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Is it the Temperature or the Population the Perpetrator of COVID-19 Pandemic in India?

Gaurav Badoni[1], Diksha[1], Kumud Dhyani[2], Nilotpal Chowdhury[3], Manju O Pai[3*]

[1] Department of Microbiology, AIIMS Rishikesh
[2] Centre International de Development Pharmaceutique Biotech India Private Limited, New Delhi
[3*] Department of Pathology and Lab Medicine AIIMS Rishikesh, manjuohripai@gmail.com

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Abstract: Background: The ongoing CORONA pandemic is still spreading its wings and diving high in an exponential manner across the globe. Great efforts have been put forth to study the factors affecting its growth and prevalence like temperature, precipitation and air pressure, but still there is a need of continuous scrutiny for the factors affecting its spread. This study is aimed to study such factors taking the temperature and population density of India into account and see whether they have any effect on the spread of this pandemic. Methods: Daily confirmed cases from all the states and a few union territories of the country were taken from the government websites from the month of February 2020 to May 2020. Robust linear mixed model fit using R (statistical software) version 3.6 statistical software was used to examine the relationship between temperature and population densities at various states and union territories of India with respect to the spread of COVID-19 infection.

Keywords: COVID-19, pandemic, temperature, population density, India

I. INTRODUCTION

January 30th, 2020 was the day that marked the first report of CORONA virus infection in India in the state of Kerala by a group of students who had come back from the city of Wuhan, China. Then after the month of February did not see much cases of COVID-19 infections till its end. Month of March welcomed the season of spring with the gradual increase of CORONA virus cases across the country (India Today, Jan 2020). This hike in number of cases was the result of transmission that proliferated after several people with travel histories to COVID affected countries reached India and transmitted the virus to people coming in their contact. On

June 3rd the number of cases breached 2 lakhs with the case fatality rate of 2.8% which was much lower than global rate of 6.13% (The New Indian Expression, June 2020). This was seen even after government strategy of lockdown was imposed on the whole country thus controlling the hike in cases to some extent. Besides this, the number of cases still increased in the major metros and non-metropolitan cities of India.

There are reports from various parts of the world that try to find correlation of several factors like climate, temperature, population density etc. with the CORONA virus outbreaks (Hemmes et al., 1960). It is well documented in many studies as how climate plays a crucial role in human health. Temperature and precipitation are the essential components of a climate change that directly affect the health of an individual. May it be linked to its social or economic environment they can play a significant role in public health in terms of epidemic spread and control (McMichael et al., 2008). In terms of the global infections, it is well studied that temperature has a strong linkage with the viral infections. The growth, persistence and spread of the viruses are directly related to the climatic changes. All the organisms, including viruses have an ambient temperature for their growth, and studies show that the transmission and spread of viral infections are more at lower temperatures (Tan et al., 2005). Thus, in this ongoing CORONA virus pandemic, the arrival of summer was thought to reduce the transmission of the COVID-19. A previous study from China have suggested that the SARS outbreak was significantly associated with the temperature, as there was an increase in rate of infection at lower temperatures (Tan et al., 2005). Not only SARS2 and 3 but other influenza viruses have also been linked for their spread with weather variables such as cold temperatures. Cold and /or dry air have been associated with influenza transmission (Chan et al., 2011). Studies done during 2011-2018 from Northern Europe have also correlated low temperatures and low UV index with spread of Influenza viral infections (Ianevski et al., 2019). A report by Jakkhola et al, (2014) also supports that cold temperature and lowering in humidity supports the viability and growth of influenza A and B viruses. The same school of thought prompted observational studies for COVID-19 infections, and similar interpretations were drawn (Triplett, 2020; Wang et al., 2020a; Wang et al., 2020), however, there is still lack of significant evidence. Therefore, it is essential to understand the role that weather conditions could have a role on the transmission of COVID-19. In a Chinese report by Xie et al, (2020) stated that there was a positive undeviating correlation between the mean temperature and COVID-19 cases. But there is lack of literature which supports that with increase in temperature or when it gets warmer, is there a decline in the number of COVID-19 cases or not?

Keeping these observations in mind, it was hypothesized that with the entry of summer season, and subsequent increase in the UV index in India, there might be a declining trend in COVID-19 transmission. Amidst the various measures taken by Indian government to decrease or flatten the curve of Covid-19 cases like putting a lockdown, city and state border screenings, airport screenings and not encouraging inter and intra state travels, still, the number of cases is increasing not only in India but throughout the world. So, is it justified to say that the spread of this infection is dependent on temperature or humidity or it's the population density which matters at every place which caters to the spread? This report summarises the temperature variations from the month of February to May in different states of India taking into account the state's population density as well.

II. MATERIALS & METHOD

Study Area

India is situated in the continent of Asia. It lies completely in the Northern hemisphere and Eastern hemisphere between latitudes 84′ N and 37°6′N and longitudes 68°7′ E and 97°25′ E. It is the second most populated country in the world with nearly a fifth of the world's population. According to the 2019 revision of the World Population Prospects population stood at 1,352,642,280. ("Overall total population" – World Population Prospects: The 2019 Revision" (xslx). population.un.org (custom data acquired via website). United Nations Department of Economic and Social Affairs, Population Division. Retrieved 9 November 2019.). Reported covid positive cases from 28 states and 8 union territories of India with their respective population density were collected (http://www.mygov.in/covid-19).

Data Collection

The data set of the Covid-19 positive cases reported in different states and union territories of India were obtained from the website updates of Indian Council of Medical Research (ICMR) and the population updates were taken from the information portal of Unique Identification Authority of India (UIDAI) and population per square meter from Indian Government information portal of NITI AAYOG. The data was calculated and represented as cases/million that is Covid positive cases with respect to the population of respective states with temperature variations from the month of February to April and May2020. Humidity and pollution parameters were also taken into account as the influencing factors. The air quality index ($PM_{2.5}$) and humidity % data from February 2020 to May 2020 of major cities, New Delhi, Mumbai, Chennai, Kolkata, Lucknow and Jaipur was retrieved from Central Pollution Control Board, Ministry of Environment, Forest and Climate Change Government of India and en.climate-data.org (https://en.climate-data.org/) respectively.

Data Analysis

As the data was not normally distributed therefore Robust linear mixed model fit by using R® version 3.6 statistical software and Robust Linear Mixed Model package (RLMM) was used to examine the relationship between temperature and population densities at various states and union territories of India with respect to the spread of COVID-19 infection. The weeks were used as random effect variables while the logarithm of population density and temperature was used as fixed effects variables using the RLMM packages.

III. RESULT AND DISCUSSION

Three parameters were analysed that are: temperature, states and population density with respect to the COVID-19 infection in India. As it was difficult to have a parametric multivariate analysis of all these factors while meeting statistical assumptions with respect to COVID-19 infection, we opted for Robust linear mixed model fit in R®. The RLMM is robust to the assumptions of the statistical analysis not being met, allowing valid conclusions to be drawn. The data here shows that among the two variables that is temperature and population density in different states and union territories of India, the cases of COVID-19 were correlated. The results show a positive correlation of COVID-19 infection with population density, but no significant correlation was found with temperature change.

Random effects

Groups	Name	Std.Dev.
Week	(Intercept)	1.433
Residual	1.416	

Fixed Effects

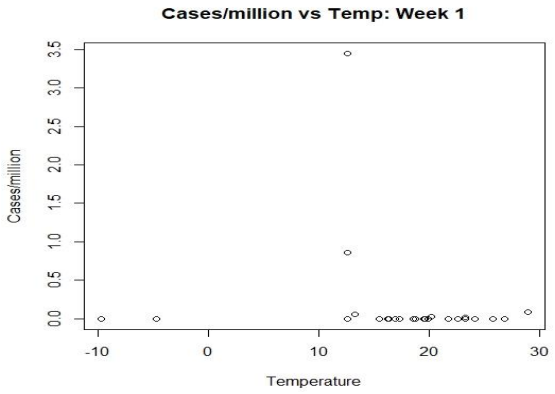
(Intercept)	log (popden; population density)	Temp
-0.22288 (-1.268-0.822)	0.169 (0.056-0.281)	0.0153(-0.007-0.038)

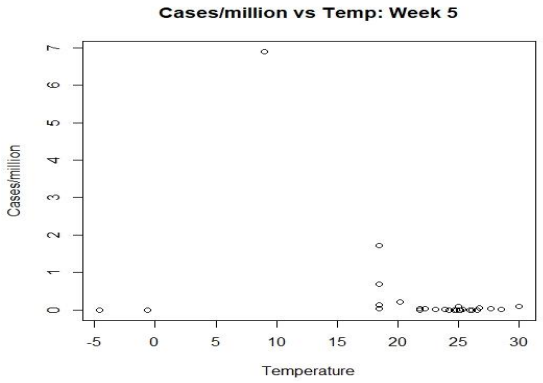
The graphs below (Fig 1) show a clear picture about the distribution of COVID-19 cases/million (wrt population density) in different states Vs temperature variation in the 12 weeks' time (i.e. from month of February to April). It can be seen that till 6 weeks, maximum of 10 cases per million were observed in different states of India below 30°C. After that slowly a rise in COVID-19 cases was seen. Taking each week separately, no definite trend was visualised between the cases per million and temperature. The month of April i.e the ninth week onwards there was a sharp increase in number of cases. Interestingly, the sharp increase was more evidently seen in the metros as compared to the rest of the areas of the country. Fig 2 depicts the graph (with values of positive cases from Feb-May) with the red values on the histograms showing the percentage of COVID-19 positive cases coming exclusively from metros. Inspite of the temperature rise, the hike in COVID-19 cases in India is also caused by the increase in mobility of the people. As the capital city of India, Delhi and other metros like Tamilnadu, Ahemadabad and Maharashtra are the economic destination for job seekers including migrant labourers and daily wagers. And these places being highly populated, the increase in population density allows COVID-19 transmission to be very fast.

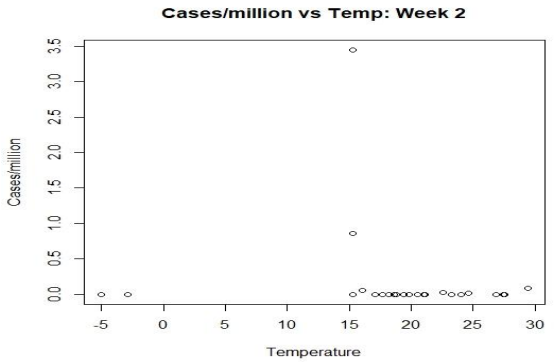
It is well believed and established fact that nature and environment play a very crucial role in the well-being of human life and temperature is an essential component which can play a significant role in public health with respect to any epidemic development and control (McMichael et al., 2011). In case of infection, the culprit organism either it is bacteria, fungi or virus has a specific ambient temperature at which it remains viable, grows and propagates. Recent reports on covid infection have said that specific temperature especially lower temperature best fits the benefit of the virus growth and that cold temperatures contribute to its transmission because it is when the vulnerability increases (Tobias and Molina, 2020). But this scenario has not been seen in India, with the virus creeping in at the mid of winter with lower cases followed by gradual increase in covid cases with the beginning of summer, which is still on a hike till date, as shown in our results. In-fact the temperature and virus propagation went hand in hand. In contrast, a report from China, (Wang et al., 2020a) found a strong influence on the *R* value, with a significant level of 1% for both that temperature and relative humidity. Sajadi et al.,2020, recently have also shown that temperature and humidity have a significant correlation with distribution and seasonal behaviour of respiratory viruses. Worldwide, the studies conducted on covid infections have predicted and shown high correlation ($r^2 > 0.6$) with meteorological variables using real data (Chen et al., 2020; Pani et al., 2020). Wuhan, is an example of Covid-19 where transmission is associated and correlated with weather and disease spread. Their study also demonstrate that warm weather suppresses the disease (Guo et al., March 2020). But this isn't the case in many of the countries right now. Our country has been experiencing warm weather since March, and as discussed above our results show that there was a gradual hike in covid19 cases from the month of March (i.e 6th week onwards).

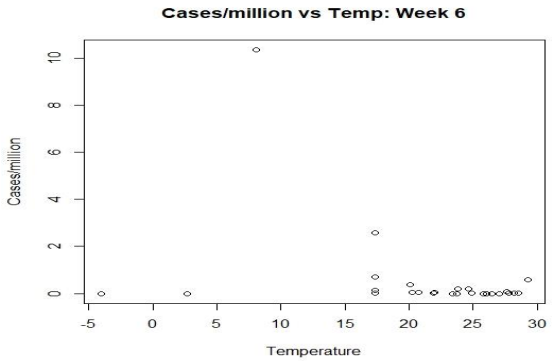
Indian government successfully carried out overall lockdown from March 24, 2020 to May 3, 2020 due to the pandemic of COVID-19. During this period the level of $AQI_{PM\ 2.5}$ significantly decreased of all selected cities from March to May. Fig.3 (A-F) shows that the highest drop of $AQI_{pm2.5}$ was recorded in the month of April 2020 from all selected cities. On the other hand, places like Delhi, Chennai, Lucknow, Jaipur have shown that increased humidity does have a positive correlation with the increased covid cases.

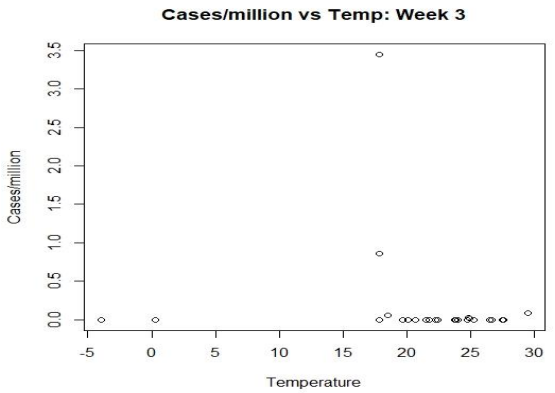
Studies from other countries have also shown that the viability and stability of the viruses depend on weather related factors like wind speed, pollution, visibility and humidity (Ma et al. 2020; Poole 2020, Monebo et al.,2020). The incidence rate of COVID-19 in Jakarta, Indonesia was significantly correlated with temperature and population density of that area (Tosepu et al, 2020). This pandemic had a similar face in Turkey where results showed that the highest correlation of covid infection was observed with population, wind speed and temperature respectively (Sahin, 2020). A study from the USA, New York explained weather association with the COVID-19 pandemic where temperature and air quality were the major felons (Gupta et al., 2020). A study in the Lancet (April 2020) shows the status of India in lockdown (The Lancet-Editorial). Even if there was migration of immigrant labourers the mobility did not affect the hike in covid19 cases (Economic Times). As the imposed lockdown was eased and the mobility among territories and states was allowed, the hike in cases were observed (Malvika et al., 2020).

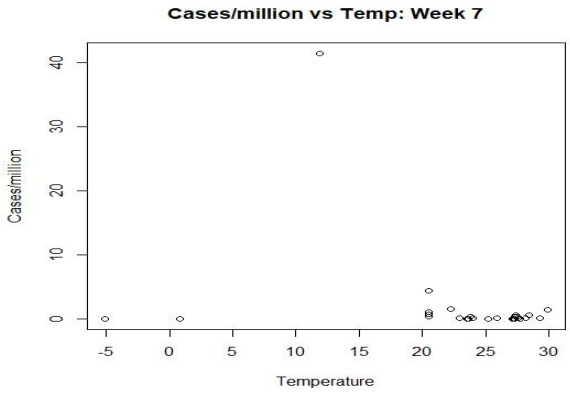

Cases/million vs Temp: Week 1
Cases/million
Temperature

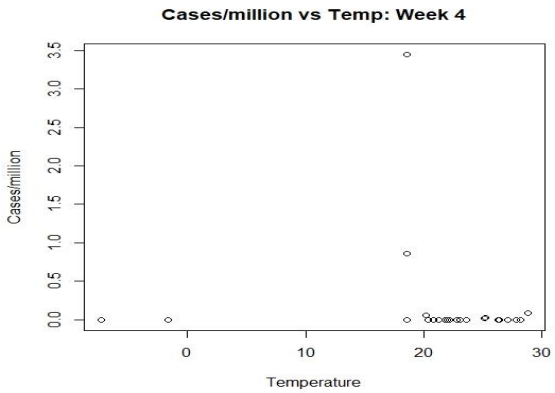

Cases/million vs Temp: Week 5
Cases/million
Temperature

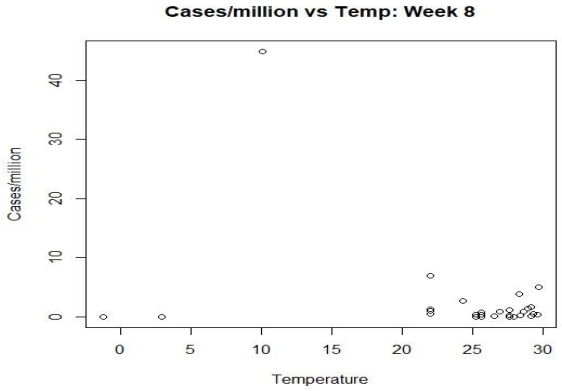

Cases/million vs Temp: Week 2
Cases/million
Temperature


Cases/million vs Temp: Week 6
Cases/million
Temperature


Cases/million vs Temp: Week 3
Cases/million
Temperature


Cases/million vs Temp: Week 7
Cases/million
Temperature


Cases/million vs Temp: Week 4
Cases/million
Temperature


Cases/million vs Temp: Week 8
Cases/million
Temperature

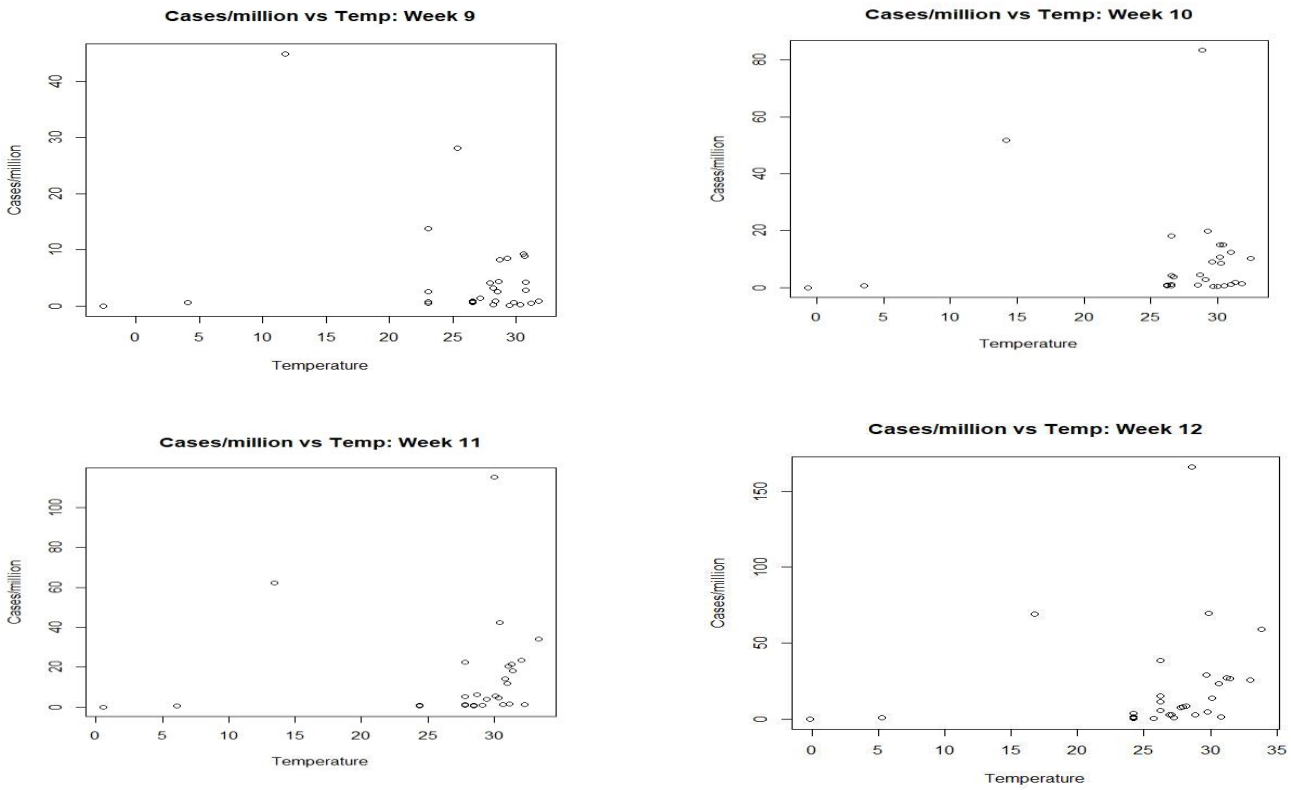


Fig 1. The graphs here depict cases/million on Y axis with the increase in temperature ^{o}C (on X axis). The circular dots represent each state of the country. And the week 1 starts from 1st of February and goes till 30th April 2020 (in total 12 weeks).

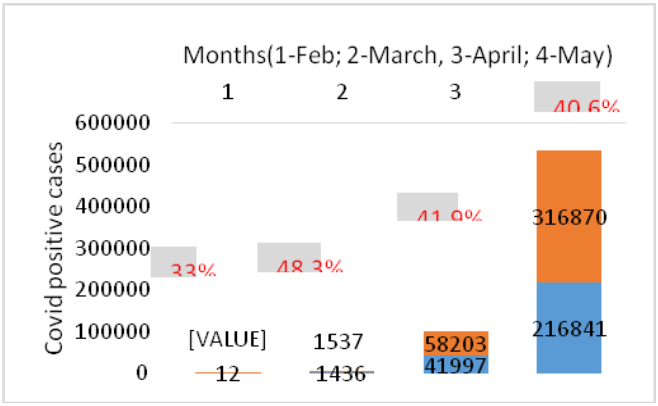


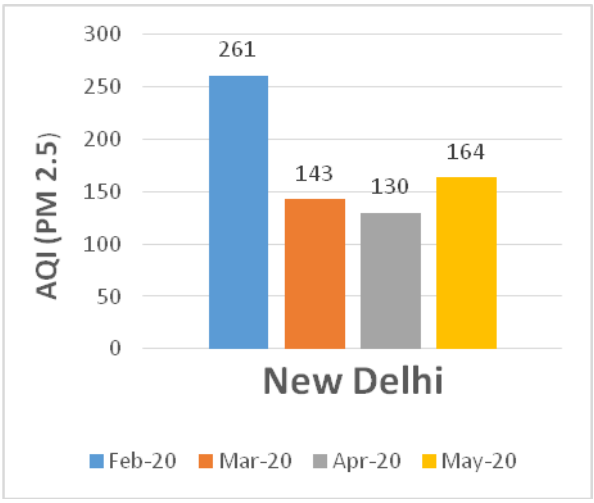
Fig 2. Bar graph depicting the total number of cases in India in the months of February, March, April and May. Blue and the orange areas in total shows the number of covid positive cases amongst which the blue-coloured areas (lower values) show the cases exclusively coming from the metros of the country. Values in red given in the grey boxes above the bars shows the percentage of cases coming positive every month from the metros.

IV. Conclusion

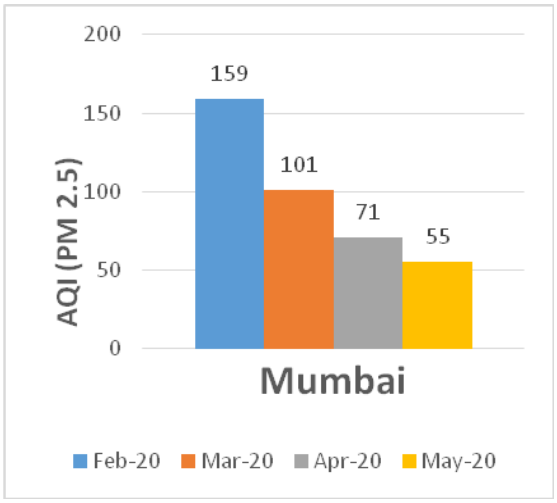
Despite the findings of the weather and population density on covid-19, this study has certain limitations like the viral resistance with different factors, population endurance, general awareness status among the public about individual health. Basic knowledge with routine practice of personal hygiene like hand washing habits, use of hand sanitizers, donning a mask while going in public has to be adopted. However, this study is just the preliminary analysis which will input in strategy making in the prevention of COVID-19 as the country prepares to combat this viral infection even in hard weather conditions and with the removal of lockdown. The strong conclusions may it be from any country data, will require a continuous surveillance of the disease incidence and spread, which has to be followed for a long period of time.

Declaration of Conflict of Interest

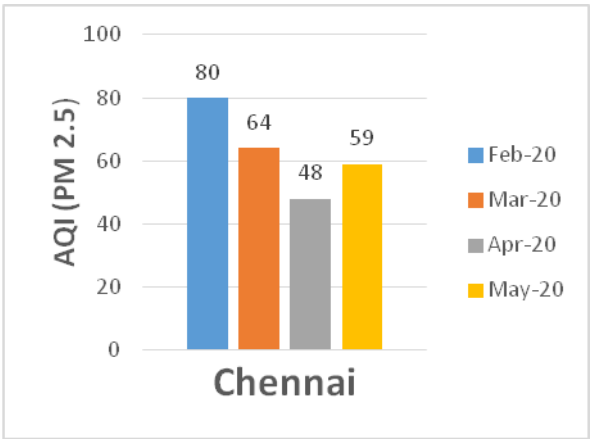
The authors declare that they have no conflict of interest.


AQI (PM 2.5)
300
250
200
150
100
50
0
261
143
130
164
New Delhi
Feb-20
Mar-20
Apr-20
May-20

A


AQI (PM 2.5)
200
150
100
50
0
159
101
71
55
Mumbai
Feb-20
Mar-20
Apr-20
May-20

B


AQI (PM 2.5)
100
80
60
40
20
0
80
64
48
59
Chennai
Feb-20
Mar-20
Apr-20
May-20

C

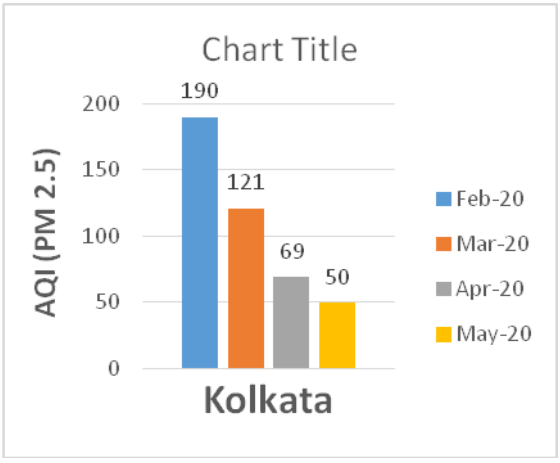
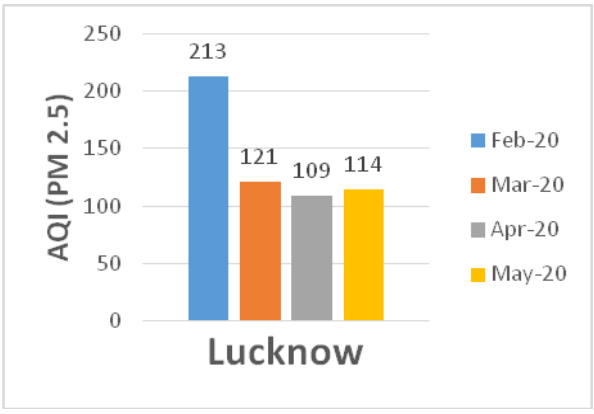


Chart Title
AQI (PM 2.5)
200
150
100
50
0
190
121
69
50
Kolkata
Feb-20
Mar-20
Apr-20
May-20

D


AQI (PM 2.5)
250
200
150
100
50
0
213
121
109
114
Lucknow
Feb-20
Mar-20
Apr-20
May-20

E

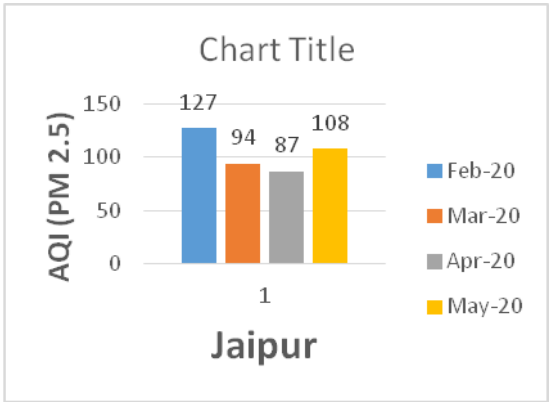
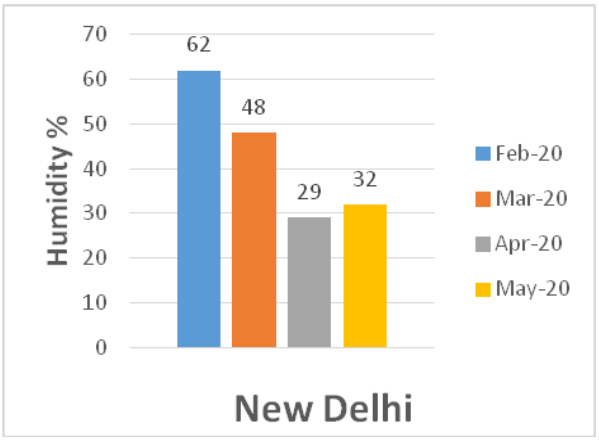
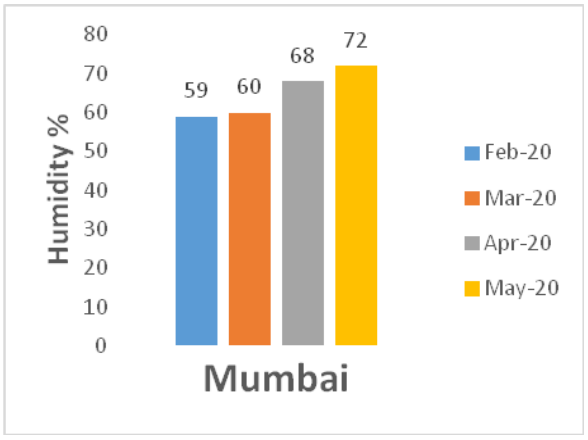


Chart Title
AQI (PM 2.5)
150
100
50
0
127
94
87
108
1
Jaipur
Feb-20
Mar-20
Apr-20
May-20

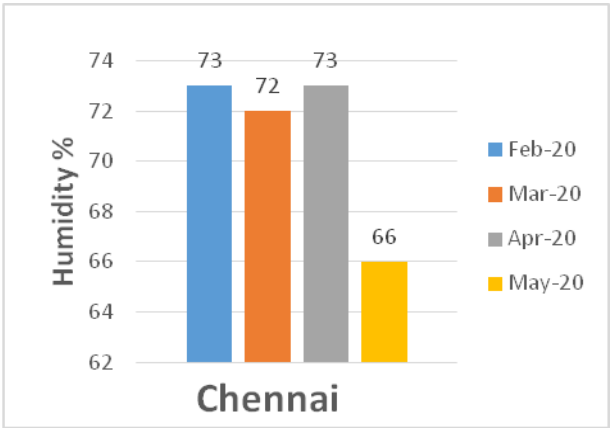
F



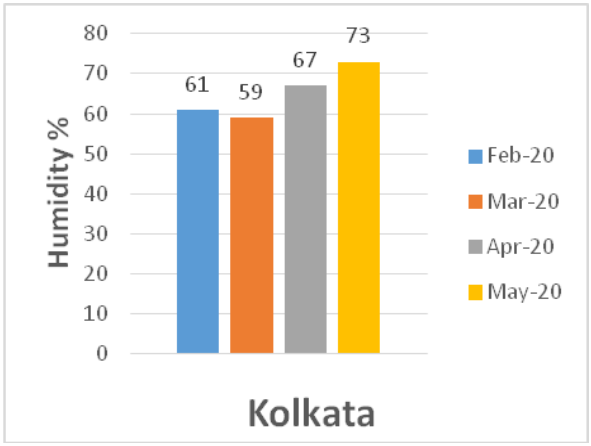
A1



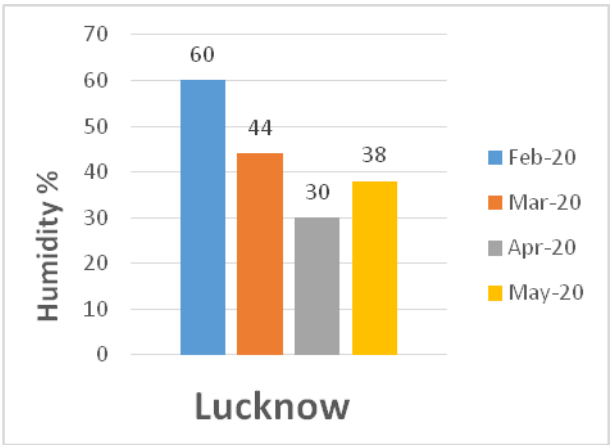
B1



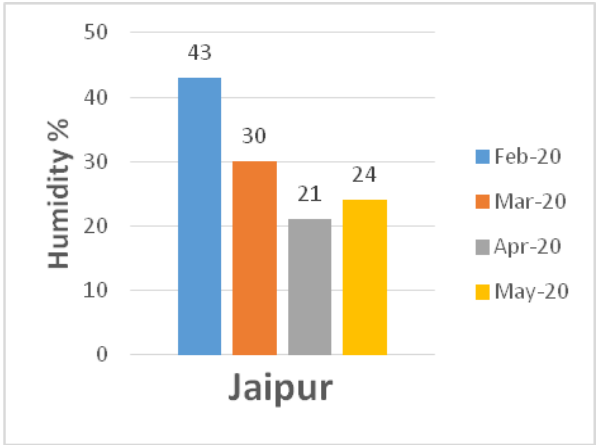
C1



D1



E1



F1

Fig. 3 (A-F) shows that the highest drop of $AQI_{pm2.5}$ was recorded in the month of April 2020 from all selected cities; (A1-F1) shows the humidity levels (%) from the month of February to may in major cities of the country.

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