Research Article

IMPACT OF WIND AND TEMPERATURE ON COVID-19 OUTBREAK: INVESTIGATORY ANALYSIS IN INDIA

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ABSTRACT

The number of infected cases of COVID-19 has risen to over 100 million. With a recovery rate of 72.9% and a mortality rate of 2.2%. Although the safety measures, such as the protective face masks (PFMs) and social distancing, have been implemented, there was an explosion of infected cases in India over the span of 6 months in 2020, that is, May to October; under accordance with the arrival of monsoon. The virus spread shows preference to low temperatures and wind speed, as seen throughout India. Here, the study will shed light on the link between the spread of the pandemic in India and the meteorological factors of air temperature and wind speed. Weather data across state capitals and major cities is studied along with nation-wide data on COVID-19 infection cases. The study depicts the behavior of a variant of coronavirus in India, as less stable and low transmission rates at high temperatures and lower wind speeds. On the other hand, its stability, transmission and infection severity are considerably higher at lower temperatures and wind speed. The study traces the importance of self-isolation and social distancing, especially during cold weather conditions.

Keywords: *SARS-CoV-2, Coronavirus, COVID-19, Meteorological Factors*

1. INTRODUCTION

The pandemic of the coronavirus (COVID-19), also called the severe acute respiratory syndrome 2 (SARS-CoV-2) has devastated the economy of the world. Industries, the corporate sector, education and almost every other way of life has come to a standstill. The first encounter of this virus with humanity took place in China, in a city called Wuhan, in December 2019. The virus is named "Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) by the International Committee on Taxonomy of Viruses (ICTV), as it is genetically related to the coronavirus responsible for the SARS outbreak of 2003. Since then, it has spread all over the globe and has been titled a pandemic by the World Health Organization (WHO).

As of January 1st, 2021, there have been 83743729 infected cases, 1824202 deaths, and 58796613 recovery cases reported globally. And India has a share of 10303409 infected, 149205 deaths, and 9901929 recovery cases (https://epidemicstats.com/coronavirus). There have been many safety protocols implemented throughout the country to prevent human-to-human transmission. These measures are put-forth to decrease transmission through the country, which might have been influenced by meteorological factors [7]. There have been many studies that have examined the relationship between coronavirus and meteorological factors, such as humidity [8], temperature [9], and air pollution [18], there is also the study done by Sarkodie and Owusu, which focuses on wind speed, surface pressure, precipitation and other meteorological factors (2020). The COVID-19 has shown a genetic variability due to which it has mutated during its time [19].

The WHO has reported four variants of the coronavirus, out of which, the one extracted in India is the UK variant. This study will focus on the meteorological factors of wind speed and temperature and their effects on the pandemic. The study will examine the number of infected cases along with the changes in weather conditions of India, and provide clarity on the effects of temperature and speed of winds on the pandemic.

2. METHODOLOGY

Using national-level data on each month and comparing the fluctuations in temperature and wind speed with cases of infections, the study will construct a data structure. Cities of Mumbai, Delhi, Ranchi, Kochi, Patna, Bilaspur, Jaipur, Bhopal, Chennai, Hyderabad, Shimla, Chandigarh,

Kolkata, Ahmedabad, Guwahati, Bhubaneswar (old), Dehradun, Lucknow, Puducherry, and Gangtok are taken under consideration for weather analysis throughout the affected states of India. For better investigation, all the considered cities are divided in four different parts of India i.e. Northern cities (Chandigarh, Shimla, Lucknow, Dehradun and Delhi), Eastern cities (Bhubaneswar, Gangtok, Ranchi, Guwahati and Patna), Southern cities (Puducherry, Visakhapatnam, Kochi, Mumbai, and Chennai), Western and Central cities (Jaipur, Bhopal, Jabalpur, and Bilaspur). The scarcely affected regions having consistent weather throughout the year are to be discarded for better analysis of fluctuating weather conditions. Weather parameters of temperature (max. & min. ^{o}C) and wind speed (km/hr), considered under the time frame of April 1st, 2020 to December 31st, 2020, are used for comparison with numbers of infection cases.

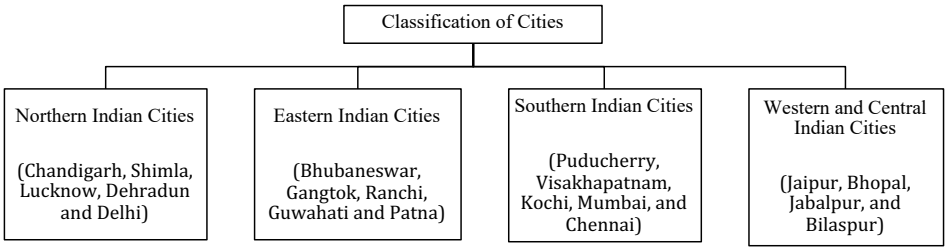

Figure 1. Classification of all the Cities used for the study of Wind Speed and Temperature

3. **MATERIALS**

The data used in this study has been taken from Weather Data Services | Visual Crossing, Weather Atlas (www.weather-atlas.com) for temperature and Epidemic Stats (https://epidemicstats.com/coronavirus) for statistics on COVID-19 cases and Weather Online (www.weatheronline.in) for wind speed, with data maps for COVID-19 cases from Wikipedia and OurWorldInData.org (https://ourworldindata.org/coronavirus-data). The temperature data consists of: Average temperatures, taken from April 1st, 2020 to December 31st, 2020. And the wind speed data consists of: Average wind speeds, for the same range.

The COVID-19 cases data (collected at the ends of the months) comprises of April, infected – 34862, deaths – 1154, recovered – 9068; May, infected – 190609, deaths – 5408, recovered – 91852; June, infected – 585792, deaths – 17410, recovered – 347836; July, infected – 169705, deaths – 36551, recovered – 1095647; August, infected – 3687939, deaths – 65435, recovered – 2837377; September, infected – 6310267, deaths – 98708,

recovered – 5270007; October, infected – 8136166, deaths – 122149, recovered – 7489203; November, infected – 9463254, deaths – 137659, recovered – 8888595; December, infected – 10286329, deaths – 149018, recovered – 9881786.

Table 1. Data considered for the Investigation

Data Category	Dates Taken		Units Used
	From	To	
Temperature	1st April, 2020	31st December, 2020	Degree Celsius (symbol: °C)
Wind Speed (Average)	1st April, 2020	31st December, 2020	Km/Hr.

4. DATA MODEL AND RESULTS

COVID-19 cases:

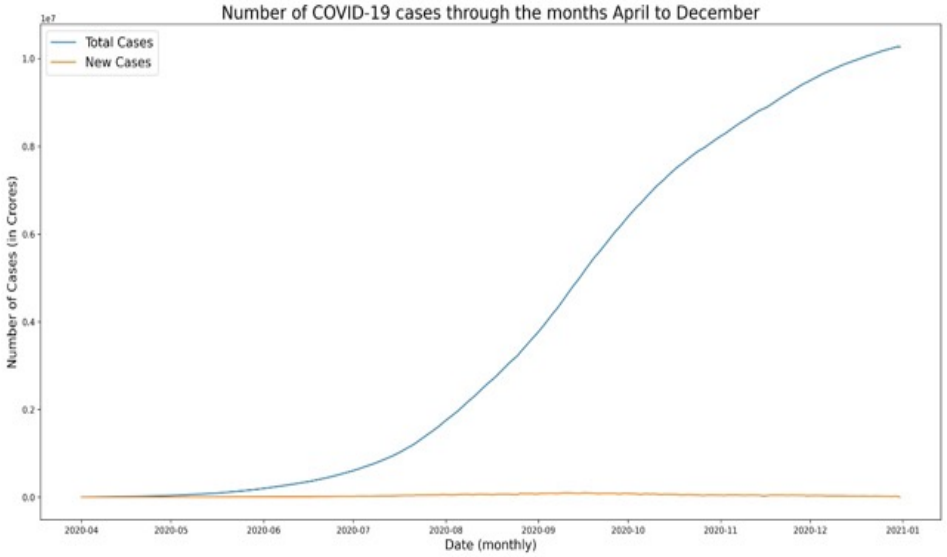

Figure 2. shows the number of COVID-19 cases through the months April to December of 2020, in India. Source: OurWorldInData

The number of COVID-19 cases show a steady incline till the month of August, where it starts increasing exponentially till October, and show a steady incline again afterwards. This is in accordance with the fall of temperatures and wind speed after the initial months of monsoon. The onset of the pandemic in India, came at the end of the month of March, April and may were plagued with steady increase of COVID-19 cases. The cases started increasing exponentially with the beginning of monsoon and lockdown relaxation in the months of August and September, and stabilizing in the winter.

A. Monthly Average Maximum and Minimum Temperatures:

I. For Eastern Indian Cities

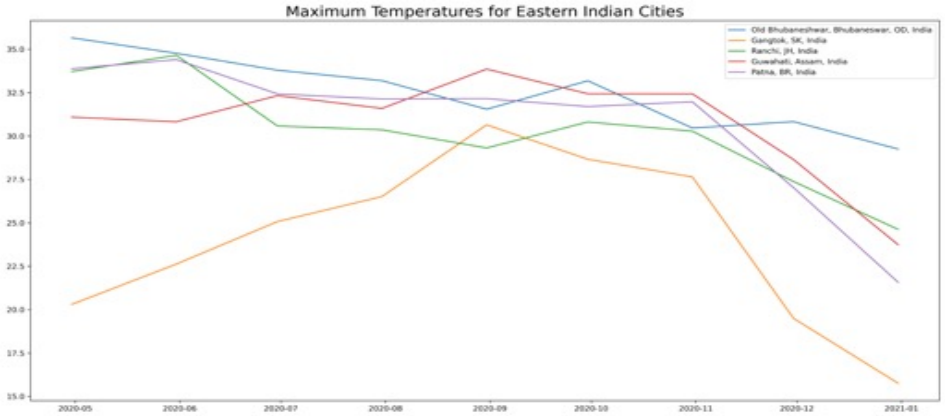

Fig 3. (a)

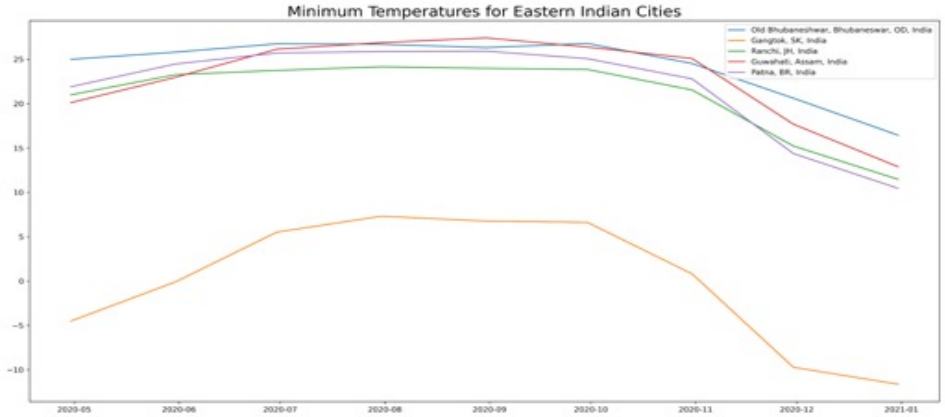

Fig 3. (b)

Figure 3. (a) and (b) show maximum and minimum monthly average temperatures for the cities of Bhubaneswar, Gangtok, Ranchi, Guwahati and Patna (Eastern Indian Cities)

Fig 3. Shows max and min monthly averaged temperatures of East Indian Cities. The maximum temperature lies between 35 ^{o}C to 20 ^{o}C and minimum temperature from 25 ^{o}C to 20 ^{o}C. As these cities lies in the eastern part of India, which means many of them are costal and hilly cities, due to which the temperature remains in this range and do not show much rise. Bhubaneshwar hold a steady minimum temperature of 26.63^{o}C and declining max. temperature from 34.7 to 33.1^{o}C over monsoon. Ranchi holds a steady minimum temperature of 23.92^{o}C and maximum temperature of 30.26^{o}C. Patna holds a minimum temperature of 25.63^{o}C and the maximum temperature declines from 32.42 to 31.7^{o}C. Guwahati

and Gangtok both show an exception to the temperature decline and fluctuations with both reaching their highest temperatures in the month of September. However, Gangtok depicts low temperatures throughout the year due to its geographical location, and thus the implied exception becomes irrelevant.

II. For Northern Indian Cities

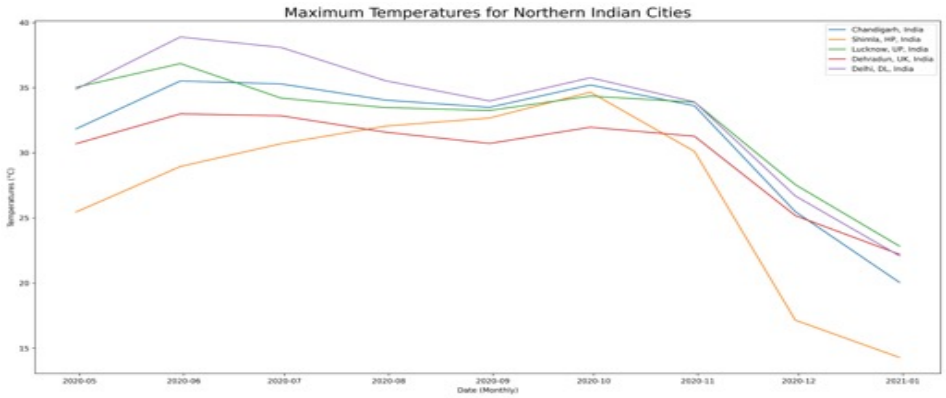

Fig 4. (a)

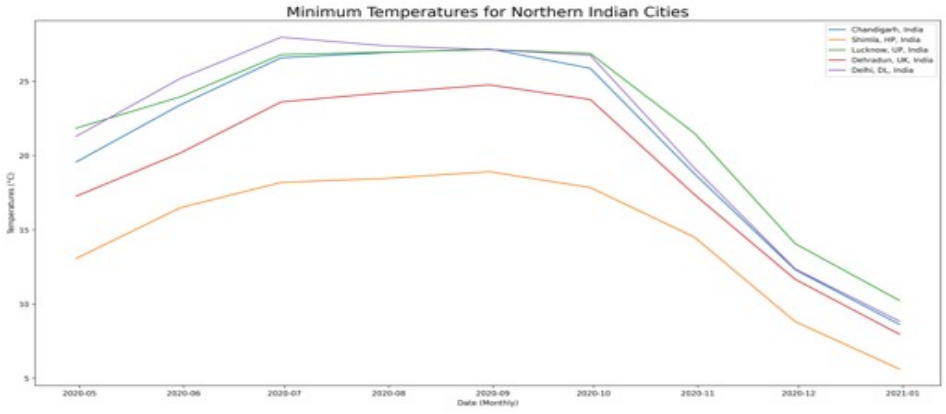

Fig 4. (b)

Figure 4. (a) and (b), depicts maximum and minimum average monthly temperatures for the cities of Chandigarh, Shimla, Lucknow, Dehradun and Delhi. (Northern Indian Cities)

Fig 4. Shows max and min monthly averaged temperatures of North Indian Cities. The maximum temperature lies between 38 °C to 25 °C and minimum temperature from 28 °C to 15 °C. As these cities lies in the northern part of India, most of the cities are highly populated, hilly and away from coast, hence due to which temperature in summer months is comparatively greater than in winter months. The temperature in early winter months

like October and November shows a peak, due to the offset of Monsoon and rise of humidity. Chandigarh showed decline in both maximum and minimum temperatures, with initial temperatures at 35.29°C and 26.59°C declining to 33.61°C and 18.77°C respectively. Lucknow and Delhi show similar trends to Chandigarh. Dehradun shows steady temperatures for both maximum and minimum, with minor fluctuations. Shimla shows an exception as it reaches its highest temperatures during monsoon.

III. For Northern Indian Cities

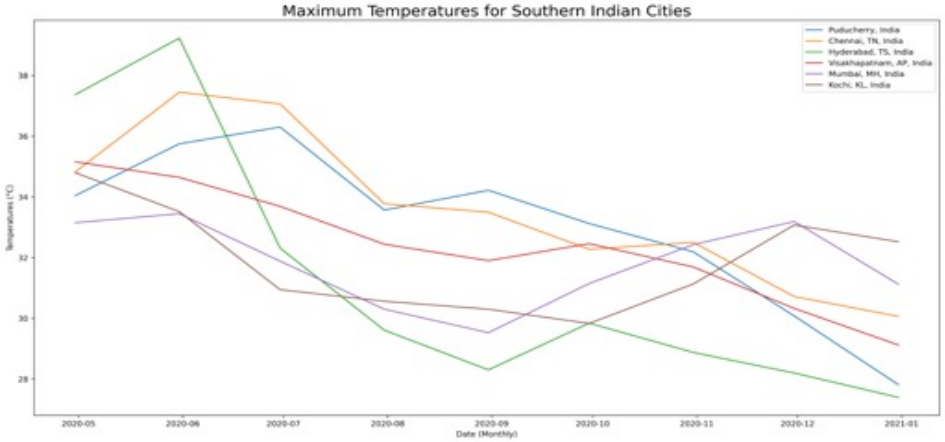

Fig 5. (a)

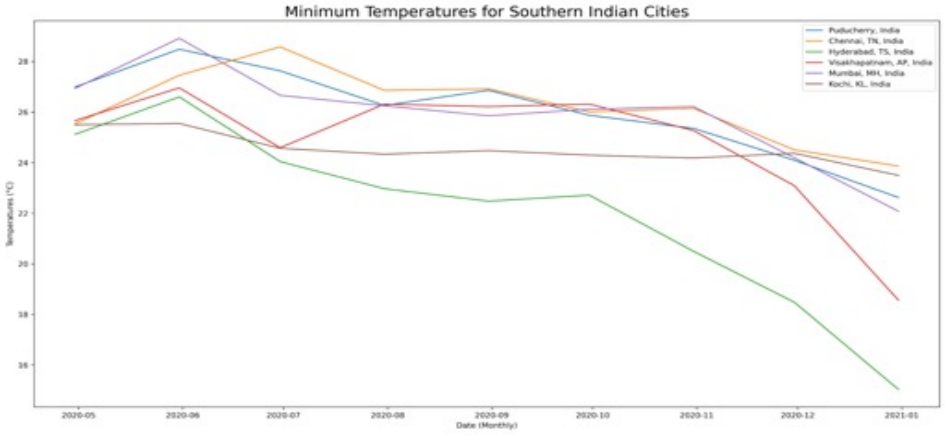

Fig 5. (b)

Figure 5. (a) and (b), depicts maximum and minimum monthly average temperatures for the cities of Puducherry, Visakhapatnam, Kochi, Mumbai, and Chennai. (Southern Indian Cities)

Fig 5. Shows max and min monthly averaged temperatures of North Indian Cities. The maximum temperature lies between 38 °C to 30 °C and minimum temperature from 28 °C to 25 °C. As these cities lies in the southern part

of India, the cities are mostly close to coast of India. The coastal cities relatively have moderate temperature and high humidity. The temperature is controlled by the humidity in these cities. During monsoon months the humidity is approximately near to null, due to which the maximum temperature falls. Puducherry, Vishakhapatnam, Kochi, Mumbai and Chennai without exception show drop in temperatures during monsoon with Hyderabad showing extreme drops. Also, one of the factors which can be considered is, these cities have various manufacturing industries which also rises the temperature.

IV. For Northern Indian Cities

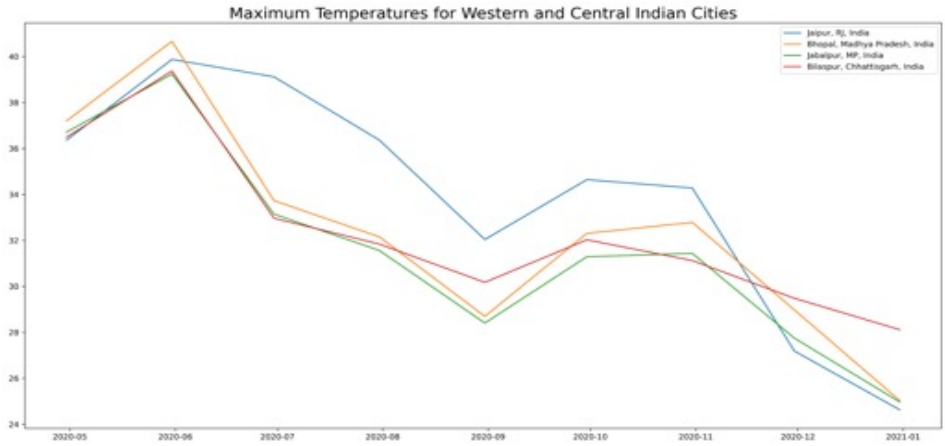

Fig 6. (a)

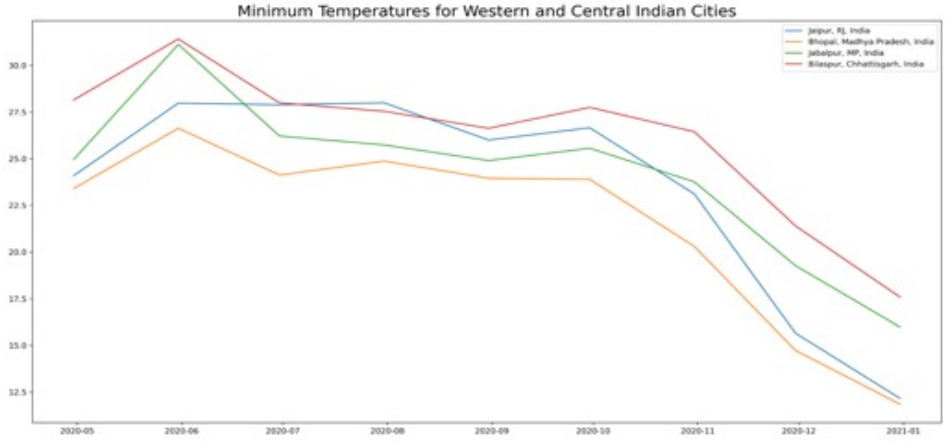

Fig 6. (b)

Figure 6. (a) and (b), depicts maximum and minimum monthly average temperatures for the cities of Jaipur, Bhopal, Jabalpur, and Bilaspur. (Western and Central Indian Cities)

Fig 6. Shows max and min monthly averaged temperatures of North Indian Cities. The maximum temperature lies between 38 °C to 30 °C and minimum temperature from 28 °C to 25 °C. As these cities lies in the western and central part of India, they are densely populated, plain cities and central cities. In the months of May and June, the temperature shows a rise, as the monsoon reaches the central and western regions little late as compared to the rest part of India. The onset of monsoon is marked in the months of late July till the beginning of October. Hence the temperature remains to be slightly less than the other months. Bilaspur, Jaipur, Jabalpur and Bhopal Show decline in both maximum and minimum temperatures after the onset of monsoon. Late October and November relatively experiences a high humid environment.

B. Monthly Average Wind Speed:

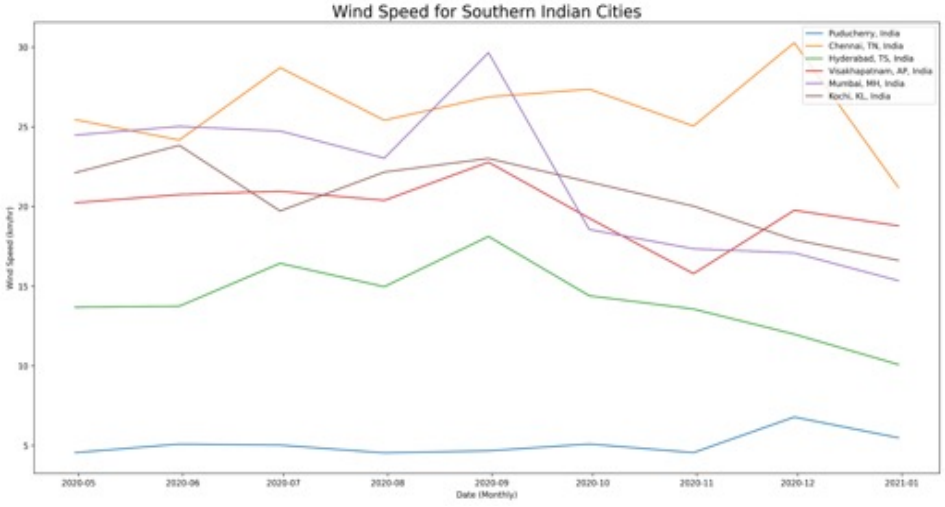

Fig 7. (a)

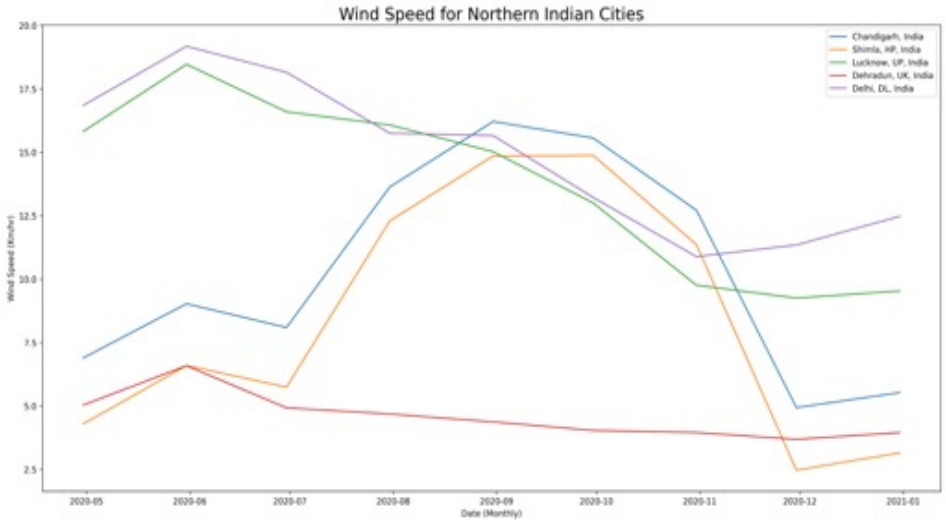

Fig 7. (b)

Shimla, Chandigarh, Mumbai and Chennai show unusual temperature trends, that spike in the middle months and then stabilize in the Winter period. The month of September shows the most unusual behavior, Chennai has a temperature spike even in the Winter.

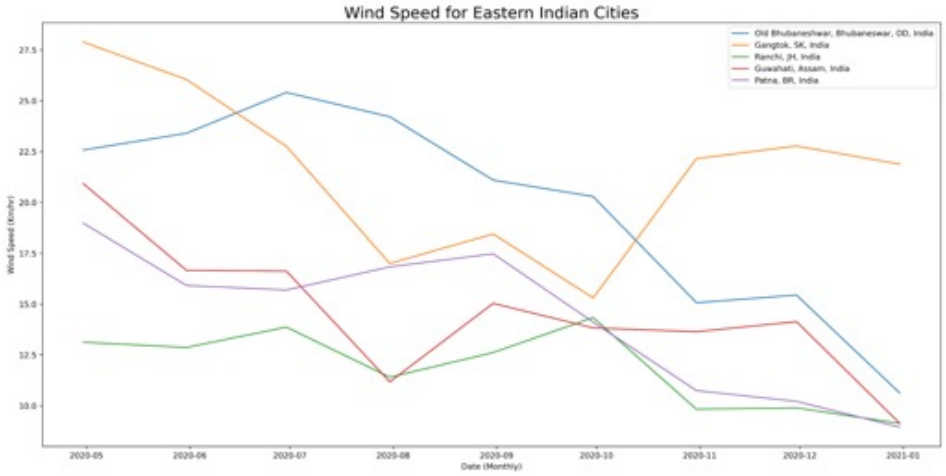

Fig 7. (c)

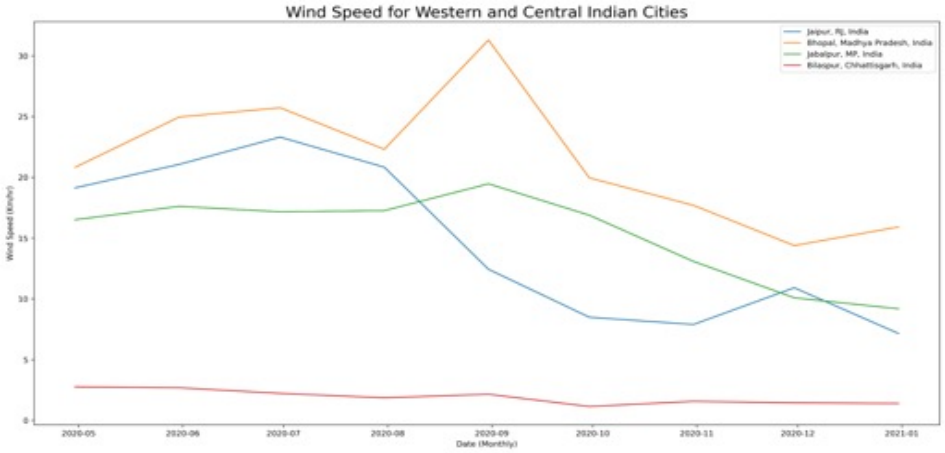

Fig 7. (d)

Figure 7. (a), (b), (c) and (d) depicts monthly average wind speed for the Indian cities.

The lowest average wind speed came in September for Chhattisgarh, an average of only 1.14 km/h. While the highest monthly wind speed average was for Bhopal, an average of 31.3 km/h. The majority of the cities show a decline from June to September, the monsoon season, with a momentary rise in June and July and a steep drop in August in some cities. The only exceptions are Shimla, Gangtok, Chennai and Puducherry, forming four exceptions out of twenty cities with Puducherry showing low temperatures throughout the year.

India experiences Summer in the months of April and May and monsoon from June to September. Therefore, it is a given that the cities will experience a decrease in both maximum and minimum temperatures. With only exceptions of Shimla, Gangtok and Assam. Which due to topographical factors, witness a rise in maximum temperatures(average). It is important to note that the cities showing exceptions (viz. Shimla, Guwahati, Gangtok) never showed greater temperatures than other cities during the concerned period, i.e. other cities always had higher temperatures than the cities in question. By comparing the above data, we can clearly see that as there is a drop in the temperature and wind speed, there is an exponential increase in the number of COVID cases. We can see a steep decrease in temperature in August and a corresponding increase in the number of infected people. There is a good recovery rate of 97.1% as of February 2021, but a steady death rate of 1.4%. Through the studied data given above from April to December 2020, a total of 10266674 people was infected.

5. DISCUSSION

High temperatures have shown to reduce the spread of COVID-19, whereas low temperatures are reported to facilitate the transmission of coronavirus [6]. Several studies report a rapid decline and viability of coronaviruses, such as the Middle East Respiratory Syndrome (MERS–Cov) and severe acute respiratory syndrome coronavirus (SARSCoV) at high temperatures [2,14]. The virus seemingly stabilizes in cold and dry climatic conditions, whereas warm and wet climatic conditions seems to help in reduction of Covid-19 spread, but these variables alone have been insufficient in explaining the transmission rates of the virus. Altamimi et al. [23] have found that MERS-CoV, in Saudi Arabia, prefers warmer weather conditions. Change in temperature, wind speed and humidity were meteorological variables that could affect SARS-Cov-1 transmission. According to the report released by the WHO there are currently four variants of COVID or SARS-CoV-2 circulating around the globe. The newer variants are supposedly more dangerous, but there is no clear evidence that they are causing increasingly severe outcomes. The variant found in India is the UK variant, which is less stable, viable and has lesser chances of transmission at higher temperatures and wind speed, and is more stable in lower temperature and wind speed, as shown in our study. Therefore, it is recommended that self-isolation and social distancing be practiced, along with other safety measures, especially during cold and rainy weather conditions.

6. CONCLUSION

The study has tried to clarify the effects of air temperature and speed on the pandemic situation. We collected the data through various modes and formed a link, which shows a relation between the fluctuations of meteorological factors and the spread of the coronavirus. By analyzing the data on temperature and wind speed, we can conclude that lesser temperature and lower wind speed causes the virus to concentrate at a place and causes the increase of infection cases. It also affects the recovery rate as recovery rates are seen to be higher at higher temperatures. Therefore, it is clear that the arrival of the monsoon and the drop-in temperature and wind speed had a negative impact on the pandemic situation in India.

7. LIMITATIONS

a. With temperature and wind speed there are also other meteorological factors that affect the pandemic, therefore it is difficult to reach a point of certainty.

b. There are also different variants of coronavirus that react differently to different weather conditions, so it is necessary to gather enough genetic evidence before reaching a concrete conclusion.

c. Various cultural and sociological factors also interfere in data analysis, as they affect the spread of the pandemic to a large extent.

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