be different due to limited resources. Policy makers need to identify early at risk infected-clusters as quickly as possible. India due to its rich diversity and vast population, would need to look at each of the states individually to decide further actions to contain the spread of the disease, which can be crucial for the specific states only.

Almost all the nations including India have been greatly impacted and attempts to control and expend efforts on containment of COVID-19 are ongoing. Future work should incorporate additional data elements such as clinical data, COVID-19 hospitalization and treatment data combined with social determinants of health data such as education, income, healthcare access to design and develop a more robust and highly responsive surveillance systems to have better ability to track the spread of COVID-19 and its impact in years to come.

Limitations

Although the present study focuses on examining the spatiotemporal variation of COVID-19 burden across Indian states and union territories using SMAART RAPID Tracker, but the data

from the SMAART RAPID Tracker may be used for a comprehensive inter disciplinary approach with respect to other diverse fields like economics, environment and other social and medical sciences. This can further enhance our understanding and help in preparing a rapid and evidence-based response to other unforeseen pandemics.

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