Environmental Factors Affecting Covid-19 Dynamics: A Study in Bengaluru City of Karnataka State of India

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Abstract
The horrifying and fast spreading COVID-19 pandemic has shocked India and in fact the entire world to its core. Indian Government has taken all the possible preventive steps to contain the wider spread of this highly contagious disease but the second wave in the month of April, 2021 has turned this strong country in a helpless position. In this paper, the effect of environmental factors like temperature and air quality index on the new confirmed cases along with recovered cases has been seen in Bengaluru Urban district of Karnataka State of India. Regression analysis has been carried out with the help of SPSS software. The outcomes from the paper will definitely give some valuable insights for the researchers around the world in their future combat measures.

Keywords AQI · SPSS · Covid-19 · ANOVA

1 Introduction
Today World is suffering from the lethal viral disease Covid-19 which is causing a real threat to human life [6, 18]. WHO in its notification dated 11th March, 2020 announced this disease a pandemic [3]. The pandemic affects almost all spheres of lives like education economy, business, the health sector, industry and livelihood.

India too falls in trap of this deadly disease and is now at a critical phase in this deadlock war. Kerala was the first state of India which reported a positive case of corona virus on 30th January, 2020. With the passage of time, situation of COVID-19
pandemic worsened in other states of country. The highest provinces in the COVID-19 affected are Maharashtra, Kerala, Tamilnadu, New Delhi, Gujarat and Karnataka states of India (https://www.covid19india.org/). It has been suggested that COVID-19 and other viruses like Ebola and influenza had significant relationship with ecological factors [5, 9, 10, 15, 19].

Undoubtedly, the consequences of lockdown, because of this pandemic have been significant reduction in AQI levels, carbon emission, suspended particulate matter, improved air quality index and green gas emissions have dropped considerably [4, 13, 17, 20]. In the meantime, this pandemic also causes some adverse affects to the environment because of bulky quantity of household and medical litter. The people linked with recycling have the fear to get infected to this contagious virus which in turns worsened the situation in absence of proper recycling of this waste [21].

Many geographical researchers elaborated in their research that the severity of Coronavirus depends on geographical/climatological such factors mainly on temperature, sun exposure, humidity and average rainfall [2, 12, 14, 16]. Pollution is one of the crucial factor affecting the mortality rate of Covid-19 [1, 11]. No doubt environmental factors influence the COVID-19 transmission dynamics, yet there is a need to investigate the relationship with the help of advanced statistical techniques. The main aim of the present paper is to explore the effect of temperature and air quality index on the dynamics of covid-19 in Bengaluru city of Karnataka state of India. The effect of maximum & minimum temperatures along with AQI (air quality index) on transmission risk of Covid-19 has been investigated. Therefore, it is realistic to analyze the relation between environmental indicators (temperature and air quality index) and confirmed and recovered cases of Covid-19. Being an emerging study domain, the present survey study can formulate an analysis of current state of industrial city like Bengaluru that could provide directions to future research.

2 Methods

2.1 Study area

Bangalore which is now officially named as Bengaluru is one of the most developed city of India. Bengaluru is the capital city of Indian state Karnataka and well known for its famous gardens and modern life along with some good ancient architecture. It is the largest city of Karnataka with a population of around 8 million. It is located in Southern India on the Deccan Plateau. Bengaluru is the favorite tourist place to visit because of its lovely weather conditions all over the Year. Among all the cities of India, the elevation of Bengaluru is maximum. The coldest month in Bengaluru is December with mean highest and lowest temperatures 26.2 °C and 16 °C respectively. The hottest month is April with mean highest and lowest temperatures 35.8 °C and 21.8 °C respectively. The air quality index (AQI) at Bengaluru is however better than Delhi and Mumbai, yet it is one of the most polluted city of India ranked 82nd with a 2019 PM2. It is placed in moderate bracket for its polluted air by environmental regulatory authorities of India.
2.2 Data Collection

The set of maximum and minimum temperatures along with daily AQI (air quality index) ranging from 25th April 2021 to 22nd May, 2021 was obtained from the official website of American Media Company accuweather inc. (https://www.accuweather.com/en/in/bengaluru/204108/weather-forecast/204108). Also the daily confirmed cases of Covid-19 in Bengaluru along with daily recoveries for the same time period were derived from the official website of Indian government www.covid19ind.org.

2.3 Data Analysis

A two step multiple regression study was carried out in order to explore the significance of environmental factors like maximum and minimum temperatures along with daily AQI on the dynamics of Covid-19 in Bengaluru City of Karnataka. In first step, daily confirmed cases of covid-19 have been taken as dependent variable with environmental factors being the predictors. In the second step, daily recovered number of cases is taken as dependent variable with same predictors. The significance of the predictors on the dependent variables have been analyzed using ANOVA.

3 Results and Discussions

In the statistical investigation of the dataset, the dynamics of Covid-19 cases in Bengaluru has been studied with climate change parameters like temperature (maximum & minimum) along with AQI. The Fig. 1 shows the pattern of the daily confirmed cased of covid-19 from 25th April, 2021 to 22nd May, 2021. It can be seen that there is sudden surge in cases in end of April which continues to increase till 8th of May, 2021 with highest single day recorded case count of 26,756 recorded on 30th April, 2021. In the third week of May, the case count starts decreasing significantly with only 8214 cases reported on 22nd May. Similarly the Fig. 2 shows the everyday recovery chart of Covid-19 disease in Bengaluru. It can be seen from the figure that highest single day recovery of 23,706 people from the disease on 6th May, 2021. Similar plots have been given for maximum and minimum temperatures.

Fig. 1 Variation of confirmed cases day wise
recorded on daily basis (Figs. 3 and 4). Figure 5 shows the daily AQI data for the same time period in Bengaluru. It can be seen that AQI value has crossed 100 in the period from 25th April to 5th May, 2021. Bengaluru reported one of the most polluted days in this time frame with highest recorded AQI of 145 reported on 28th April, 2021.

Now, we will carry out multiple regression analysis firstly by taking daily confirmed cases of covid-19 as dependent variable. The descriptive stats for the dataset have been shown in Table 1. Further, Table 2 shows that the value of R square comes out to be 0.618 which shows that 61.8 percent of the variance of dependent variable (confirmed cases) has been explained by the three independent variables which are maximum and minimum temperatures along with AQI. The difference between the value of R square and adjusted R square is also less than 0.05 which justifies the characteristics of a good model. The value of F change is 12.954 which is more than 10 with a significant p value (Table 3).

Also, it has been noted from the regression analysis that the value of t statistics for the AQI comes out to be more than 1.96 (Table 4) with p value less than 0.05 and tolerance value 0.570 which is greater than 0.5 along with VIF value 1.755 which is sufficiently less than 5. So all these parametric values justifies that AQI is playing the significant role in
Fig. 4  Minimum temperature day wise

![Minimum temperature day wise chart]

Fig. 5  AQI (air quality index) day wise

![AQI day wise chart]

Table 1  Descriptive statistics with Confirmed cases as dependent variable

|                          | Mean        | SD          | N  |
|--------------------------|-------------|-------------|----|
| Confirmed cases          | 17,111.9643 | 5266.55091  | 28 |
| AQI                      | 85.5714     | 37.92920    | 28 |
| Maximum temperature      | 32.3929     | 1.79174     | 28 |
| Minimum temperature      | 22.4643     | 1.03574     | 28 |

Table 2  Determinants of performance

| R         | R²       | Adjusted R² | Change in R² | Change in F | df1 | df2 | Sig. F Change |
|-----------|----------|-------------|--------------|-------------|-----|-----|---------------|
| 1         | .786a    | .618        | .570         | 3451.57870  | .618| 12.954 | 3 24 .000     |

*a  multiple correlation
the surge of infected cases. However, the t stats values for maximum and minimum temperatures are not significant. The correlation coefficient between daily confirmed cases and AQI is 0.463. The positive significant value of correlation coefficient shows that number of arrival of Covid-19 cases depends upon AQI of the region and the number of cases considerably increases with increase in AQI.

Now we will again carryout the regression analysis by taking daily recovered cases as dependent variable and keeping all the predictors same. The descriptive statistics for the dataset has been shown in Table 5. Further, Table 6 shows that the value of R square comes out to be 0.418 which shows that 41.8% of the variance of dependent variable (recovered cases) has been explained by the three independent variables which are maximum & minimum temperatures along with daily AQI of Bengaluru. The difference between the value of R square and adjusted R square is also less than 0.05 which justifies the characteristics of a good model. The value of F change is 5.754 which is considered to be reasonably good for a model. (Table 7).

Also, it has been noted from the regression analysis that the modulus value of t statistics for the AQI comes out to be more than 1.96 (Table 8) with p value less than 0.05 and tolerance value 0.570 which is greater than 0.5 along with VIF value 1.755 which is sufficiently less than 5. So all these parametric values justifies that AQI is playing the significant role in the daily recovered cases of Covid-19. However, the t stats values for maximum and minimum temperatures are not considerable. The correlation coefficient between confirmed cases and AQI is −0.513. The significant value of correlation coefficient between recovered cases and AQI truly justifies the fact that daily recovery from the disease depends upon the daily AQI of the Bengaluru city of Karnataka. The negative sign of correlation coefficient shows that daily recovered cases will increase with decrease in daily AQI.

### Table 3 ANOVA table

|                      | Sum of squares | df | Mean square | F    | Sig  |
|----------------------|----------------|----|-------------|------|------|
| Regression           | 462,965,586.512 | 3  | 154,321,862.171 | 12.954 | .000b |
| Residual             | 285,921,492.452 | 24 | 11,913,395.519  |       |      |
| Total                | 748,887,078.964 | 27 |              |       |      |

b significant value at 1% level

4 Conclusion

In the present study, the affect of air quality index (AQI) on covid-19 transmission dynamics in Bengaluru city of Karnataka state of India has been explored. The statistical analysis from the paper indicates that air pollution significantly affect the susceptibility to this highly contagious disease. The multivariate regression analysis has been carried out, firstly with confirmed cases of Covid-19 as dependent variable and then by taking daily recovered cases as dependent variable. It has been seen that with increase in air pollution, there is an increase in daily confirmed cases of Covid-19 and decrease in daily recovered cases. This dependence of disease transmission on AQI can be attributed to the fact that this virus in presence of poor AQI worsens the scenario by weakening the respiratory system that leads to more cases of covid-19 along with poor recovery of infected individuals. The Governments of almost all states are trying at their level best to prevent the wider spread of this disease by imposing lockdowns, enlarging the medical infrastructure, vaccinating...
Table 4  Regression analysis

| Model | Unstandardized coefficients | Standardized coefficients | T         | Sig | Correlations | Collinearity statistics |
|-------|-----------------------------|---------------------------|-----------|-----|--------------|------------------------|
|       | B                           | SE                        | Beta      |     | Zero-order   | Partial | Part | Tolerance | VIF |
| 1     | (Constant) − 41,255.670     | 19,325.529               | − 2.135   | .043|              |          |      | .570      | 1.755 |
|       | AQI 59.373                  | 23.201                    | .428      | 2.559| .017         | .714     | .463 | .323      | .606 |
|       | Max temp 734.717            | 455.034                   | .250      | ......| .119         | .606     | .313 | .204      | .664 |
|       | Min temp 1312.635           | 810.198                   | .258      | ......| .118         | .625     | .314 | .204      | .627 |

*aDependent variable: confirmed cases*
the public, creating awareness among people about the preventive measures like wearing masks, washing hands etc., yet there is a dire need to enforce some more significant regulations from the government side to curb AQI which in turn will surely help in containment of this highly contagious disease. Our study will certainly provide some useful insights for the policy makers in their combat actions against this Covid-19 pandemic.

Table 5  Descriptive statistics with Confirmed cases as dependent variable

|                          | Mean       | Std. Deviation | N  |
|--------------------------|------------|----------------|----|
| Recovered cases          | 13,394.9286| 9159.57739     | 28 |
| AQI                      | 85.5714    | 37.92920       | 28 |
| Max temp                 | 32.3929    | 1.79174        | 28 |
| Min temp                 | 22.4643    | 1.03574        | 28 |

Table 6  Determinants of performance

| R  | R²    | Adjusted R² | Change in R² | Change in F | df1 | df2 | Sig. F Change |
|----|-------|-------------|--------------|-------------|-----|-----|---------------|
| 1  | .647a | .418        | .346         | 7409.35012  | .418| 5.754| .004          |

a multiple correlation

Table 7  ANOVA table

| Model          | Sum of squares | df  | Mean square | F    | Sig  |
|----------------|----------------|-----|-------------|------|------|
| 1 Regression   | 947,678,903.396| 3   | 315,892,967.799| 5.754| .004b|
| Residual       | 1,317,563,262.461| 24  | 54,898,469.269|
| Total          | 2,265,242,165.857| 27  |               |

b significant value at 1% level
| Model | Unstandardized coefficients | Standardized coefficients | t   | Sig | Correlations | Collinearity statistics |
|-------|-----------------------------|---------------------------|-----|-----|--------------|-------------------------|
|       | B SE | Beta  |       |     | Zero-order | Partial | Part | Tolerance | VIF |
| 1     | (Constant) | 39,289.776 | 41,485.253 | .947 | .353 | .645 | .513 | .456 | .570 | 1.755 |
|       | AQI | −145.738 | 49.805 | −.603 | −2.926 | .007 | −.384 | −.040 | −.031 | .664 | 1.506 |
|       | Max temp | −192.253 | 976.802 | −.038 | ...... | .846 | −.384 | −.040 | −.031 | .664 | 1.506 |
|       | Min temp | −320.340 | 1739.216 | −.036 | ...... | .855 | −.404 | −.038 | −.029 | .627 | 1.596 |
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Data availability statement  The datasets generated during and/or analysed during the current study are available in the [https://www.covid19india.org/] repository, and [https://www.accuweather.com/en/in/bengaluru/204108/weather-forecast/204108].

Declarations

Conflict of interests  Authors declare that they have no conflict of interests.

Code availability  None.

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