Int J Epidemiol Health Sci 2023;4: e49
doi: http//doi.org/10.51757/IJEHS.4.2023.699932

Original Article

The influence of humidity on seasonality in India's COVID-19 and the effectiveness of policy controls in the second and third waves of 2021 and early 2022

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Cite this article: Mane, V., Prabhu, P., Bhalerao, P. I The influence of humidity on seasonality in India's COVID-19 and the effectiveness of policy controls in the second and third waves of 2021 and early 2022. Int J Epidemiol Health Sci 2023;4: e49. Doi: 10.51757/IJEHS.4.2023.699932.

Abstract

Background: The first wave of COVID-19 in India began to decline suddenly in September 2020 and appeared to be nearly over by the end of January 2021. At the time, no models or papers predicted or explained this decline. The authors hypothesized in their previous study that the cases decreased due to increased Relative Humidity during Monsoon and forecasted that another wave would begin with the dry season in February 2021 and would be contained by monsoon humidity. The current study was carried out to put the seasonality hypothesis to the test in 2021-22. The study also included findings about the effectiveness of policy control measures on case decline.

Methods: Humidity cycles in India were studied to determine the most humid periods, which corresponded to changes in daily cases across the country, on a zone-by-zone basis, and in smaller regions. The enforcement date and subsequent case decline (if any) were observed for the effectiveness of policy control measures.

Results: In low humidity periods, there was a clear relationship between relative humidity and case decline and case increase. Policy controls have been found to be effective in reducing and halting case increase, resulting in a subsequent decline.

Conclusion: In India, COVID-19 increases during the dry season around February and decreases during the monsoon season. Policy controls (lockdowns) are an effective way to halt the virus's exponential spread. The findings may be useful in planning local control and prevention activities.

Keywords: SARS-COV2, COVID-19, Seasonality, Epidemiology, Public Health, Humidity, Infectious Diseases, Policy Control Measures, India

Introduction

The COVID-19 pandemic was expected to have a significant impact on India. The primary reasons are as follows: a) second most populous country after China (1), b) high population density of 464 per square km, second only to Bangladesh among the top 15 countries with populations of 100 million or more (1), and c) inadequate public health infrastructure (2). Important Environmental and population related factors related to COVID-19 cases can be seen in **Figure 1**.

During the first wave of 2020, India imposed a strict and complete nationwide lockdown on March 24,

2020. While the lockdown was initially announced for three weeks, it was later extended until the end of May 2020 (2). This prolonged lockdown resulted in a labor migration away from the hotspots, where the COVID-19 was supposed to be contained, to their rural homes. Cases began to increase nationwide in June 2020, owing in part to labor migration and subsequent post-lockdown relaxations in general (3, 4).

In comparison to other countries, India's first wave was relatively mild. In September 2020, when COVID-19 was spreading almost everywhere in the world, India's daily cases began to decline abruptly and inexplicably (or "mysteriously," as some call it) around mid-September (5), after peaking at around 97,894 on September 17, 2020. COVID-19 showed signs of reaching bottom by end-January 2021, with daily cases reaching 8,579 on 2-Feb-2021, a proper wave completion as seen in such pandemics.

According to many news articles and reports written in the end of January and beginning of February 2021, the decline in cases was thought to be a success story for the country having conquered the pandemic, with a few such news articles (6-9) and others wondering end of pandemic but a "spurt" might be seen in the next monsoon, i.e., of 2021 (10).

While no logical explanation for the cause of the decline was found, we discovered a correlation between India's increased Relative Humidity (RH) due to Monsoon and end-of-year Western Disturbances (a phenomenon that brings post-Monsoon and Winter rains) and hypothesized Seasonality of India is due to Relative Humidity in our article "The potential role of Monsoon-induced humidity in India's unexpected COVID-19 case decline and subsequent rise (11). Furthermore, it had forecasted in the Discussion and Conclusion sections that a much worse second wave would be seen, beginning with the dry season in February/March 2021 and declining around mid-September 2021 if no policy measures were implemented by the government and earlier than mid-September if lockdowns and restrictions were enforced, and that the second wave may not show an exponential decline and that cases would rather decline "naturally" only after the dry season.

As predicted in the article, cases in India began to rise after the RH dropped significantly and the dry season began in the first week of February, around the 2nd of February 2021, as shown in **Figure 2**. The case increase rate was extremely high, reaching a peak of around 415,000 cases on May 6, 2021. This was India's second wave. As with the first wave, the Union Government did not impose a single nationwide lockdown (12), instead allowing individual states to impose containment measures with varying degrees of restrictions in accordance with the Ministry of Home Affairs order (13). With a high number of cases and deaths, the second wave proved to be the most damaging to the country (14, 15). The vaccination rollout had also just begun in mid-January/February 2021 for Healthcare and Frontline personnel, followed by Senior Citizens in March, 45+ years in April, and 18+ years in May (16), implying that vaccine protection to the general population at the time of exponential rise was negligible.

It is well known that in temperate climate zones, a decrease in temperature and humidity increases the occurrence of influenza (17, 18). It is also known that virus-containing aerosols evaporate faster and stay airborne longer in dry / low humidity climates, reducing the occurrence of influenza (19), and that the virus has a high viability below 50% relative humidity (20). (21). Studies on Covid-19 show that environmental factors, one of which is humidity, affect COVID-19 and cause seasonality (22, 23). It has been discovered that enveloped viruses with lipid membranes fare better in low relative humidity (RH) (24). It has been discovered that rehydration of enveloped viruses caused by higher humidity influences their viability (25, 26).

The current study was designed to test the hypothesis further in the second wave of 2021, and the results show that the hypothesis is sound. This article establishes the Seasonality of COVID-19 in India by demonstrating that the High RH caused by Monsoon (July - October) and Western Disturbances (November to mid-January) is the reason behind the decline of cases in India and the start of dry / low-humidity periods corelate to case rises (during the Second Wave in 2021 and the Third Wave in early 2022). The study also examines the effectiveness of Policy Control Measures such as complete lockdowns and/or strict crowd control restrictions such as curfews.

Methods

This study employs a Time Series Study and Observational Descriptive Analysis approach. The method employed is to monitor the daily Mean Relative Humidity (RH) in selected locations (districts) in India, along with Policy Controls such as complete or partial lockdowns, curfews, restrictions, and so on, and then compare and correlate to the reported daily COVID-19 cases using Descriptive Statistical Analysis.

To understand the role of both behavioral and environmental factors on the COVID-19, an extensive literature search was conducted (17, 22-24, 27-31).

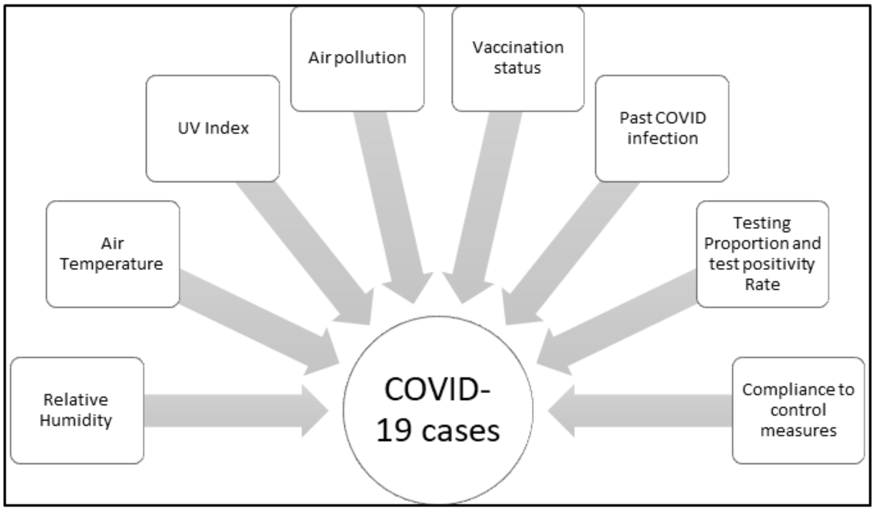

Figure 1. Important Environmental and population related factors related to COVID-19 cases

Table 1. Summary of results

Number	Level	Effect of cases	COVID-19 wave
Cause-National level			
1	Start of Dry – Low RH* period in First week of Feb 2021	Rapid increase in 4 weeks	Start of second wave
2	Policy Controls (lockdowns/restrictions)	Decline in about 2 weeks (16 days)	
3	Monsoon High RH all over the country	Natural decline in 9 weeks	
4	RH dropped after monsoon over (Oct 2021)	Increase in 8-9 weeks	Third wave
5	Western Disturbance High RH	Decline in 4 weeks	
Cause-District level			
1	Start of Dry – Low RH period	Rapid increase within 5 weeks in 88% districts	Mean **3.27 ±1.20** weeks
2	Policy Controls (lockdowns/restrictions)	Decline • within 2 weeks in 76% districts • within 2 to 4 weeks in 20% of districts	Mean **1.42 ±0.81** weeks
3	RH dropped after monsoon over (Oct 2021)	Increase in 7 to 10 weeks with 91% districts showing rise in within 10 weeks	Mean **7.44 ±2.18** weeks
4	Western Disturbance High RH at National level (Oct/Nov 2021)	Decline in 3 to 5 weeks with 90% districts showing the decline within 5 weeks	Mean **3.71 ±1.39** weeks

*RH = Relative humidity

According to a study conducted by Brunelli and colleagues (27), relative humidity, UV radiation, and temperature were negatively associated with COVID-19, while air pollution was positively associated with it. The relative humidity was a significant factor with a strong correlation. Temperature was discovered to have a negative correlation in temperate countries, but India is in subtropical and tropical regions with milder winters, so temperature was excluded from this model. As a result, it was decided to investigate the time required for changes in relative humidity to influence COVID-19. Due to a lack of uniform data availability across all data observation points, other environmental factors were not considered.

Population-related factors such as vaccination coverage, previous COVID-19 infection, testing proportion and test positivity rate, and adherence to control measures were all considered. However, many of them were observed due to a lack of objective and reliable data sources. Vaccination coverage was gradually increasing. However, during the second COVID-19 wave, it was limited to only health care workers and front-line workers. Even though it was high during the third wave caused by Omicron, it was not very protective against infection due to immune escape potential (32, 33). As a result, it was decided to include multiple sites from different states and climate zones for observation, to ensure that the distribution of all other confounders is different and cannot show a consistent effect. As described later, it was decided to test the consistency of the effect of relative humidity across different region bands.

The major and distinguishing cause of increased humidity in most of the country is the Monsoon season, which lasts about 4 months from mid-late June to October, with onset as detailed in "Salient Features of Southwest Monsoon 2021" (34) and withdrawal as per the press release "Withdrawal Of South West Monsoon From Goa On 23rd October 2021" (35) followed by a phenomenon known as "Western Disturbances," which brings post-Monsoon and (36). This research identifies significant humidity change periods and establishes a link between them, and subsequent case rises and falls. Policy control timelines are also thought to be related to case declines.

Monsoon (South-West Monsoon) progression observations were made on Macro, Mid, and Micro levels for the study of relative humidity, as follows:

A. Macro Level - Country:

The entire country specific Covid-19 daily case data for the period 1 January 2021 to 30 April 2022 is considered. Because India is a large country, the Monsoon rain and humidity arrive at different times in different parts of the country. Because a single country-wide humidity curve/number is not possible, an approximation of the day after the monsoon envelopes the entire country is used (**Figure 2**).

For the Policy Controls in 2021, the Union Government did not impose a nationwide lockdown as it did in the first wave of 2020 (12), but instead delegated the decision to the various states (13) who imposed varying degrees of restrictions beginning in April 2021 and lasting until July 2021, so a period of 20th April 2021 to 30th June 2021 is used as an approximation for considering the period of effective countrywide restrictions.

B. Mid-Level - Region Bands:

The Monsoon follows a predictable path from states in the southern peninsula to states in the north and north-west. Rain and humidity levels in these areas rise around the same time. This progression extends across multiple states. According to Indian Meteorological Department (IMD) monsoon progression details, 33 (thirty-three) states and union territories are grouped together in 5 (five) region bands for this study (**Figure 4**: India Monsoon Bands showing monsoon period). Monsoon arrives first and lasts the longest in Band A (Blue), while it arrives last and lasts the shortest in Band E (Orange). Bands A and B are divided into two to account for the impact of the North-East Monsoon on South-Eastern states. Bands A.2 and B.2 receive more rain from October to December. For humidity data, the Covid-19 daily case data and humidity of representative locations (weather stations) are observed. These five bands are investigated from 1-January-2021 to 30-April-2022, ranging from the earliest and longest to the latest and shortest Monsoon durations.

C. Micro Level - Smaller Locations:

A local administrative unit of a 'district,' which has similar humidity in towns in that region, and Covid-19 case data are studied for finer observations. 34 (thirty-four) districts are studied, the majority of which contain major hotspots in the country, to obtain specific and accurate regional climatic, i.e., RH data, and the corresponding effect on cases. This is a micro level analysis that provides a more detailed and immediate reflection of RH and policy control measures (local lockdowns, restrictions, and so on) daily. The study of smaller locations provides observations for local declines and rises that occur over time. This study used Daily COVID-19 cases and RH data from January 1, 2021, to April 30, 2022.

According to official Indian Meteorological Department data, the monsoon arrived in India on June 3rd, 2021, and covered the entire country by July 13th (34). (**Figure 4)** According to the Indian Meteorological Department, the monsoon began to withdraw around the 8th of October 2021 and followed a similar path during reversal before officially ending and leaving the country on the 25th of October 2021. (35). The southern states of Tamil Nadu and Kerala have an extended rainy season from October-November to January due to the North-East Monsoon (36). In this study, a relatively lower RH period was observed almost everywhere in the country from around the 1st to the 26th of December (**Figure 2**). During the winter months of October to December, the North-Western states experience a phenomenon known as "Western Disturbance" (WD), which brings rains and increased RH (37).

Data Sources

Since 2004, Reliable Prognosis, Raspisaniye Pogodi Ltd., St. Petersburg, Russia, has collected relative humidity data, which is published and downloadable online at https://rp5.ru.

Data for the Daily COVID-19 case is gathered from data aggregator websites that pull information from Ministry / State bulletins and official social media handles. A group of volunteers/organizations validates the data before it is published via downloadable files and/or API. The first website, www.covid19india.org, ceased operations in October 2021, but made their source code and processes public, and the task was taken over by two others: www.covid19tracker.in (managed by Indian Institute of Technology, Hyderabad, Govt of India) and www.covid19bharat.org (managed by private organizations DataKind BLR and Development Data Lab, according to https://covid19bharat.org/about).

Data Sources/Credits can be summarized here:

1. India Coronavirus Pandemic Data – data aggregator sites:
   a. https://www.covid19india.org/
   b. https://covid19tracker.in/
   c. https://covid19bharat.org/
2. Relative Humidity Data - Reliable Prognosis, Raspisaniye Pogodi Ltd., St. Petersburg, Russia: https://rp5.ru/Weather_in_the_world
3. Weather Data:
   a. Indian Meteorological Department: https://mausam.imd.gov.in/
   b. Western Disturbances - https://en.wikipedia.org/wiki/Western_Disturbance
   c. Western Disturbances – Detailed - https://empowerias.com/blog/daily-articles/western-disturbances-and-its-impact-on-the-indian-subcontinent-gs:-3-empower-ias
4. The Following data files are used for this study:
   i) National and State level:
      a. https://api.covid19india.org/csv/latest/state_wise_daily.csv
      b. https://api.covid19tracker.in/data/csv/latest/state_wise_daily.csv
      c. https://data.covid19bharat.org/csv/latest/state_wise_daily.csv
   ii) District level:
      a. https://api.covid19india.org/csv/latest/districts.csv
      b. https://api.covid19tracker.in/data/csv/latest/districts.csv
      c. https://data.covid19bharat.org/csv/latest/districts.csv

Results

The study findings are discussed in the sections below at various levels adapted in the Method, Macro, Mid, and Micro:

A. Macro – Country Level:

The high RH of the Western Disturbances decreased significantly around the end of January/beginning of February 2021, with a significant drop in RH observed in all districts studied and listed in table (Table 1: Time to Case Increase after Western Disturbance RH Drop) and shown in **Figure 2** with average of 2 February 2021 as an approximation of countrywide drop. Meanwhile, the residue of the first wave and case decline continued to reach around 9,000 by the beginning of February 2021; after briefly hovering at that level, a rapid rise began near the end of February 2021.

Following the significant drop in RH in early February 2021, cases on the national level began to rise in about 4 weeks, i.e., by early March 2021. There was nothing to stop the exponential growth of cases in this second wave because no uniform/single national lockdown was imposed, and the decision was delegated to states. While some local district administrations implemented short 10-to-15-day lockdowns in February and early March (this is discussed in detail in Section C. Smaller Locations), by late April and May, many of states had implemented lockdowns and/or curfews. Based on the data, the average date of 20 April 2021 is regarded as an approximate day on which the entire country had policy control measures in place. The National Peak in cases was observed on 6-May-2021, i.e., just over two weeks (16 days) after countrywide lockdowns. Section C. Smaller Locations depicts the policy controls in greater detail. (Note: the study shows that in a few districts where short lockdowns were imposed, there was a brief decrease in cases followed by an increase. Some of these districts imposed multiple lockdowns or were subjected to subsequent policy controls imposed by their respective states to influence another case decline). Throughout the lockdown, the number of reported cases decreased exponentially. The RH due to monsoon in the entire country reached a maximum around June 25th, 2021. By the end of June/early July 2021, the policy controls had been gradually reduced or removed.

As restrictions began to be lifted gradually in June, from early-July to early-September, the "rapid / smooth" exponential decline ceased, and the rate of decline in cases began to slow and plateaued, mostly hovering around 40,000, with a few brief increases. This is seen in **Figure 2**, as well as in **Figure 3**, which is a better indicator of trend in the spread because it removes the factor of variability in the number of total tests done.

As previously observed during the first wave, a "natural" decline in cases began in the week of August 29th, 2021, and lasted approximately 9 weeks due to high RH covering the entire country. These findings are consistent with our (authors') observations and hypotheses in our article on India's Covid-19 Seasonality (11). The slow decline continued until the end of the year. The Delta variant was primarily responsible for the Second Wave (38).

After the monsoon had passed and the RH had dropped (the approximate average date for a significant national drop was 1 November 2021), a sharp increase in cases was observed in about 8-9 weeks. The significant RH rise caused by Western Disturbances began on December 26th, 2021. Following this increase, the cases peaked, and the decline began four weeks later. The Third Wave was primarily caused by the Omicron variant (33), which has demonstrated a very high transmission rate (32).

Even though the testing in India did not cover the entire extent of the Omicron wave, the findings in the current seasonality study will not be affected because seasonality is about time trends rather than numbers.

B. Region Bands:

Observations at the Band level (a group of similar states based on monsoon arrival and withdrawal) show consistent results (**Figure 4**) depicts the dates when the monsoon is active in each band. The results show that lower RH is followed by more cases, while higher RH is followed by a decline. The policy control measures were not considered for this portion of the observations. The purpose of these band-based studies is to demonstrate how case increase/decrease are related to the arrival/withdrawal of the monsoon.

The daily cases are plotted in a time series along with various significant events in each of the bands for easier visual comprehension (See **Figures 3 to 9**) The graphs include:

- **Blue** vertical dashed lines to show significant RH increases due to monsoon as well as Western Disturbances
- **Red** vertical dashed lines to show significant drops in RH
- **Green** vertical dashed lines to show the day of enforcing policy controls like lockdowns, curfews, restrictions, etc.
- **Black** vertical dashed lines to show start of rise in daily cases

The micro-level data for districts in those bands is used to calculate the approximate day for changes in humidity and lockdowns.

The most noticeable result is that all the bands exhibit a consistent pattern: a) a decrease in RH is followed by an increase in cases b) Lockdowns are immediately followed by case drop. c) An increase in RH is followed by a case drop and/or the suppression of a case rise. The case rises in the bands began at different times due to RH drops occurring at different times and pre-existing case load, as explained in more detail below.

i) Band A

Band A.1 (**Figure 5**) contains the Western states (Karnataka, Kerala) and Band A.2 (**Figure 6**) contains the Eastern states (Tamilnadu), which have different Monsoon timings and are significantly more humid.

In Band A.1, which is Western states, the South-West monsoon arrives first, and the RH rises by 10 May 2021, and the region experiences extended rains due to the North-East monsoon, the RH drops by the third week of November 2021, and the cases plateau for a short time. There are a variety of other causes, other than climatic, behind the relatively high cases in the region, and particularly in the state of Kerala (e.g., relaxations of for tourism, a significant population returning from Middle Eastern countries, and many people working in the nursing/health-care sector), but this state is a special case that must be studied separately. In Band A.2, the initial case decline is due to lockdowns, the RH rises due to Monsoon in the first week of September 2021, and another case decline begins in the first week of October 2021.

ii) Band B

This Band is divided into two zones: Band B.1 (**Figure 7**), which includes the Western states, and Band B.2, which includes the Eastern states (majorly Maharashtra, which is significantly dry low humidity state). After the RH drop on January 26, 2021, the case rises much faster in comparison to other bands by February 11, 2021, in just over two weeks. This band has had the highest case load at the bottom of the first wave of around 3,000 - 4,000 cases daily for a long time, resulting in the faster rise. The band stands out because Maharashtra is the most affected state; the wave is also seen to be much larger in the sense that the incline and decline are not steep; the reasons for this are discussed in the following section, which shows the role of multiple lockdowns in the same districts, RH not rising as expected in a few districts, causing cases to remain high, and a few more local factors.

Band B.2 (**Figure 8**) includes the eastern states of Andhra Pradesh and Telangana, which are significantly more humid, the case rise occurs much later, approximately 6 weeks after the RH drop. After the monsoon, around the 10^{th} of November 2021, the cases rise slightly and remain at that level before rising exponentially due to the Omicron variant by early January 2022.

The relative humidity in Band B.2, the Eastern region, drops around 4 February 2021, followed by a slower case rise. One possible explanation for the slow rise in Band B.2 appears to be a long period of very low case load of less than 300. The policy control measures began with night curfews and partial lockdowns, and full lockdowns went into effect only around mid-May, resulting in a brief plateau at the peak before the decline began.

iii) Band C

As shown in **Figure 9**, the RH drop occurs later, and the case rise occurs later as well, around 11 March 2021. The post-monsoon RH drop occurs much later, around 5 November 2021, and does not result in case rise even when policy control measures are removed.

iv) Band D

This band has a similar pattern to Band E, as shown in **Figure 10**, but after the monsoon and after RH drops around October 27, 2021, no rise was seen as in Band E - this is very likely due to a very low case load of around 200 cases daily for a long period.

v) Band E

Monsoon arrives here last in the country and departs first, i.e., it has the shortest duration and thus has a shorter high RH period than other bands; for more information, see **Figure 11**. The Case Rise (Second Wave) began in the country first. Lockdown was the only way to keep the case rise under control. Following the Monsoon, after the RH dropped significantly around 18 October 2021, a case increase was observed beginning in early November (this rise is not easily seen in individual locations but a collective result of combining multiple states shows rise clearly – Low testing). This was also observed in the first wave of 2020.

Smaller Locations

The findings at the district level are more accurate and show a clear correlation between relative humidity and case incidence, as well as how effective the policy controls are.

The cases rapidly increased after the start of the dry, low RH period in late January/early February 2021, causing the start of the Second Wave in all regions of the country in 3 to 4 weeks (Mean 3.27 ± 1.20 weeks), with 88% of the districts studied showing the rise within 5 weeks. (**Table 1**).

The policy control measures show a very clear correlation in these local regions. Cases begin to decline within two weeks in 76% of the 40 district instances observed, and another 20% decline within two to four weeks, with a mean of 1.42 ± 0.81 weeks (**Table 2**).

The policy control measures show a very clear correlation in these local regions. Cases begin to decline within two weeks in 76% of the 40 district instances observed, and another 20% decline within two to four weeks, with a mean of 1.42 ± 0.81 weeks (**Table 3**).

The case decline continued after the start of the monsoon with increased RH. As restrictions were relaxed, the rate of decline slowed and/or plateaued for a short period before continuing at a rapid rate as the RH took effect. Because the smaller locations differ in terms of local conditions, case load, and so on, the effect is not as pronounced as it would be in a clear plateau on the national level, as discussed in theResults Section Macro - Country Level (A). The districts with the highest caseloads clearly demonstrated that decline.

After the monsoon season ends and the RH drops, a rise occurs within 7 to 10 10 weeks (Mean 7.44 ± 2.18 weeks), with 91% of districts experiencing a rise within 10 weeks (**Table 4**).

Following that, as the RH rises due to Western Disturbances, another drop in cases occurs within 3 to 5 weeks (Mean of 3.71 ± 1.39 weeks), with 90% of districts showing the decline within 5 weeks (**Table 5**).

The above results were obtained after examining the charts for each of the 34 districts. From left to right, RH and case curves are plotted as blue and black lines, respectively, while various events are marked with colored and/or dashed column markers with descriptions in callouts. Drops in RH and any policy control or other measure that has a negative impact on the spread (e.g., relaxations, unlocks, festivals, etc.) are denoted by red columns, while increases in RH and any policy control measure that has a positive impact on the spread (e.g., restrictions, complete, partial, night, or weekend lockdowns/curfews, etc.) are denoted by green columns. The increase in cases is indicated by a Black Dashed Column and a "up arrow - ↑ " in the callout.

i) Districts in Band A

Chennai in Band A.2 had a high case load prior to entering the dry period in the first week of February, and the case load increased within 3 weeks, though the increase is not as steep as in other major cities in the country. Chennai and the state are located on the eastern side of the Indian peninsula and have high RH almost all year, with a noticeable increase during the monsoon season. Policy control measures, such as lockdowns, resulted in an exponential decline until June relaxations. As a result, the cases of rangebound RH increased in mid-August, and a slow "natural" decline began in mid-September (**Figure 17**).

Kerala state is located on the western side of the Indian peninsula and experiences a different monsoon season than Chennai. Thiruvananthapuram, the representative district in this band, has a slow case rise from mid-March, followed by an exponential rise in the first week of April, following a drop in the RH in the first week of February. The imposed lockdowns cause cases to decline by mid-May, and the decline continues until policy control measures are relaxed. Following the relaxations, the case decline slows and stabilizes at around 1000 cases per day until mid-August. The Kerala state government granted complete relaxations for multiple days from mid-to-late August on Independence Day and Onam Festival; the holidays were immediately followed by a sudden spike in cases, which then continued to decline until September (**Figure 18**).

ii) Districts in Band B

Since the first wave of Band B.1, the Pune district has been one of the hotspots. Even before and after the dry period began on January 25, 2021, the case load was high, averaging 500-600 cases per day. Within three weeks of the RH drop, an exponential rise began in the second week of February. The local city and district (as well as the state) administrations were slow to enforce lockdowns, causing the cases to peak at around 13,000 and then hover for about 4 weeks before beginning an exponential decline. Pune is one of the state's and country's largest and most developed cities, with a wide range of medical facilities. Patients from surrounding districts were brought to city hospitals and thus counted in the district tally, which is a major reason for the decline to last much longer than in other locations and even Pune itself in the 2020 first wave. Restrictions were eased beginning in the first week of June, causing the exponential decline to halt and stabilize as the RH increased, before continuing the "natural" decline beginning in early September. Following the monsoon RH drop in late October, there was a brief increase. The Omicron Third Wave begins in the final week of December (**Figure 15**).

Telangana state in Band B.2 exhibits similar behavior to Pune (**Figure 16**).

iii) Districts in Band C

Ranchi district policy controls, particularly lockdown, caused the exponential decline in April. After policy controls were relaxed in July, the exponential decline slowed, and a stable bottom was reached until the Omicron-induced Third wave rise in late December (**Figure 14**).

iv) Districts in Band D

Delhi state is one of the first to see a rise around the 24th of February, about 3 weeks after the RH drop.

Delhi was slow to implement policy controls, particularly lockdowns, and as a result, daily cases were extremely high, reaching around 28,500 cases per day. The exponential decline began with a 6-day lockdown on April 21st and continued to be extended. Following the relaxation of policy controls in June, the exponential decline ceased, and a slow drop continued as monsoon RH picked up. Following the monsoon, when the RH dropped in mid-October, asmall case increase was observed in the following few weeks. The rise continued, eventually combining with the Omicron-induced Third wave rise in late December (**Figure 13**).

v) Districts in Band E

Jaipur district is one of the first to rise, but it takes over 4 weeks after the RH drops. As the dry period began, the case load was low, around 20-30, causing the rise to be late and slower at first. This demonstrates the quick effect of the lockdown on the beginning of the initial decline in mid-May. Jaipur also shows that after the monsoon, when the RH dropped in mid-October, there was a small case increase in the following few weeks. Similarly, the Third Wave rise was one of the country's first (**Figure 12**).

Based on the study and analysis of the above results, a definite correlation between Relative Humidity (RH) and Daily Cases is observed, providing a reasonable explanation for Seasonality in India. Seasonality, or the period conducive to rapid growth, is from March to the start of the Monsoon, with a decline in the first half of September, after the monsoon-induced high RH takes over the entire country, which reduces and reverses the growth rate. In addition, the Government's Policy Controls measures have proven to be effective in putting an almost immediate stop to the growth of cases.

Summary of results can be seen in **Table 1**.

Discussion

The findings of this study support the hypothesis and forecast made in the first wave study in 2020. The difference in the second wave was that the virus was prevalent throughout the country, whereas in the first wave, the virus was initially concentrated in international gateway cities that had become hotspots, and it took some time for the virus to spread throughout the country. The first wave of decline began "naturally" in mid-September (without any external measures like policy controls). The virus was given a favorable environment (low RH period) during the second wave, and it spread quickly. This time, the lockdowns were implemented "while" the cases were rapidly increasing, whereas in the first wave, the long 3-month lockdown was to stop the new virus's entry/spread in the country and it was "before" the large-scale spread occurred.

There is a myth that lockdowns are ineffective at containing the spread (39), but this study found that lockdowns and restrictions were effective, with 76% of districts showing a decrease in COVID-19 cases within 2 weeks and 96% showing a decrease in COVID-19 cases within 4 weeks of implementation. People and the economy suffer because of policy controls, but so does the pandemic. The Union Government avoided using a single lockdown in the second wave because it had faced criticism for the lockdown in the first wave (12, 13), which the authors believe was important and helped to slow/delay the spread but the relatively low increase in cases made people think it was unnecessary. The states were responsible for containment measures in the second wave, and they, too, acted cautiously to avoid public backlash, which caused the covid situation to spiral out of control, putting a huge strain on the healthcare infrastructure, filled hospitals, oxygen shortages (40), fires/accidents resulting in patient deaths (41), full mortuaries, continuously operating cremation areas, and cemeteries. Lockdowns had to be implemented to prevent this from happening again.

In our previous article on India's first COVID-19 wave (11), we noted that the effectiveness of policy control measures could not be studied then due to a lack of data because not many lockdowns were enforced when cases were increasing at a faster rate. It was also observed that policy controls were much more effective in large cities because implementing the measures, such as stopping businesses, shopping malls, multiplexes, restaurants, stringent masking rules, asking people to work from home as much as possible, and so on, was much easier with enough law enforcement to keep a watch and not allow any violations. While this is less true in rural areas, law enforcement is difficult in small towns, villages, and communities with low populations spread far and wide, and a single person could bring infection by visiting a nearby city/marketplace and infect multiple contacts at the same time.

Several other studies on influenza, enveloped viruses, show that virus viability is greatest at low RH (less than 50%) and decreases as RH increases. Apparently, the mechanism is not well understood, and hypotheses include increased aerosol weight due to vapor absorption, which causes them to fall to the ground faster, changes in aerosol salinity, and so on. Coronaviruses, like Influenza, are enveloped viruses, so their effects are more likely to be similar (17-19, 21, 25). The exact relationship between increased humidity and decreased cases, or rather virus viability, is not linear. More research can be done to investigate the relationship between RH and COVID-19.

SARS-COV-2 is a virus of the Coronavirus family; these viruses are enveloped, which means their genetic material is encapsulated in a lipid membrane. There are several other studies about influenza that show that the viability of the virus is maximum atlow RH (below 50%), and the spread decreases as the RH increases; this is very well seen and understood for temperate climate countries in the northern hemispheres, i.e., the cases of influenza increase during the winters that are dry/low humidity (17-19). There have been studies that show the effects and mechanisms of humidity on droplet and aerosol (21, 25), and they show that the viability of the virus is greatest when RH is 50%; however, the exact reason for these mechanisms is not yet conclusively understood. Furthermore, in low humidity, aerosols and droplets tend to stay afloat in the air longer and travel farther, whereas in high humidity, aerosols and droplets absorb water and tend to become heavier, settling down faster. Finally, contrary to previous beliefs, the surface transmission of SARS-COV-2 is now thought to be very low (42, 43). Recent COVID-19 studies in the United States show a negative correlation between humidity and cases in (30), the same as in Australia (44), and Bangladesh (29). Water (relative humidity, precipitation total, and column of water vapor) has also been shown to play a regulatory role in the transmission of COVID-19 in the southern hemisphere (27). Other studies have found winter seasonality in England and Wales (31), Germany (28) and temperate countries (45), and while the conclusion is more in favor of lower temperatures, the fact that the winters in this region have very low humidity should be noted. In India, we have seen an increase in cases during the summer when temperatures are high but humidity is low, as opposed to temperate regions.

Furthermore, studies specific to Covid-19 have shown that environmental factors influence the severity of the disease. Aside from RH, other factors such as UV index and temperature are thought to have an impact (22). (24). As different studies have considered various environmental factors, it was decided not to consider UV Index in this India-specific study because the incidence rate decreased during Monsoon when UV Index is low due to thick cloud cover and humidity. Similarly, temperature was not taken into account, despite the fact that increased incidence rates have been observed in hot, warm, and cold temperatures. Another aspect that this study did not address was coastal locations that are highly humid all year, with relatively smaller changes in RH but even these small changes showed up in corresponding incidence rate changes, which can be addressed in the studies mentioned above.

One of the study's key strengths is that it is simple to replicate with only two parameters and can be completed in a short period of time. Monitoring the rise and fall in RH may alert policymakers to take appropriate precautions and plan ahead of time.

This study concludes that the COVID-19/SARS-COV2 has a National Seasonality from February/March to September, and that Policy Control Measures such as Lockdowns and Restrictions are effective in halting the case increase and causing a decrease, usually within two weeks. Furthermore, unlike other countries, the North-East Monsoon and Western Disturbance during the winter months appear to be beneficial in maintaining higher relative humidity during the winter months.

Conclusion

The Second COVID-19 wave demonstrated both seasonality and the effectiveness of policy controls. This Agreement will aid in the provision of health-care infrastructure, medicines, and timely public awareness campaigns. This will allow for time-bound mass vaccination drives, as well as studies of vaccine effectiveness durations and preparation for booster vaccinations, if necessary. The study can be expanded to neighboring Indian countries and other parts of the world where seasonal patterns of humidity exist. The study is relatively simple to carry out and can be repeated in the future to take timely preventive measures.

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Table 2. Time to Case Increase after Western Disturbance RH Drop

#	District	Band	Significant Drop in RH in the week of	Daily Case Increase Stated in the week of	Weeks to Rise
1	Ludhiana, Punjab	E	1-Feb-21	14-Feb-21	1.86
2	Jaipur, Rajasthan	E	22-Jan-21	25-Feb-21	4.86
3	Lucknow, Uttar Pradesh	D	15-Feb-21	12-Mar-21	3.57
4	Dehradun, Uttarakhand	D	1-Mar-21	17-Mar-21	2.29
5	Bhopal, Madhya Pradesh	D	25-Jan-21	18-Feb-21	3.43
6	Ahmedabad, Gujarat	D	1-Feb-21	21-Feb-21	2.86
7	Delhi	D	1-Feb-21	24-Feb-21	3.29
8	Kolkata, West Bengal	C	8-Feb-21	24-Feb-21	2.29
9	Bhubaneswar, Odisha	C	22-Feb-21	19-Mar-21	3.57
10	Ranchi, Jharkhand	C	8-Feb-21	5-Mar-21	3.57
11	Raipur, Chhattisgarh	C	8-Feb-21	5-Mar-21	3.57
12	Patna, Bihar	C	8-Feb-21	18-Mar-21	5.43
13	Gauhati, Assam	C	8-Feb-21	18-Mar-21	5.43
14	Thane, Maharashtra	B.1	25-Jan-21	15-Feb-21	3.00
15	Solapur, Maharashtra	B.1	18-Jan-21	18-Feb-21	4.43
16	Ratnagiri, Maharashtra	B.1	1-Feb-21	11-Mar-21	5.43
17	Sindhudurg, Maharashtra	B.1	1-Feb-21	4-Mar-21	4.43
18	Pune, Maharashtra	B.1	25-Jan-21	13-Feb-21	2.71
19	Nashik, Maharashtra	B.1	18-Jan-21	4-Feb-21	2.43
20	Nagpur, Maharashtra	B.1	25-Jan-21	10-Feb-21	2.29
21	Mumbai, Maharashtra	B.1	1-Feb-21	10-Feb-21	1.29
22	Sangli, Maharashtra	B.1	1-Feb-21	28-Feb-21	3.86
23	Satara, Maharashtra	B.1	1-Feb-21	25-Feb-21	3.43
24	Kolhapur, Maharashtra	B.1	25-Jan-21	24-Feb-21	4.29
25	Jalgaon, Maharashtra	B.1	25-Jan-21	14-Feb-21	2.86
26	Aurangabad, Maharashtra	B.1	25-Jan-21	10-Feb-21	2.29
27	Amaravati, Maharashtra	B.1	18-Jan-21	27-Jan-21	1.29
28	Goa State	B.1	1-Feb-21	25-Feb-21	3.43
29	Hyderabad, Telangana	B.2	8-Feb-21	11-Mar-21	4.43
30	Visakhapatnam, Andhra Pradesh	B.2	1-Feb-21	8-Mar-21	5.00
31	Chennai, Tamilnadu	A.2	1-Feb-21	24-Feb-21	3.29
32	Bangalore, Karnataka	A.2	1-Feb-21	26-Feb-21	3.57
33	Kochi, Kerala	A.1	8-Mar-21	26-Mar-21	2.57
34	Thiruvananthapuram, Kerala	A.1	1-Feb-21	17-Mar-21	6.29
				3 to 5 weeks	18 (**52.94%**)
				Less than 3 weeks	12 (**35.29%**)
				3 to 5 weeks	18 (**52.94%**)
				More than 5 weeks	4 (**11.76%**)
			Mean	**3.27** weeks	
			Median	**3.43** weeks	
			Standard Deviation	**1.20** weeks	

Table 3. Time taken to Start of Drop in Daily Cases after Lockdowns

#	District	Band	Lockdown/ Strict Curfews	Start of Decline	Weeks to Decline
1	Ludhiana, Punjab	E	8-May-21	14-May-21	0.86
2	Jaipur, Rajasthan	E	19-Apr-21	8-May-21	2.71
3	Lucknow, Uttar Pradesh	D	19-Apr-21	26-Apr-21	1.00
4	Dehradun, Uttarakhand	D	28-Apr-21	8-May-21	1.43
5	Bhopal, Madhya Pradesh	D	12-Apr-21	5-May-21	3.29
6	Ahmedabad, Gujarat	D	27-Apr-21	29-Apr-21	0.29
7	Delhi	D	21-Apr-21	7-May-21	2.29
8	Kolkata, West Bengal	C	16-May-21	25-May-21	1.29
9	Bhubaneswar, Odisha	C	5-May-21	23-May-21	2.57
10	Ranchi, Jharkhand	C	22-Apr-21	3-May-21	1.57
11	Raipur, Chhattisgarh	C	9-Apr-21	17-Apr-21	1.14
12	Patna, Bihar	C	29-Apr-21	7-May-21	1.14
13	Gauhati, Assam	C	13-May-21	25-May-21	1.71
14	Thane, Maharashtra	B.1	5-Apr-21	12-Apr-21	1.00
15	Solapur, Maharashtra	B.1	15-Apr-21	18-May-21	4.71
16	Ratnagiri, Maharashtra*	B.1	15-Apr-21	21-Apr-21	0.86
17	Ratnagiri, Maharashtra*	B.1	9-May-21	16-May-21	1.00
18	Sindhudurg, Maharashtra*	B.1	15-Apr-21	21-Apr-21	0.86
19	Sindhudurg, Maharashtra*	B.1	9-May-21	15-May-21	0.86
20	Pune, Maharashtra	B.1	15-Apr-21	25-Apr-21	1.43
21	Nashik, Maharashtra	B.1	15-Apr-21	28-Apr-21	1.86
22	Nagpur, Maharashtra*	B.1	15-Mar-21	28-Mar-21	1.86
23	Nagpur, Maharashtra*	B.1	15-Apr-21	30-Apr-21	2.14
24	Mumbai, Maharashtra	B.1	5-Apr-21	12-Apr-21	1.00
25	Sangli, Maharashtra	B.1	5-May-21	12-May-21	1.00
26	Satara, Maharashtra	B.1	5-May-21	9-May-21	0.57
27	Kolhapur, Maharashtra	B.1	5-May-21	15-May-21	1.43
28	Jalgaon, Maharashtra	B.1	5-Apr-21	15-Apr-21	1.43
29	Aurangabad, Maharashtra*	B.1	11-Mar-21	21-Mar-21	1.43
30	Aurangabad, Maharashtra*	B.1	15-Apr-21	1-May-21	2.29
31	Amaravati, Maharashtra*	B.1	22-Feb-21	28-Feb-21	0.86
32	Amaravati, Maharashtra*	B.1	15-Apr-21	22-Apr-21	1.00
33	Amaravati, Maharashtra*	B.1	9-May-21	23-May-21	2.00
34	Goa State	B.1	30-Apr-21	12-May-21	1.71
35	Hyderabad, Telangana	B.2	21-Apr-21	3-May-21	1.71
36	Visakhapatnam, Andhra Pradesh	B.2	5-May-21	21-May-21	2.29
37	Chennai, Tamilnadu	A.2	26-Apr-21	15-May-21	2.71

38	Bangalore, Karnataka	A.2	27-Apr-21	9-May-21	1.71
39	Kochi, Kerala	A.1	26-Apr-21	9-May-21	1.86
40	Thiruvananthapuram, Kerala	A.1	8-May-21	17-May-21	1.29
				Case Decline In	**Districts**
				less than 2 weeks	31 (**77.50%**)
				2 to 4 weeks	8 (**20.00%**)
				more than 4 weeks	1 (**2.50%**)
			Mean	1.42 weeks	
			Median	1.43 weeks	
			Standard Deviation	0.81 weeks	
* Districts imposed Lockdowns multiple times					

Table 4. Relative Humidity (RH) increase due to Monsoon in Second Wave

#	**District, State**	**Band**	**Significant Rise* in RH in the week of**	**Daily Case Decline Stated in week of****	**Weeks to Decline**
1	Ludhiana, Punjab	E	12-Jul-21	-	-
2	Jaipur, Rajasthan	E	12-Jul-21	-	-
3	Lucknow, Uttar Pradesh	D	14-Jun-21	-	-
4	Dehradun, Uttarakhand	D	12-Jul-21	-	-
5	Bhopal, Madhya Pradesh	D	12-Jul-21	-	-
6	Ahmedabad, Gujarat	D	19-Jul-21	-	-
7	Delhi	D	19-Jul-21	-	-
8	Kolkata, West Bengal	C	14-Jun-21	-	-
9	Bhubaneswar, Odisha	C	14-Jun-21	-	-
10	Ranchi, Jharkhand	C	14-Jun-21	-	-
11	Raipur, Chhattisgarh	C	14-Jun-21	-	-
12	Patna, Bihar	C	14-Jun-21	-	-
13	Gauhati, Assam	C	10-May-21	-	-
14	Thane, Maharashtra	B.1	7-Jun-21	-	-
15	Solapur, Maharashtra	B.1	13-Jul-21	-	-
16	Ratnagiri, Maharashtra	B.1	14-Jun-21	-	-
17	Sindhudurg, Maharashtra	B.1	17-May-21	-	-
18	Pune, Maharashtra	B.1	7-Jun-21	-	-
19	Nashik, Maharashtra	B.1	19-Jul-21	-	-
20	Nagpur, Maharashtra	B.1	14-Jun-21	-	-

21	Mumbai, Maharashtra	B.1	14-Jun-21	-	-
22	Sangli, Maharashtra	B.1	7-Jun-21	-	-
23	Satara, Maharashtra	B.1	7-Jun-21	-	-
24	Kolhapur, Maharashtra	B.1	14-Jun-21	-	-
25	Jalgaon, Maharashtra	B.1	12-Jul-21	-	-
26	Aurangabad, Maharashtra	B.1	7-Jun-21	-	-
27	Amaravati, Maharashtra	B.1	8-Jun-21	-	-
28	Goa State	B.1	8-Jun-21	-	-
29	Hyderabad, Telangana	B.2	14-Jun-21	-	-
30	Visakhapatnam, Andhra Pradesh	B.2	5-Jul-21	-	-
31	Chennai, Tamilnadu	A.2	-	-	-
32	Bangalore, Karnataka	A.2	12-Jul-21	-	-
33	Kochi, Kerala	A.1	17-May-21	-	-
34	Thiruvananthapuram, Kerala	A.1	3-May-21	-	-

* Significant Rise: this is sudden increase from a low RH band to higher, e.g. From 50% to 75%-85% or more. In always high RH region this could be from 80% to 95%

** The decline started due to Lockdowns continued after the dry period was over and humidity increase, **hence no case Drop relation applicable here**.

Table 5. Increase in Daily Cases after RH drops after Monsoon

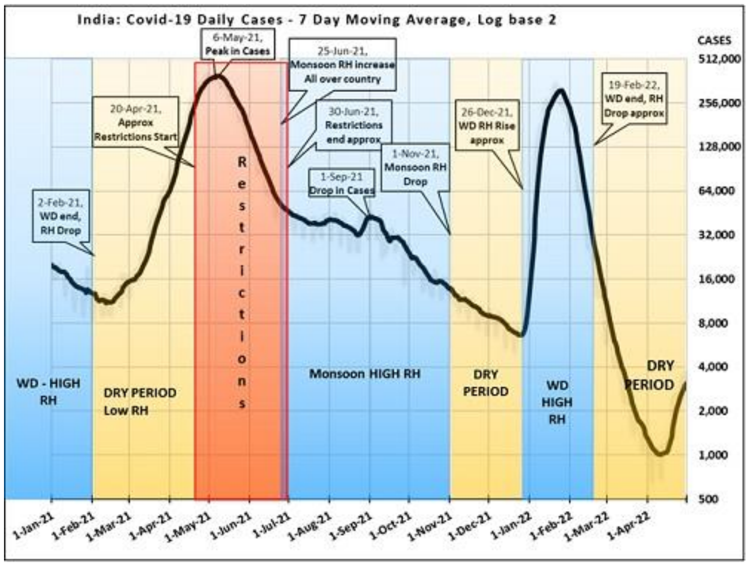
#	District	Band	Significant Drop in RH in the week of	Daily Case Rise Stated on	Weeks to Rise
1	Ludhiana, Punjab	E	18-Oct-21	29-Dec-21	10.29
2	Jaipur, Rajasthan	E	18-Oct-21	30-Dec-21	10.43
3	Lucknow, Uttar Pradesh	D	25-Oct-21	29-Dec-21	9.29
4	Dehradun, Uttarakhand	D	1-Nov-21	27-Dec-21	8.00
5	Bhopal, Madhya Pradesh	D	1-Nov-21	27-Dec-21	8.00
6	Ahmedabad, Gujarat	D	1-Nov-21	27-Dec-21	8.00
7	Delhi	D	18-Oct-21	3-Dec-21	6.57
8	Kolkata, West Bengal	C	8-Nov-21	25-Dec-21	6.71
9	Bhubaneswar, Odisha	C	8-Nov-21	27-Dec-21	7.00
10	Ranchi, Jharkhand	C	1-Nov-21	20-Dec-21	7.00
11	Raipur, Chhattisgarh	C	1-Nov-21	30-Dec-21	8.43
12	Patna, Bihar	C	8-Nov-21	27-Dec-21	7.00
13	Gauhati, Assam	C	-	29-Dec-21	
14	Thane, Maharashtra	B.1	25-Oct-21	20-Dec-21	8.00
15	Solapur, Maharashtra	B.1	1-Nov-21	31-Dec-21	8.57

16	Ratnagiri, Maharashtra	B.1	1-Nov-21	29-Dec-21	8.29
17	Sindhudurg, Maharashtra	B.1	1-Nov-21	1-Jan-22	8.71
18	Pune, Maharashtra	B.1	25-Oct-21	24-Dec-21	8.57
19	Nashik, Maharashtra	B.1	18-Oct-21	25-Dec-21	9.71
20	Nagpur, Maharashtra	B.1	18-Oct-21	24-Dec-21	9.57
21	Mumbai, Maharashtra	B.1	25-Oct-21	15-Dec-21	7.29
22	Sangli, Maharashtra	B.1	18-Oct-21	26-Dec-21	9.86
23	Satara, Maharashtra	B.1	25-Oct-21	29-Dec-21	9.29
24	Kolhapur, Maharashtra	B.1	18-Oct-21	1-Jan-22	10.71
25	Jalgaon, Maharashtra	B.1	1-Nov-21	31-Dec-21	8.57
26	Aurangabad, Maharashtra	B.1	25-Oct-21	30-Dec-21	9.43
27	Amaravati, Maharashtra	B.1	25-Oct-21	2-Jan-22	9.86
28	Goa State	B.1	25-Oct-21	24-Dec-21	8.57
29	Hyderabad, Telangana	B.2	25-Oct-21	27-Dec-21	9.00
30	Visakhapatnam, Andhra Pradesh	B.2	29-Nov-21	1-Jan-22	4.71
31	Chennai, Tamilnadu	A.2	6-Dec-21	23-Dec-21	2.43
32	Bangalore, Karnataka	A.2	6-Dec-21	24-Dec-21	2.57
33	Kochi, Kerala	A.1	25-Oct-21	29-Dec-21	9.29
34	Thiruvananthapuram, Kerala	A.1	20-Dec-21	2-Jan-22	1.86
				Case Rise in	**Districts**
				7 to 10 weeks	**24 (72.73%)**
				Less than 7 weeks	**6 (18.18%)**
				More than 10 weeks	**4 (9.09%)**
			Mean	7.44 weeks	
			Median	8.57 weeks	
			Standard Deviation	2.18 weeks	

Table 6. Decline in Daily Cases after Relative Humidity (RH) increase due to Western Disturbances

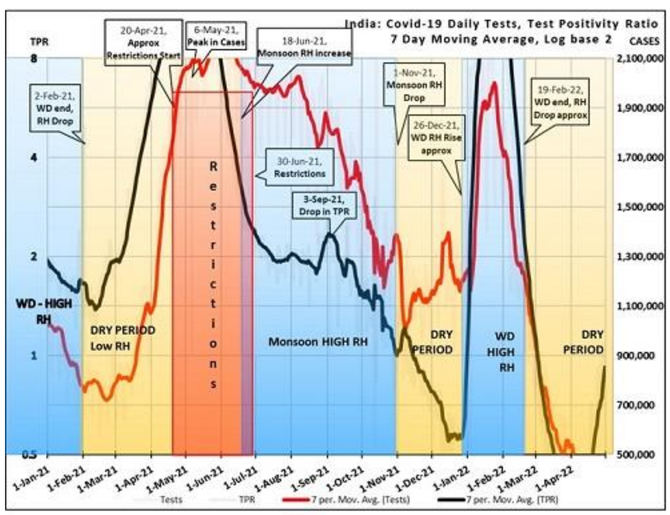
#	District, State	Band	Significant Rise in RH in the week of	Daily Case Decline Stated on	Weeks to Decline
1	Ludhiana, Punjab	E	3-Jan-22	25-Jan-22	3.14
2	Jaipur, Rajasthan	E	3-Jan-22	30-Jan-22	3.86
3	Lucknow, Uttar Pradesh	D	27-Dec-21	25-Jan-22	4.14
4	Dehradun, Uttarakhand	D	3-Jan-22	26-Jan-22	3.29
5	Bhopal, Madhya Pradesh	D	27-Dec-21	29-Jan-22	4.71
6	Ahmedabad, Gujarat	D	27-Dec-21	24-Jan-22	4.00

7	Delhi	D	27-Dec-21	15-Jan-22	2.71
8	Kolkata, West Bengal	C	27-Dec-21	13-Jan-22	2.43
9	Bhubaneswar, Odisha	C	27-Dec-21	19-Jan-22	3.29
10	Ranchi, Jharkhand	C	27-Dec-21	13-Jan-22	2.43
11	Raipur, Chhattisgarh	C	27-Dec-21	18-Jan-22	3.14
12	Patna, Bihar	C	27-Dec-21	18-Jan-22	3.14
13	Gauhati, Assam	C	-	-	
14	Thane, Maharashtra	B.1	-	14-Jan-22	
15	Solapur, Maharashtra	B.1	-	27-Jan-22	
16	Ratnagiri, Maharashtra	B.1	-	-	
17	Sindhudurg, Maharashtra	B.1	-	24-Jan-22	
18	Pune, Maharashtra	B.1	29-Nov-21	25-Jan-22	8.14
19	Nashik, Maharashtra	B.1	27-Dec-21	26-Jan-22	4.29
20	Nagpur, Maharashtra	B.1	3-Jan-22	27-Jan-22	3.43
21	Mumbai, Maharashtra	B.1	22-Nov-21	13-Jan-22	7.43
22	Sangli, Maharashtra	B.1	-	25-Jan-22	
23	Satara, Maharashtra	B.1	-	25-Jan-22	
24	Kolhapur, Maharashtra	B.1	-	27-Jan-22	
25	Jalgaon, Maharashtra	B.1	3-Jan-22	27-Jan-22	3.43
26	Aurangabad, Maharashtra	B.1	3-Jan-22	27-Jan-22	3.43
27	Amaravati, Maharashtra	B.1	3-Jan-22	27-Jan-22	3.43
28	Goa State	B.1	-	22-Jan-22	
29	Hyderabad, Telangana	B.2	3-Jan-22	28-Jan-22	3.57
30	Visakhapatnam, Andhra Pradesh	B.2	27-Dec-21	26-Jan-22	4.29
31	Chennai, Tamilnadu	A.2	-	22-Jan-22	
32	Bangalore, Karnataka	A.2	-	25-Jan-22	
33	Kochi, Kerala	A.1	-	3-Feb-22	
34	Thiruvananthapuram, Kerala	A.1	-	27-Jan-22	
				Case Drop in	**Districts**
				3 to 5 weeks	**16 (76.19%)**
				Less than 7 weeks	**3 (14.29%)**
				More than 10 weeks	**2 (9.52%)**
			Mean	3.71 weeks	
			Median	3.43 weeks	
			Standard Deviation	1.39 weeks	



WD – Western Disturbance, **RH** - Relative Humidity

Figure 2. India Daily Cases, Policy Controls and Relative Humidity



WD – Western Disturbance, **RH** - Relative Humidity, **TPR** – Test Positivity Ratio

Figure 3. Daily Tests and Test Positivity Ratio

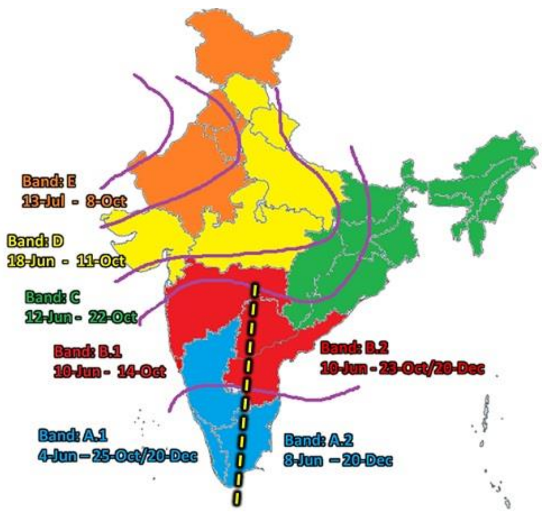


Figure 4. India Monsoon Bands showing monsoon period

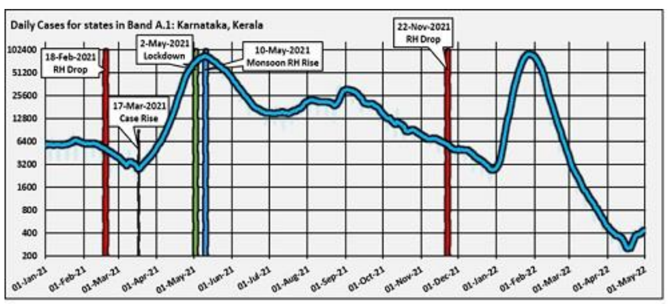


Figure 5. Band A.1

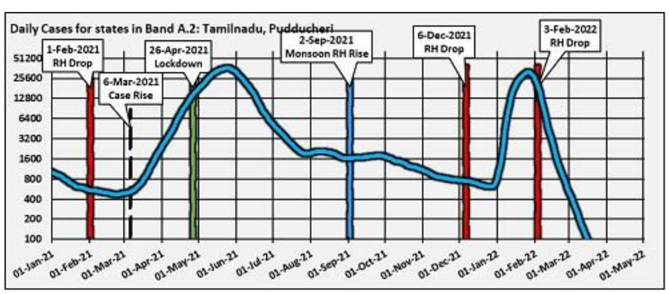


Figure 6. Band A.2

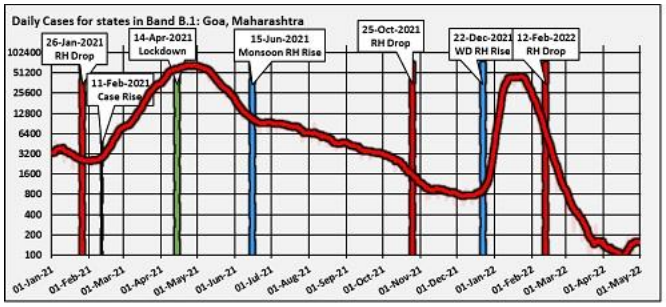


Figure 7. Band B.1

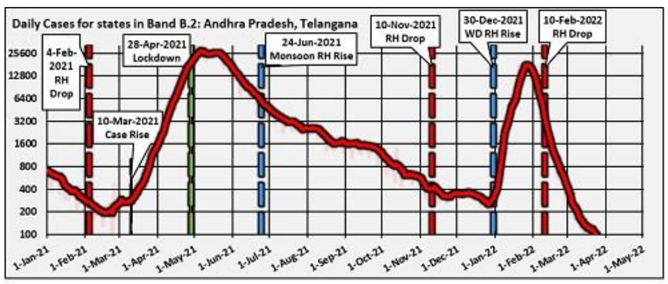


Figure 8. Band B.2

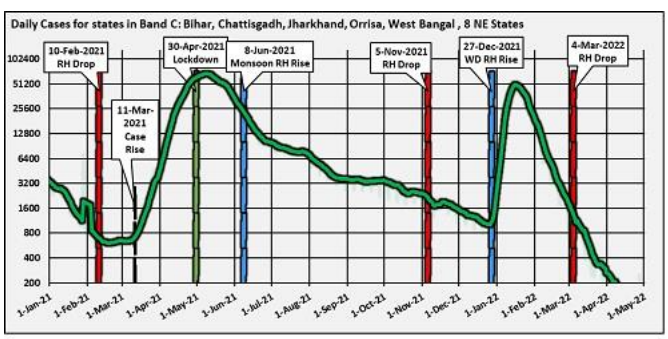


Figure 9. Band C

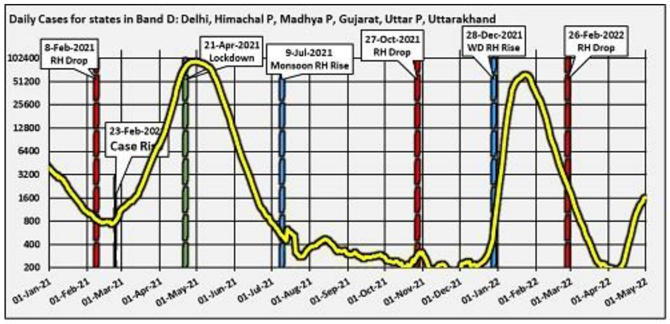


Figure 10. Band D

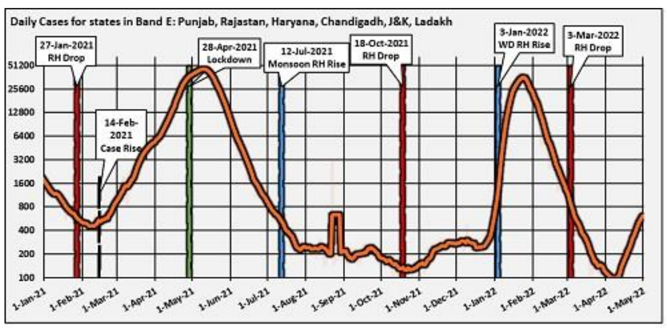


Figure 11. Band E

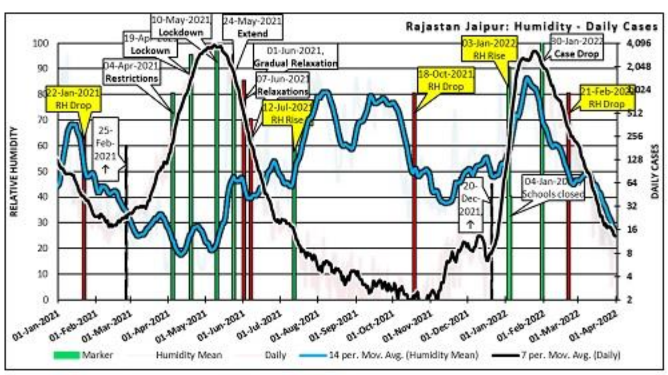


Figure 12. Band E: Jaipur, Rajasthan

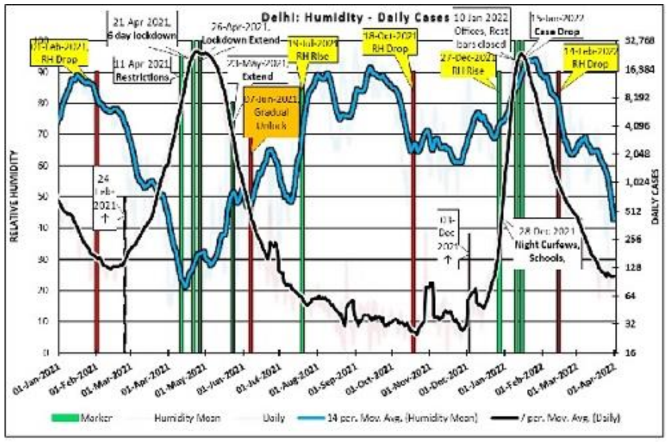


Figure 13. Band D: New Delhi

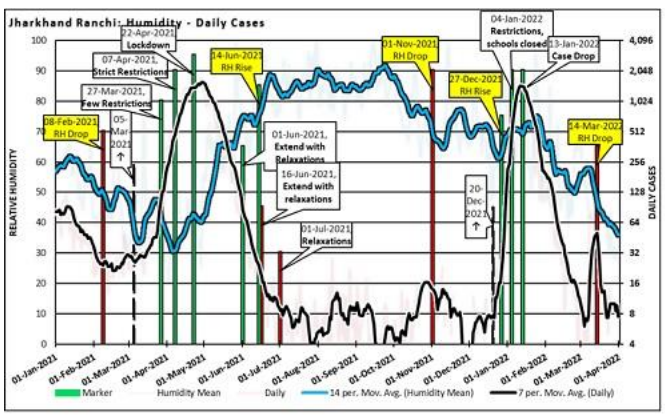


Figure 14. Band C: Ranchi, Jharkhand

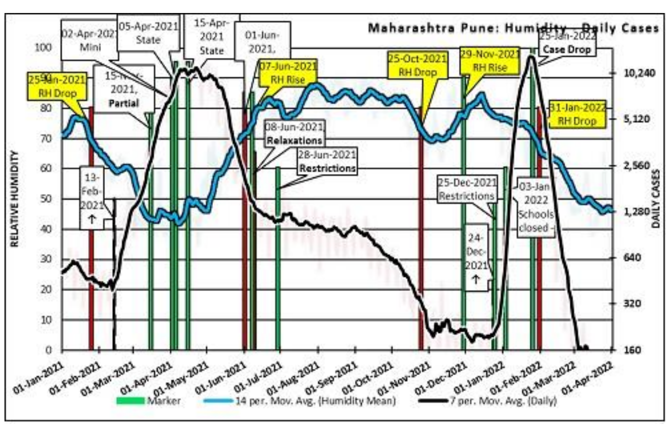


Figure 15. Band B.1: Pune, Maharashtra

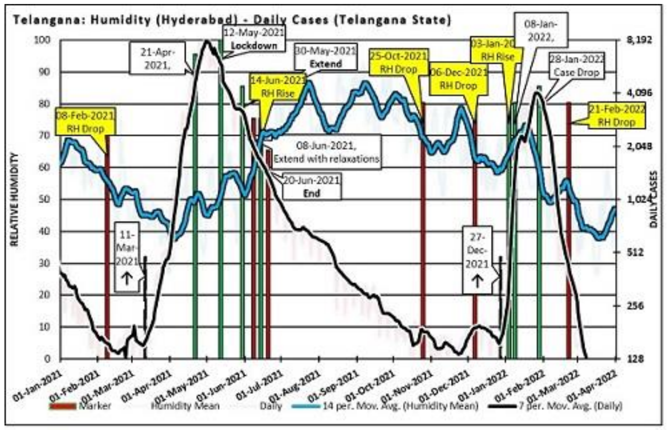


Figure 16. Band B.2: Telangana State Cases

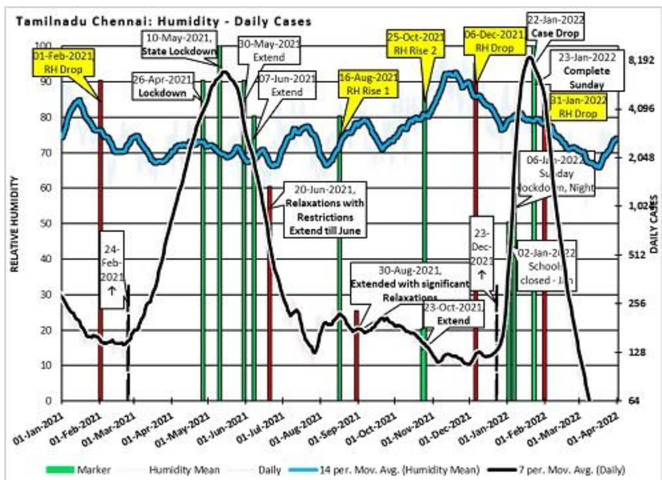


Figure 17. Band A.2: Chennai, Tamilnadu

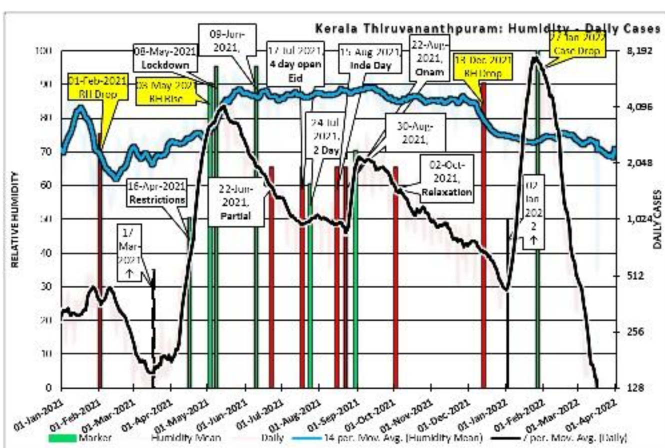


Figure 18. Band A.1: Thiruvananthapuram, Kerala