



Association of Environmental Parameters with COVID-19 in Delhi, India

Nikhilesh Ladha¹ · Pankaj Bhardwaj¹ · Jaykaran Charan² · Prasenjit Mitra³ · Jagdish Prasad Goyal⁴ · Praveen Sharma³ · Kuldeep Singh⁴ · Sanjeev Misra⁵

Received: 2 July 2020 / Accepted: 11 August 2020 / Published online: 19 August 2020
© Association of Clinical Biochemists of India 2020

Abstract The present study explores the association between weather and COVID-19 pandemic in Delhi, India. The study used the data from daily newspaper releases from the Ministry of Health and Family Welfare, Government of India. Linear regression was run to understand the effect of the number of tests, temperature, and relative humidity on the number of COVID-19 cases in Delhi. The model was significantly able to predict number of COVID-19 cases, $F(4,56) = 1213.61$, $p < 0.05$, accounting for 99.4% of the variation in COVID-19 cases with adjusted $R^2 = 98.8\%$. Maximum Temperature, average temperature and average relative humidity did not show statistical significance. The only number of tests was significantly associated with COVID-19 cases.

Keywords COVID-19 · Temperature · Humidity · Cases

Introduction

The whole world, including India, is facing the Coronavirus pandemic which was started in Wuhan provenance of China in December 2019. In India, the first case of coronavirus was detected on January 30, 2020, in Kerala, and till June 1, 2020, 8:00 am 19,0648 cases have been confirmed. The Indian government has taken stringent action to fight against the COVID-19 by timely lockdown throughout the country and taking various measures like increasing the testing capability and increasing the number of beds for the management of COVID-19 patients. The 5 most populous cities in India are Mumbai, Maharashtra (18.4 million people),

Delhi, Delhi (16.3 million people), Bangalore, Karnataka (8.44 million people), Hyderabad, Telangana (6.73 million people), and Ahmedabad, Gujarat (5.57 million people).

The spread of novel SARS CoV- 2 between people, seems to be primarily via respiratory droplets and aerosols and fomites; however, transmission through the feco-oral route is also a possibility [1]. Environmental factors such as temperature and humidity influence the spread of coronavirus transmission [2]. The other viruses of coronavirus family including SARS CoV-1 and Middle East respiratory syndrome coronavirus (MERS-CoV) showed temporal association with temperature and humidity [3, 4]. The previous research from China showed a negative correlation between relative humidity and SARS CoV-1 and a positive relationship with temperature [5]. Though, a study from Saudi Arabia on MERS-CoV found a significant positive association of cases with low humidity and temperature [3]. However, another study demonstrated high temperature and low humidity as a significant contributor to MERS-CoV infection [6]. Therefore, temperature and

✉ Jagdish Prasad Goyal
jgoyal@rediffmail.com

¹ Department of Community and Family Medicine, All India Institute of Medical Sciences (AIIMS), Jodhpur, Rajasthan, India

² Department of Pharmacology, All India Institute of Medical Sciences (AIIMS), Jodhpur, Rajasthan, India

³ Department of Pediatrics, All India Institute of Medical Sciences (AIIMS), Jodhpur, Rajasthan, India

⁴ Department of Biochemistry, All India Institute of Medical Sciences (AIIMS), Jodhpur, Rajasthan, India

⁵ All India Institute of Medical Sciences (AIIMS), Jodhpur, Rajasthan, India

humidity play an essential role in the transmission of both SARS-1 and MERS-CoV infection.

Recent evidence suggested that COVID-19 infection is more common in cold and temperate climate as compared to a warm climate, similar to the influenza virus which tends to disappear when the weather becomes warm. The first of its kind study from China on COVID-19 and environmental factors demonstrated the significant negative association between COVID-19 cases with temperature and humidity [7]. It was observed that average daily confirmed cases decreased by 11–12% when there was an increase in average humidity of 1% with a temperature range of 5–8 °C. It was also suggested that the novel COVID-19 pandemic had affected more seriously in countries within a temperature range of 3 to 17 °C with absolute humidity between 3 and 9 g/m². Therefore, it has been proposed that dry and moderately cold environment is the most convenient state for transmission of COVID-19 [8].

Since India has the second largest population in the world and weather conditions are extreme and different from the countries severely affected by COVID-19; therefore it is essential to know the association of temperature and humidity on COVID-19. Moreover, the data on environmental factors and COVID-19 is still limited. Thus, this study will contribute to predict the factors for COVID-19 and better pandemic response to policymakers regarding additional public health measures.

Methods

Study Area

Delhi is one of the most crowded cities in the world, is the capital of India and is the largest city in the country as well. It is located close to the geographical center of the country. Delhi lies between 28.7041° North latitude and 77.1025 East latitude. Delhi covers a land area 1484 km². The population of Delhi as per census 2011, was 16,368,899 inhabitants with a population growth rate of 1.39% per year.

Data Collection and Analysis

The dependent variable was the number of COVID-19 cases in Delhi from April 1 to May 31, 2020. The figure of these cases was gathered with the help of print media report from a daily newspaper which published data by a press release from the Ministry of Health and Family Welfare, Government of India. Independent variables were the number of COVID-19 tests performed, daily temperature, and daily relative humidity. For a number of COVID-19

tests, a crowdsourcing platform was used which captures data from different sources ranging from media reports to official twitter handles of state authorities (www.covid19india.org). For meteorological data, an online weather forecasting website (www.worldweatheronline.com) was used which uses satellite-based imagery for prediction and has a record of previous data. From here past data of daily maximum temperature, average temperature and average relative humidity was taken. All these data entered into excel and cross-checked. SPSS ver 21 was used to model this data with the help of linear regression.

Result

A total of two-month data were used. By April 1, 2020 total of 120 cases were reported from Delhi which increases to 18,549 by May 31, 2020. In the same way by April 1, 2020, a total of 2621 tests were performed which reached 2,12,784 by May 31, 2020. The mean maximum temperature was 40.4 ± 3.6 °C ranging from 33 to 48 °C. The mean average temperature was 35.6 ± 3.6 °C ranging from 28.5 to 43 °C. In the same way, average relative humidity % was 21.2 ± 7.6 ranging from 8 to 39.5% (Fig. 1).

Linear regression was run to understand the effect of the number of tests, temperature, and relative humidity on the number of COVID-19 cases in Delhi. To assess linearity, a scatterplot of the number of COVID-19 cases against the number of tests, maximum temperature, average temperature, and average relative humidity with a superimposed regression line was plotted. Visual inspection of these plots indicated an approx. A linear relationship between the variables (Fig. 2).

The model was significantly able to predict number of COVID-19 cases, $F(4,56) = 1213.61$, $p < 0.001$, accounting for 99.4% of the variation in COVID-19 cases with adjusted $R^2 = 98.8\%$. As shown in Table 1, the only number of tests significantly affects COVID cases. With every 100 extra tests performed leads to approx. 8 cases increase in COVID cases. Maximum Temperature, average temperature and average relative humidity did not show statistical significance.

Discussion

This study pattern of temperature and humidity change provides a depiction of the occurrence of COVID-19 cases in Delhi, India. We did not find a significant association of temperature and humidity with COVID-19 cases after regression. Our findings are consistent with results of previous research which also showed no relationship of

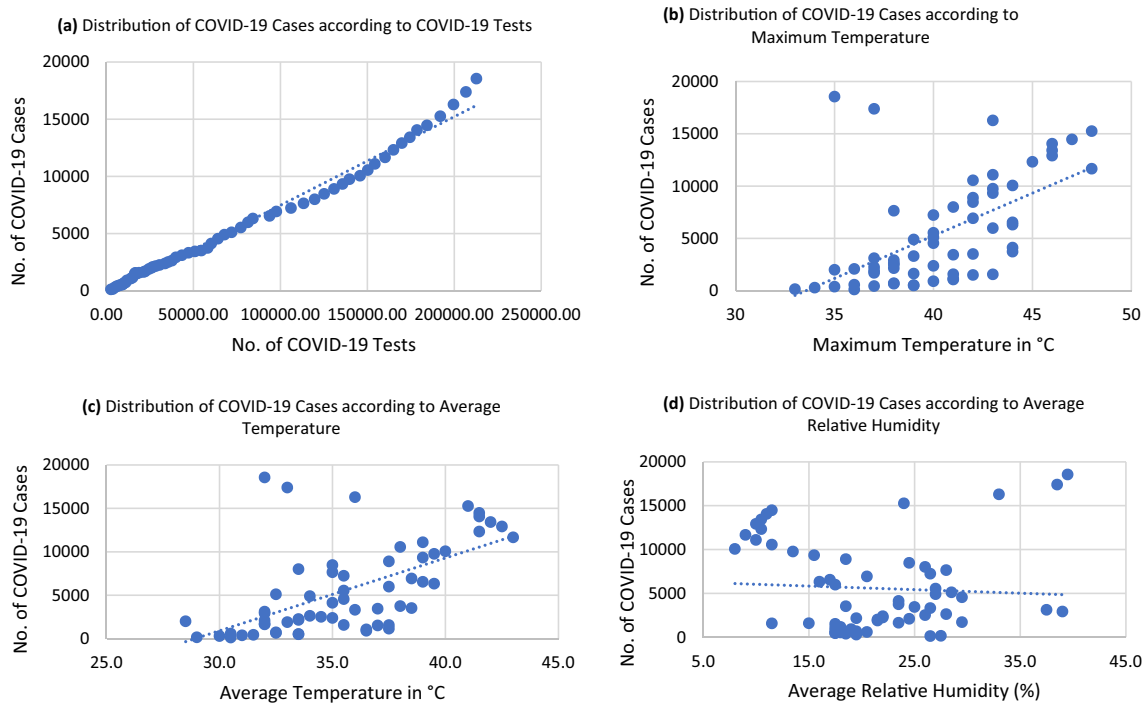


Fig. 1 **a** Correlation between COVID-19 cases and COVID-19 tests, **b** correlation between COVID-19 cases and maximum temperature, **c** correlation between COVID-19 cases and average temperature, **d** distribution of COVID-19 cases according to average relative humidity

COVID-19 with temperature [9, 10]. The study from Indonesia showed a positive correlation of average temperature with COVID-19; however, they did not adjust the variable by regression analysis [11]. The research from Brazil also suggested that higher mean temperatures and average relative humidity favored the COVID-19 transmission, finding different from coldest countries or periods under cool temperatures [12]. The study on the effects of temperature and humidity on the daily new cases and new deaths of COVID-19 in 166 countries demonstrated that temperature and relative humidity were both negatively related to daily new cases and deaths. It was observed that each 1 °C increase in temperature is associated with 3.08% (95% CI 1.53%, 4.63%) reduction in daily new cases after adjusting with all other variables. Similarly, a 1% increase in relative humidity was associated with a 0.85% (95% CI 0.51%, 1.19%) reduction in the daily new case [13]. However, the countries included in this study had temperatures ranged from − 5.28 to 34.30 °C. The average temperature in our study ranged 28.5–43 °C which was quite warm and different from this study. Moreover, there are certain factors like migrant workers, high density of population, poor health hygiene etc. that might also contribute to an increasing number of cases besides metrological parameters. The difference in results in the various study may also be due to different statistical methods.

The important findings in our study were a statistically significant association of COVID-19 cases with an increase

in the total number of tests. This is also being reflected in the country as cases have rampantly increased after increase COVID-19 testing capacity. Currently, the total number of cases reported is around 10 000 per day. India has surpassed Italy and standing at number six in COVID-19 cases. The experts suggested that testing capacity in India still needs to increase by tenfold or more to estimate the exact number of cases [14].

The major strength of our study is that we used data set from one of the most populous cities with extreme weather conditions in the World. However, our research has a few limitations. Firstly, India has a large geographic area; therefore, the result of this study might not be represented by the whole country. Secondly, there are certain factors like social distancing, hand hygiene, universal masking, migration of population etc. which may affect COVID-19 cases and need to be explored in large scale study.

Conclusion

The findings of our study provide preliminary evidence that the COVID-19 pandemic may not be suppressed with an increase in temperature and humidity. However, it is crucial to increase the testing capacity to achieve a meaningful epidemiologic understanding of the prevalence and to guide policy measures for COVID-19.

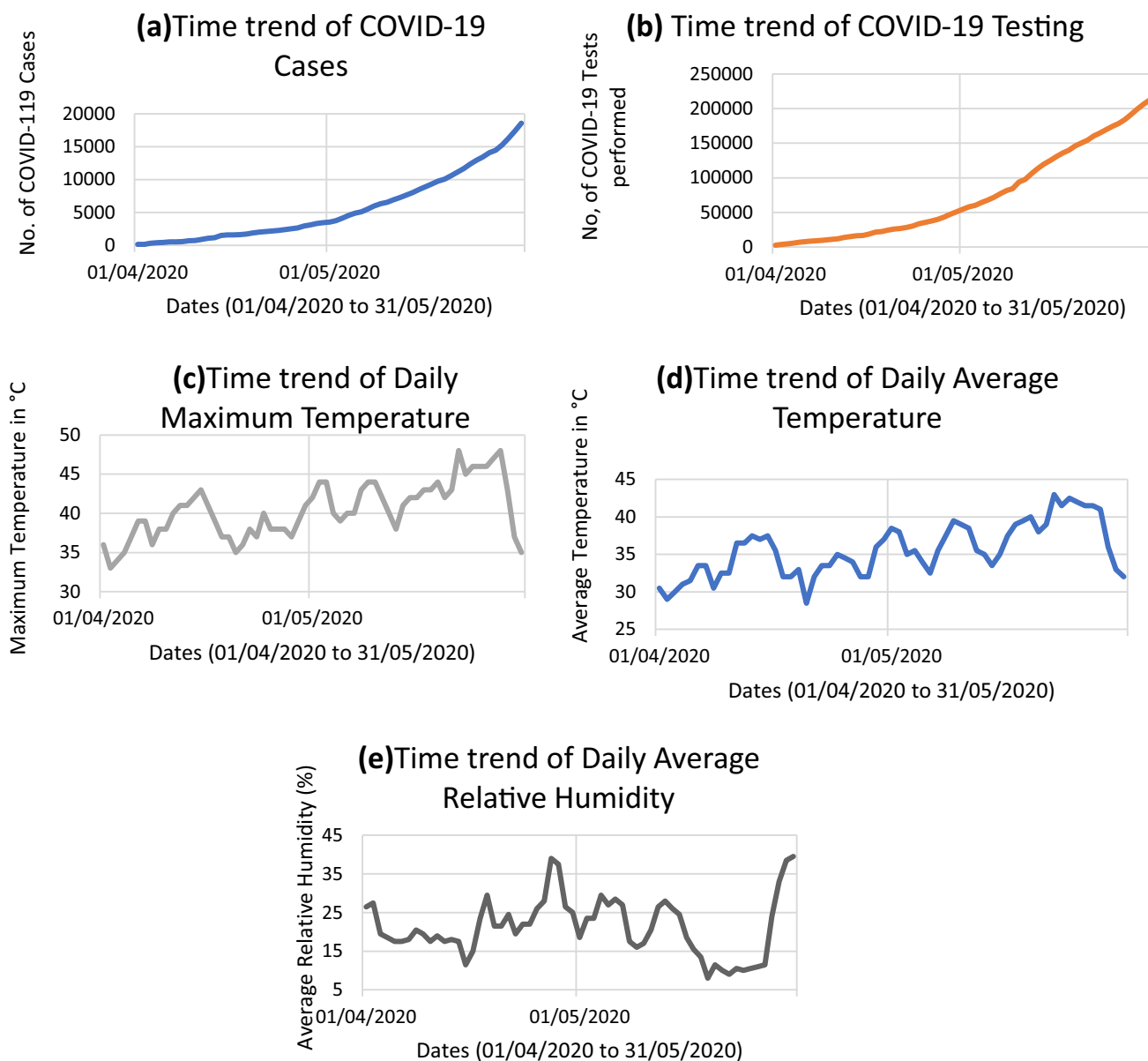


Fig. 2 a Cases of the Covid-19, b number of testing (°C), c temperature maximum (°C), d temperature average (°C) and e humidity (%) in Delhi, India from January to March 29, 2020

Table 1 Linear regression coefficients for COVID cases

Model	Unstandardized coefficients		t	Sig.	95.0% confidence interval for B	
	B	SE			Lower bound	Upper bound
(Constant)	1177.887	1503.582	.783	.437	- 1834.149	4189.924
Total tests	.079	.002	49.092	.000	.076	.083
Maximum temperature	- 44.334	58.212	- .762	.450	- 160.947	72.280
Average temperature	- 3.824	64.200	- .060	.953	- 132.432	124.785
Average relative humidity	16.228	13.494	1.203	.234	- 10.805	43.261

Authors Contribution NL: Formal analysis, data curation, methodology, writing—original draft. PB, PM: writing—review and editing. JC: writing—review and editing. JPG: conceptualization, data curation, writing—original draft. PS, KS and SM: review and editing.

Funding None.

Data Availability The data that support the finding of this study were taken from daily newspaper and public domain: <http://www.covid19india.org> and <http://www.worldweatheronline.com> and available with Principal Investigator in MS Excel.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval Not applicable since data were accessed from public domain.

References

- Cai J, Sun W, Huang J, Gamber M, Wu J, He G. Indirect virus transmission in cluster of COVID-19 cases, Wenzhou, China, 2020. *Emerg Infect Dis.* 2020;26(6):1343–5.
- Eslami H, Jalili M. The role of environmental factors to transmission of SARS-CoV-2 (COVID-19). *AMB Exp.* 2020;10(1):92. <https://doi.org/10.1186/s13568-020-01028-0>.
- Gardner EG, Kelton D, Poljak Z, Van Kerkhove M, Von Dobschuetz S, Greer AL. A case-crossover analysis of the impact of weather on primary cases of Middle East respiratory syndrome. *BMC Infect Dis.* 2019;19(1):1–10.
- Lin K, Fong DYT, Zhu B, Karlberg J. Environmental factors on the SARS epidemic: air temperature, passage of time and multiplicative effect of hospital infection. *Epidemiol Infect.* 2006;134(2):223–30.
- Chan KH, Peiris JS, Lam SY, Poon LL, Yuen KY, Seto WH. The effects of temperature and relative humidity on the viability of the SARS coronavirus. *Adv Virol.* 2011;2011:734690. <https://doi.org/10.1155/2011/734690>.
- Altamimi A, Ahmed AE. Climate factors and incidence of Middle East respiratory syndrome coronavirus. *J Infect Public Health.* 2020;13(5):704–8.
- Xie J, Zhu Y. Association between ambient temperature and COVID-19 infection in 122 cities from China. *Sci Total Environ.* 2020;724:138201. <https://doi.org/10.1016/j.scitotenv.2020.138201>.
- Scafetta N. Distribution of the SARS-CoV-2 pandemic and its monthly forecast based on seasonal climate patterns. *Int J Environ Res Public Health.* 2020;17(10):3493. <https://doi.org/10.3390/ijerph17103493>.
- Yao Y, Pan J, Liu Z, Meng X, Wang W, Kan H, et al. No association of COVID-19 transmission with temperature or UV radiation in Chinese cities. *Eur Respir J.* 2020;55(5):7–9.
- Jüni P, Rothenbühler M, Bobos P, Thorpe KE, da Costa BR, Fisman DN, et al. Impact of climate and public health interventions on the COVID-19 pandemic: a prospective cohort study. *CMAJ.* 2020;192(21):566–73.
- Tosepu R, Gunawan J, Effendy DS, Ahmad OAI, Lestari H, Bahar H, et al. Correlation between weather and Covid-19 pandemic in Jakarta, Indonesia. *Sci Total Environ.* 2020;725:138436. <https://doi.org/10.1016/j.scitotenv.2020.138436>.
- Auler AC, Cássaro FAM, da Silva VO, Pires LF. Evidence that high temperatures and intermediate relative humidity might favor the spread of COVID-19 in tropical climate: a case study for the most affected Brazilian cities. *Sci Total Environ.* 2020;729:139090. <https://doi.org/10.1016/j.scitotenv.2020.139090>.
- Wu Y, Jing W, Liu J, Ma Q, Yuan J, Wang Y, et al. Effects of temperature and humidity on the daily new cases and new deaths of COVID-19 in 166 countries. *Sci Total Environ.* 2020;729:139051. <https://doi.org/10.1016/j.scitotenv.2020.139051>.
- India's COVID-19 Testing Capacity Must Grow by a Factor of 10. Available from: <https://www.cgdev.org/sites/default/files/India-COVID%20Testing-Note.pdf>. Accessed July 2 2020.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.