

Covid-19 pandemic in India: Chronological comparison of the regional heterogeneity in the pandemic progression and gaps in mitigation strategies

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Abstract

COVID-19 second wave, in India, exerted more catastrophe than the first. The progressions of both waves were heterogeneous in the six different regions involving 28 states and 8 union territories. An analysis of the temporal variations in new cases and fatalities in all the states of India was done for both the 1st (30th January 2020 to 31st January 2021) and 2nd wave (1st February 2021 to 29th May 2021) showed India accounted for over 16% and 9% of the cases and fatalities of the world respectively. The Southern and Western regions remained the top contributor of cases and fatalities in both waves. The state of Punjab and Maharashtra reported the highest CFR (3.24 and 2.5 respectively) in the country during 1st wave, and in the second wave, Andaman & Nicobar Islands (2.6), and Punjab (2.25) reported the highest CFR. Goa and Delhi showed the highest CCR and CDR for 1st wave respectively, whereas Lakshadweep and Goa reported the highest CCR and CDR respectively in the 2nd wave. The study comprehends the severity of the second wave over all the states of the country, highlights major hotspots regions and some gaps in mitigation strategies.

Introduction

India is currently the second-largest contributor of total COVID-19 cases of the world, accounting for about 16% of the total cases and around 9% of deaths worldwide¹. The Indian subcontinent reported its first case of COVID-19 on January 30th, 2020² from Kasargod district in the state of Kerala. However, most of the other states reported their first cases in March 2020, and during this period the number of active cases started to amplify at a rapid pace. Amid this crisis, the government of India announced a nationwide lockdown with implementations of public health and social measures³, but in spite of such stringent measures, the cases in India showed a steady acceleration in numbers, particularly aggravated after the unlock phase 1 from 31st May, 2020. In most of the states, the surges in cases were visualized from the beginning of June 2020, which reached their respective maxima in the middle of September, 2020⁴. The first wave however subsided towards the end of January 2021 with only about 1.5 lakhs active cases and a much lower test positivity rate in the whole subcontinent⁵. This led to the withdrawal of many restrictions on social and political gatherings, albeit the consequence of these measures turned out to be catastrophic soon afterward⁶. Towards the beginning of March 2021, the number of infections began to soar, which marked the beginning of the catastrophic second wave of COVID-19 pandemic that overwhelmed the medical facilities of most of the states and compelled the state governments to implement lockdown-like restrictions⁷. The emergence of new indigenous mutants of the SARS-CoV-2 virus along with other international mutants was accessed as one of the major reasons for such a surge in cases^{8,9} and fatalities in the second wave of the pandemic.

The Indian subcontinent is characterized by diverse geographical and demographical regions, populated by heterogeneous cultural, political, linguistic, and ethnic groups of people^{10,11,12}, covering an area of 3.28 million square kilometers with a total population of about 138 cores^{13,14}. Thus the progression pattern of the pandemic was also turned out to be heterogeneous in each region of the country, which

therefore demands the analysis of chronological heterogeneity in the regional and state-specific infection rates, death rates, wave patterns, and testing capacities for a clear interpretation of the progression patterns of the wave across the country. In this study, we did a comprehensive analysis of the chronological changes in the first and the second-wave patterns of the pandemic in each region of the country and its respective states. India comprises 28 states and 8 unions territories¹⁵, divided along 6 administrative subdivisions,¹⁴ the Northern region(NR), Central region(CR), Western Region (WR), Eastern (ER), North Eastern Region (NER) and Southern region (SR), Indian states (Table-1,2). The analyses of the progression patterns of the two waves across these different subdivisions and their respective states are a significant step forward to evaluate the real scenario of the COVID-19 situation across the nation as well as the pandemic mitigation strategies.

Methods

Study design and data sources

A detailed study of the COVID-19 infections and their related statistics in India was done between January 2020 to May 29th, 2021. The days of first reported infection, rising(10% consistent increase in active cases) and declining phases of the two respective pandemic waves, wave's peak, numbers of new infections, death, recoveries along with the testing and demographical data for all the 6 administrative regions comprising of 28 states and 8 union territories of the country, were obtained from the online monitoring official website of the Government of India⁴ and other government and international websites.¹⁶ The pandemic wave or phase was defined as a rising number of COVID-19 cases with a definite peak, which was followed by a declining number of cases, or the trough period, where the rates of new infections and active cases have declined significantly. The day reporting the highest number of active cases was defined as the peak of the wave. The number of monthly new cases, recoveries, and deaths for each state were calculated, the chronological (monthly) contribution of new cases, deaths, and recoveries of each administrative region of the subcontinent, was calculated by summing up the respective values of the aforesaid parameters of all the states and union territories of the concerned region.

Statistical Analysis

CCR, cases per 1 lakh or 100000 populations; CDR, deaths per 100000 populations], CFR; the number of deaths reported per number of cases reported $\times 100$), tests per case (total tests: total case) ratio for both the first (30th January 2020–31st January 2021) and second waves (early February 2021 till 29th May, 2021) of the pandemic were calculated. The weekly-average numbers of confirmed cases, active cases, and deaths were quantified by estimating the changes in numbers from one day to the other day average over the span of a week. The fold changes, for the Kumbh Mela 2021, were calculated by dividing the weekly-average numbers of the later week (3rd May – 9th May 2021) by the earlier week (1st March – 7th March, 2021). The fold changes in average daily new cases for each month [before LAE (march-21),

during LAE (April-21), and after LAE (May-21)] for the 5 States which underwent elections were calculated and compared with 5 states (a major contributor of cases) that had no major public gathering events.

Results

A chronological overview of the contributions of different regions of India towards the cases and fatalities in the two waves

The chronological variations in the number of new cases and new deaths in India (Fig. 1A and 1B) and the contributions of different regions of the country towards the total cases and fatalities of the nation are noteworthy (Fig. 1E and 1F). At the beginning of the 1st wave, the SR accounted for nearly 40% of total cases in March 2020 (Fig. 1C). From April, 2020 till June 2020, the WR remained the major contributor of COVID-19 cases, (43%, 46%, and 31% of the total cases in the respective months). Subsequently from June 2020, when the first phase of unlocking (unlock-1) started in the country (Fig. 1A), till the end of October 2020, the SR contributed 41%, 40%, 34%, and 41% of the total COVID-19 cases of the country in the respective months (Fig. 1C). Only in November 2020, the NR became the highest contributor of new cases (31%), however from December 2020 till February 2021 (in the declining phase of 1st wave), SR contributed 31%, 47% and 43% of the total cases in the subsequent months (Fig. 1C). At the beginning of the rising phase of the second wave, from March 2021 till April, 2021, the WR contributed about 63%, and 30% of the nations' total cases respectively. In May 2021, the SR once again turned out to be the major contributor of new cases in the country (42%) (Fig. 1C).

In terms of fatality, the WR accounted for the highest monthly fatality from March 2020 till October 2020 (contributed nearly 35%, 59%, 62%, 51%, 41%, 37%, 39%, and 31% of total monthly deaths of the nation respectively) (Fig. 1D). The NR contribute over 33% and 31% of total fatality in November and December 2020. The WR was the highest monthly contributor of COVID-19 related fatality from January 2021 till April, 2021 (30%, 40%, 39%, and 33% of total fatality). However, in May 2021, the SR accounted for the maximum proportion of fatality of the country (28%) (Fig. 1D). Thus, it can be inferred from these results that both the Western and Southern Indian states have been the major hotspots of the COVID-19 pandemic in the Indian subcontinent (Fig. 1E, F)

The first wave of COVID-19 in India – A detailed analysis

Apart from Kerala, most of the Indian states reported their first infection in March or April 2020. The Government of India has implemented a nationwide complete lockdown protocol from 25th March 2020 to combat the spread, like many other nations. A continuous lockdown was applied, in four phases, until 31st May 2020. The unlock process, implemented in six phases, commenced from 1st June, 2020 to 30th November, 2020.¹⁷ The daily-cases though began to surge steadily, especially from the end of May 2020 (just before the beginning of the 1st phase of unlock) to September 2020 in the majority of the states (Table-1). The adverse effects of unlocking can be understood from the following statistics – from the week, before the last week of lockdown (18th May 2020 to 24th May 2020) to the week, after one

continuous week of unlock (8th June 2020 to 14th June 2020), the change in weekly-average numbers of new confirmed cases, active cases, and deaths respectively showed increases from 6369 to 11170 (1.75-fold), from 3153 to 4048 (1.28-fold), and from 144 to 340 (2.35-fold) (analysis not shown).

India reported the maximum number of daily new cases on 16th September 2020 (around 98,000) and maximum active cases on 17th September 2020 (1018454), which was marked as the peak of the wave. Subsequently, both the figures of daily and active cases started to drop steadily in the following weeks, till the end of January 2021, when the number of daily cases reduced to around 10,000 cases/day; marking the trough of the wave.

Among the 10758629 cases reported during the first wave, the highest number of cases was reported from the SR (3933360) which contributed to 36.5% of the total cases. The top contributor state from the SR was Karnataka (about 8.7%), followed by others (Table-1). Lakshadweep islands, which happened to be the last area of SI to report its first infection have contributed minimum to the nation's total cases (0.0008%). The WR comes next, which contributed 21.6% of the nation's total cases, where the top contributor state was Maharashtra (reported 2026399 cases, ~ 18.8%). States of the NR, coming next, accounted for about 16.4% of total cases where the highest contributor was the national capital, Delhi (5.9%). The ER shared 11.8% of the nation's total cases, where West Bengal contributed mostly (~ 5.3%). The CR of India produced 10.7% of the total cases, where Uttar Pradesh (5.5%) was a major contributor. The NER was the lowest contributor of cases and deaths and accounted for only 3% of the total cases of the first wave where Assam shared for the majority of cases (2%), whereas the other 7 states altogether accounted only for 1% of the cases (Table-1). The dates, representing the peaks of active COVID-19 cases, varied for the states and UTs (Table-1).

The CCR (number of cases/1 lakh of the population) was found to be highest in Ladakh (3352 cases/1 lakh) followed by Delhi (3175) and Chandigarh (1773) from the NR. The other states and union territories which reported a case/1 lakh ratio of more than 1000 are Uttar Pradesh (2668) and Chattisgarh (1053) from the CR, Goa (3468) and Maharashtra (1661) from the WR, and Andhra Pradesh (1707), Karnataka (1423), Kerala (2655), Telangana (1103), and Puducherry (2605) from the SR (Table-1).

In addition to contributing the second-highest number of COVID-19 cases, states of the WR also contributed the maximum number of deaths (accounted for 36.4% of the total deaths of the country) during the first wave out of a total of 154428 deaths nationwide. The state of Maharashtra accounted for the most number of deaths in the region (33%), followed by Gujarat (2.8%) and Goa (0.5%). The trend remained similar for the SR, which in line with its highest contribution to the number of cases, also accounted for 24.4% of the total deaths of the nation, where Karnataka (8%) and Tamil Nadu (8%) were the two major contributors (Table-1). Contribution from the Northern states were about 17.7% to the total number of fatalities of where Delhi was the major contributor (7%), followed by other states (Table-1). The CR, in this regard, accounted for 10.5% of the total deaths, where Uttar Pradesh (5.6%) reported the maximum number of deaths (Table-1). Among the 9.5% of the total deaths, contributed by the ER, West Bengal (6.6%) was the major contributor (Table-1). The NER states reported the least mortality and

contributed only about 1.51% of the total deaths of the nation (Table-1). The highest CDR was however reported by the national capital, Delhi (54 per 100000 population), followed by Goa (50), Ladakh (45), and Maharashtra (42) (Table-1).

The CFR was found to be highest in the state of Punjab (3.24) in the NR, followed by Maharashtra (2.5) in the WR with Sikkim (2.18) stands next from the NER. The state of West Bengal (1.785) accounted for the highest CFR from the ER, followed by Uttarakhand (1.71), Delhi (1.71) and Himachal Pradesh (1.69) from the NR. Among the states of Southern India, Puducherry (1.66) recorded the highest CFR (Table-1).

Regarding the testing of cases, until the end of January 2021, more than 22.84 crores (1 crore = 10 million) COVID-19 tests were performed all over India, of which the national capital, Delhi (4.81%) recorded the highest percentage from the NR, Uttar Pradesh (12.26%) tops the list from the CR, Maharashtra (6.57%) from the WR, Bihar (9.19%) from the ER, Andhra Pradesh (7.88%) from the SR, and Assam (2.83%) from the NER. The WHO has recommended an optimum of 30, test per case ratio (T: C), as standard; however apart from the states, like Jammu and Kashmir (36.5), Uttar Pradesh (46.6), Gujarat (42.1), Bihar (80.5), Jharkhand (44), Mizoram (48), and Andaman and Nicobar islands (44), all other states and union territories had a T: C ratio less than the WHO recommended mark of 30 tests/case¹⁸. (Table-1).

The second wave of COVID-19 in India – A detailed analysis

The period between the end of February, 2021 and early March, 2021, marked the rising phase of the catastrophic second wave of the COVID-19 pandemic in India. During this period, the country reported more than 3 lakhs new cases/day in April that soared to over 4 lakhs cases/day and over 4000 daily deaths in the first week of May, 2021, overburdening the healthcare system of the country. On 6th May, India reported its highest number of over 414280 new cases, which marked the peak of the wave until now. Thereafter, the daily cases started to dip gradually, however the fatality rate remained high.

Starting from 1st February till the 29th May, 2021, India reported a total number of 17134975 cases and over 1.7 lakh deaths. Until 29th May, 2021, the SR remained the top contributor of cases (32%) and the third major contributor of fatalities (22%), where the state of Karnataka (9.5%) and Kerala (9.1%) together accounted for more than half of the total cases of theregion, and again Karnataka (9.3%) and Tamil Nadu (6.3%), like in the first wave, were also the major contributors to the nation's fatalities (Table-2). Until 29th May, the WR contributed over 25% and 29% of the COVID-19 related cases and fatalities respectively, where Maharashtra was major contributor (21% and 25% of the cases and deaths). The NR contributed about 16% and 27% of the total cases and fatalities respectively, where Delhi, was the major contributor (4.6% and 7.7% of cases and fatality respectively). The CR accounted for about 13% and 14.5% of cases and deaths respectively, where Uttar Pradesh was major contributor (6.3% and 6.7% of cases and fatalities respectively). The ER contributed around 10.8% and 7.7 % cases and fatalities of the country respectively where West Bengal is the highest contributor (10.8% and 7.7% of total cases and fatalities respectively). The NER reported the least number of cases (1.63%) and fatalities (2%) in the country,

where the major contributor was Assam (over 1% and 1.2% of the cases and fatalities respectively) (Table-2).

Until 29th May, 2021, the highest CFR was reported by Andaman and Nicobar Islands (2.59) where 51 deaths were reported out of 1970 cases, followed by Punjab (2.23) from the NR and Nagaland (2.22) from the NER. The highest number of CDR was found for Goa (118 deaths/1 lakh), followed by Uttar Pradesh (51), and Lakshadweep islands (45). Lakshadweep was also found to contribute highest to the CCR (11084 cases/1lakh), followed by Uttar Pradesh (4835) and Chandigarh (3289). It is noteworthy that apart from Andaman and Nicobar Islands (86 tests/case), Himachal Pradesh (49), and Ladakh (29), the other states and union territories were lagging behind the recommended WHO level¹⁸.

One of the major contrast between the first and second wave is the evolution of new variants of the novel SARS-CoV-2 virus during the second wave which triggered a sudden surge in cases in most regions of the country. The three imported viral variants of concern that have been identified in India are the UK (B.1.1.7) variant, the South African (B.1.351) variant and the Brazilian (P1) variant, among which the B.1.1.7 variant was predominantly present in Delhi and Punjab in April, 2021. Among the two novel variants of India, the highly contagious B.1.617 variant from Maharashtra has started evolving rapidly and overtook the B.1.618 variant in West Bengal, and eventually became the major variant in most of the states. The WHO has already designated the B.1.617 variant as 'variant of concern' in May, 2021. This variant has spread in all states across the nation and is identified as one of the major causes of the calamity associated with the second wave of COVID-19 in India (especially in Delhi, Andhra Pradesh, Gujarat, Maharashtra and Odisha), as per the study conducted by the Indian SARS-CoV-2 Genomics Consortium (INSACOG), which was launched by the Ministry of Health and Family Welfare, Govt. of India, on 30th December, 2020.^{19,20}

Roles of some major mass-scale public gatherings in the second wave

Mass scale public gatherings like Kumbh Mela 2021 (9 million participants), state elections (covering 243 million residents) have contributed in faster and elevated spreading of the second wave.^{21,22} A 117-fold increase in the number of weekly-average new cases and a 266-fold increase in the weekly-average new deaths were found for the state of Uttarakhand when we compared the data between before and after the festival. Uttar Pradesh, like Uttarakhand also showed a sharp jump in the weekly-average new cases and deaths – respectively a 240-fold and 201-fold increase in the numbers of weekly-average new cases and deaths (Table S1 and Fig. S1). These numbers are much higher than the fold-increase found for the cases (20.9-fold) and deaths (35.4-fold) for the entire nation (except these two states) between the mentioned weeks. Five states Assam, Kerala, Puducherry (UT), Tamil Nadu, and West Bengal that witnessed their 'legislative assembly elections' (LAE) from late March to end of April 2021 also reported a substantial increase in the average daily cases after the elections compared to some of the states with no LAE or major public gatherings (Fig-S2, Table S2); mainly attributed to the election-related rallies and mass-scale public meetings organized by the local political parties²³. However, it is noteworthy that

dissecting out the exact contributions of such gatherings from the general increase in the numbers of cases and deaths due to aggravation of the pandemic itself is out of scope.

Discussion

The second wave of COVID-19 pandemic resulted in total disarrays in all states of the country; an escalation of the infections in such a large magnitude was never expected. While the first wave caused a little over 1.08 crore infections and over 1.5 lakhs fatality in the whole country within a period of 11 months, the ongoing second wave resulted in over 1.7 crore infections and nearly 2 lakhs fatalities in a span of merely 4 months resulting in an unprecedented chaos in the supplies of life-saving drugs and oxygen together with non-availability of hospital beds in most of the parts of the country²⁴. The average daily new cases during April 2021 was around 2.31 lakhs cases/day which soared to about 3.01 lakhs cases/day in May 2021, which is nearly 2.7 and 3.5 times of the average daily cases (87,000 cases/day) of September 2020 (when India reported its peak of the first wave). The CCR and CDR for the second wave were also found to elevate substantially in comparison to the first wave (Fig. 2A and 2B), which comprehend the high rate of infection and fatalities in the country. However, the CFR for both the waves did not show significant variation for the majority of the states to date (Table-1 and 2), which is most likely due to the similar death rates of all existing variants of the SARS-CoV-2 virus in India. Thus, the total numbers of infection and death have together increased during the second wave without changing the CFR. The advent of new and more infectious variants of the virus, inaccuracy in diagnosis, lack of testing, non-transparency in data sharing, low rate of vaccination, decreased rate of genome sequencing of the COVID-19 positive samples along with unchecked social, religious (like Kumbh Mela 2021), and political gatherings (legislative assembly general elections) towards the beginning of the year, and the serious lack of COVID-19 mitigation measures, despite previous warnings, were held responsible for this unprecedented escalation of the pandemic in the country by many reports^{25,26,27}. Despite an increase in daily test numbers, the test/case ratio has dropped in the majority of the states in the second wave. Thus, the need of the hour is to accelerate the testing rates both in the rural and urban regions of the nation to get a clear picture of the infection scenario²⁸ that may aid to avert the nucleation of another catastrophic wave of the pandemic²⁹.

A comprehensive evaluation of the available data specifically reveals that the SR and WR were the major hotspots of the pandemic in both waves. The states of Karnataka and Tamil Nadu from the SR and Maharashtra from the WR showed consistently high numbers of infections and fatalities in both waves. Irrespective of the presence of the highly infectious B.1.617 Indian variant of the SARS-CoV-2 in these states during the second wave, these results are indicative of shortfalls in the health systems and/or deficits in implementations of COVID-19 restriction protocols in the populations.

Although the data on demographical differences in infection are not made available to the public by the Ministry of Health and Family Welfare, Govt. of India, however, many recent reports suggest that a notable difference between the first and second waves in the country are that the second wave affected a

large portion of the pediatric group, which was largely asymptomatic in the first wave³⁰. As of the first week of April 2021, it was reported that over 79,000 children were affected by the disease from five states that include Maharashtra, Chattisgarh, Karnataka, Uttar Pradesh, and Delhi between 1st March to 4th April 2021, of which over 60,000 cases were from Maharashtra³¹, however, the cases of hospitalization among the children were only a handful. Trends suggests that the average gaps between the peaks of the first and second wave in majority of countries were around 5 months³², in India it was about 7.5 months, however, the escalation of the 2nd peak height was far higher in this country. At present, the second wave is on its declining phase for the majority of Indian states; however experts suggests that unless vaccination rate is accelerated, the country is set to face another 3rd wave by the end of this year^{33,34} which may largely affect the unvaccinated population especially the paediatric group in large numbers³⁵, as trends suggests each subsequent waves have been more severe than the previous one in most of the countries that have already faced the third wave³⁶, therefore ramping up of the clinical trials of a vaccine for the paediatric group, rapid vaccination of the adults³⁷ together with the strengthening of the health infrastructure of the nation, wide-scale genomic sequencing of positive samples, monitoring weekly trends in the test positivity rates' strict implementation of COVID-19 appropriate restrictions and behaviour in public, are the urgent needs of the hour to protect the future of the country and its people from another COVID-19 tsunami.

Declarations

Conflict of interests

The authors declare no conflict of interests

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Abbreviations

COVID-19:corona virus disease 19;NR:northern region; CR: Central Region; WR: Western Region; ER: Eastern Region; NER: North Eastern Region; SR: Southern Region; UT: Union Territory; CCR: Cumulative case rate; CDR: Cumulative Death rate; CFR: Case fatality ratio; SARS CoV-2: severe acute respiratory syndrome coronavirus 2;LAE:Legislative Assembly Elections

Tables

Tables 1-2 are available in the Supplementary Files.

Figures

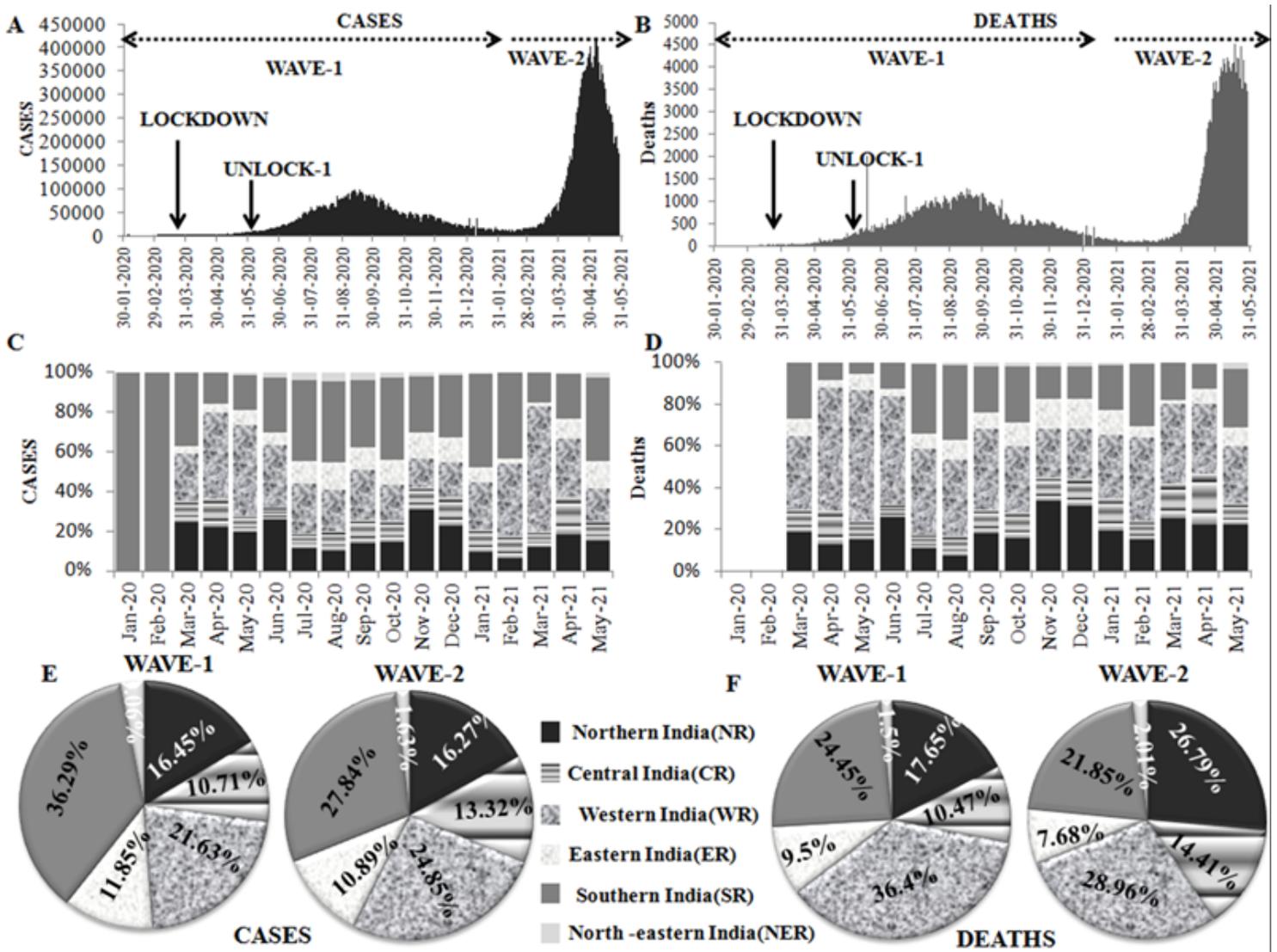


Figure 1

Chronological variations of cases and deaths during first and second COVID 19 wave in India: Variation in daily case numbers (A) and daily deaths (B) during the first and second wave (from 30th January 2020 to 29th May 2021) in India. Chronological variations in contributions of different regions of India towards total COVID-19 cases(C) and deaths (D) in the country. A comparison of the contribution of different regions of India towards total cases(E) and deaths(F) during the first and second wave of COVID-19 in the country

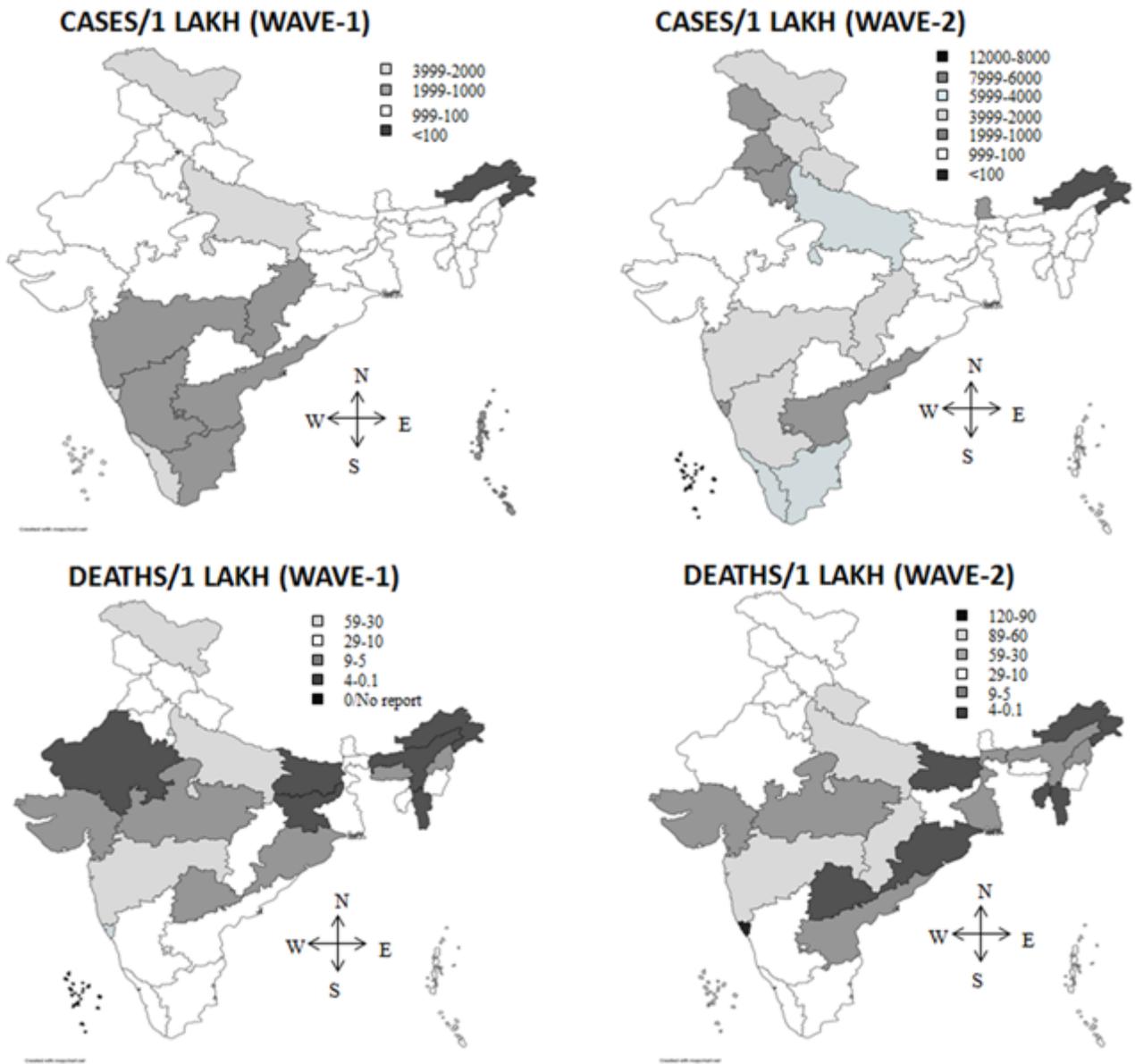


Figure 2

Covid-19 cumulative cases and deaths in India: Different states and union territories (UT) of India reporting COVID-19 cases by cases/1 lakh population during first (A) and second wave (B) of the pandemic; deaths/1lakh population in different states and UT's in first (C) and second wave(D)

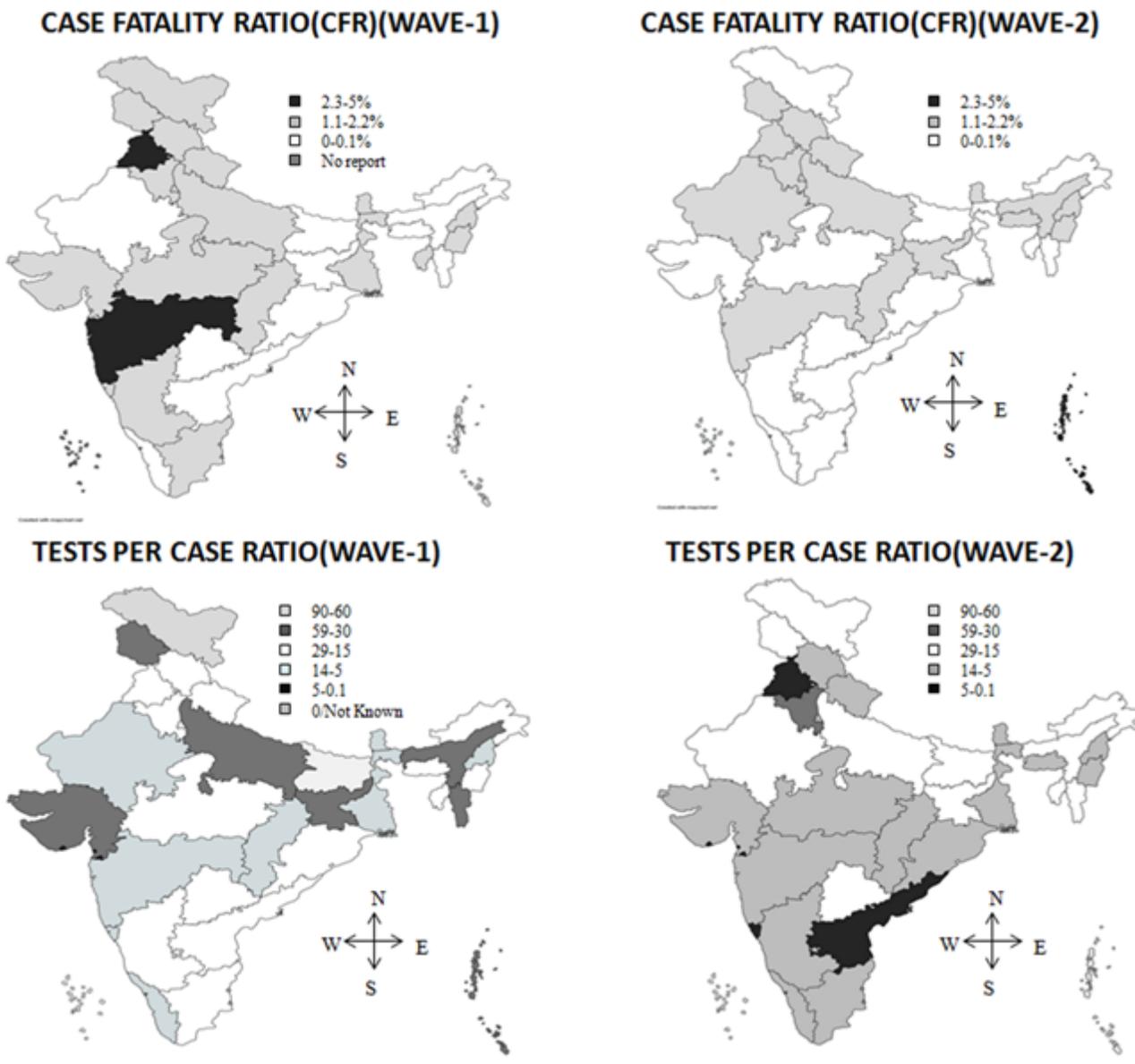


Figure 3

COVID-19 CFR and tests in India: The case fatality ratio (CFR) in different states and UT's during first (A) and second wave(B); tests per case ratio during first(C) and second(D) wave of the pandemic in different states and UT's.

Supplementary Files

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