

COVID-19 and The Impact of Climatic Parameters: A Case Study of Bangladesh

Rehana Parvin (✉ rehana.parvin@iubat.edu)

IUBAT: International University of Business Agriculture and Technology <https://orcid.org/0000-0002-4014-2607>

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Title: COVID-19 and the impact of climatic parameters: a case study of Bangladesh

Rehana Parvin

Department of Quantitative Sciences, International University of Business Agriculture, and
Technology (IUBAT)

4 Embankment Drive Road, Sector 10, Uttara, Dhaka, Bangladesh

Phone number: (88) 01911751193

E-mail: rehana.parvin@iubat.edu

Highlights

- The weather conditions and the propagation of COVID-19 were analyzed using correlation analysis.
- The lagged effects of climatic conditions on COVID-19 were investigated using the ARDL model.
- COVID-19 occurrence was shown to be linked to temperature, humidity, and wind speed.
- The distribution of COVID-19 is inversely linked with PM 2.5 levels.
- Temperature, PM 2.5, and wind speed all have significant lagged effects on COVID-19.

Abstract

This study examines the relationship between climatic factors and the prevalence of COVID-19 in Bangladesh. Pearson correlation coefficient, Spearman correlation coefficient, and Kendall's correlation coefficient have all been put to use to assess the intensity and direction of the relationship between climatic factors and COVID-19. The lagged effects of climatic parameters on COVID-19 daily-confirmed cases from Bangladesh are being looked into using the Auto Regressive Distributed Lag (ARDL) model. As a result, two non-climatic variables, such as population density and the human development index, are taken into account as control variables. As climatic variables, average temperature ($^{\circ}\text{C}$), average humidity (percent), average PM 2.5, and average wind speed (km/h) were well chosen. The time series data used in this analysis was from May 1, 2020 to April 14, 2021. The findings of correlation analysis indicate that there is an important, significant, and positive relationship between COVID-19 widespread and temperature ($^{\circ}\text{C}$), humidity (percent), and wind speed (km/h), whereas there is a negative, weak, and significant relationship between PM 2.5 and COVID-19 widespread. In addition, the ARDL findings suggested that temperature ($^{\circ}\text{C}$), PM 2.5, and wind speed (km/h) have major lagged effects on COVID-19 in Bangladesh, while humidity (percent) has negligible lagged effects. For policymakers and investors alike, the consequences of this study are important in Bangladesh.

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1. Introduction

COVID-19 disease was first detected in Wuhan, China, in December of last year. COVID-19 is a new form of virus that spreads quickly from person to person and causes a large-scale outbreak. The novel Corona virus has infected people in nearly every country on the planet. The disease's structure is very complex, and it spreads quickly. As a result, understanding disease patterns has become critical. Sadly, as of May 8, 2021, 157 million COVID-19 cases had been confirmed worldwide, with 3.27 million deaths (WHO). Since no treatment method for this virus has been identified, effective design of the health foundation and structure, where the figure of disease layout should be commended, is required. It is important to track and forecast status in order to better manage the spread of this disease.

Bangladesh is a small nation with a relatively stable population. Bangladesh's weather is unprotected (Islam 2019). Bangladesh is the third country in South Asia to be affected, following India and Pakistan. On March 8, 2020, Bangladesh reported the first COVID-19 cases (IEDCR). As of May 6, 2020, Rangamati was Bangladesh's final COVID-19-affected district (DGHS). Dhaka, Bangladesh's capital is the most severely affected city. On June 13, 2020, Bangladesh outnumbers China in terms of COVID-19 confirmed cases. Bangladesh's government announced a 10-day curfew on March 23, 2020, which was later extended to May 30, 2021, in order to combat the epidemic. Up till May 10, 2021, Bangladesh had 775027 new cases, 11972 deaths, and 712277 cases recovered (DGHS). Bangladesh's government used quarantines and lockdowns and try to contain the spread of COVID-19. For the second time, on April 5, 2021, Bangladesh's government announced a 15-day lockdown (DGHS). Bangladeshis are advised to avoid public

areas, keep a minimum of 2 meters away from strangers, and wash their hands regularly (IEDCR).

Several experiments have been performed to see whether the corona virus can be transmitted by environmental factors. In humid focused areas, Pramanik et al. (2020) discovered a close association between temperature and COVID-19 events. Some studies have found that certain meteorological variables, such as temperature, PM 2.5, and median age, are important factors in the spread of the corona virus (Ma et al., 2020; Gupta et al., 2020; Islam et al., 2020; Prata et al., 2020; Espejo et al., 2020; Jamil et al., 2020; Qi et al., 2020; Wang et al., 2020). Dogan et al. (2020) used correlation analysis and the ARDL model to investigate the impact of meteorological factors on COVID-19. COVID-19 appears to have a negative relationship with temperature, while COVID-19 appears to have a positive relationship with humidity and air quality. COVID-19 is also affected by meteorological conditions that are delayed. Cai et al. (2020) investigated the relationship between temperature and COVID-19 mortality and discovered that COVID-19 mortality and temperature are positively correlated, while COVID-19 mortality and humidity are negatively correlated.

To examine the relationship between climatic parameters and COVID-19, Islam et al. (2021) used a single study. There is no association between 7days lagged climatic factors and COVID-19, according to the author's findings. Although there is a positive relationship between COVID-19 and 14days lagged temperature, there is a negative relationship between COVID-19 and 14days lagged humidity. Duhon et al. (2021) used a multiple regression model that included climate, social, demographic, and non-pharmaceutical variables, and found that demographic and social factors are to blame for COVID-19 spread.

Chen et al. (2020) discovered a close connection between COVID-19 transmission and meteorological parameters. COVID-19 has a negative relationship with wind speed and ventilation coefficient, but a positive relationship with humidity, dew point, and temperature, according to Pani S K et al. (2020). Yuan et al. (2021) used the GAM model to look at the effects of climatic factors on COVID-19, and discovered that climatic factors are nonlinearly related to COVID-19. Many diseases are spreadable can spread via epidemiological channels (Shi et al., 2020; Wang et al., 2020). COVID-19 distribution could be influenced by changes in temperature, air quality, and wind speed (Sobral et al., 2020; Shakil et al., 2020; Bashir et al., 2020a; Suhaimi et al., 2020; Kumar S. 2020; Lorenzo et al., 2021; Bashir et al., 2020b).

The COVID-19 growth rate has a clear and optimistic relationship with emissions. As a result, it's critical to look at how climatic and weather conditions are linked to COVID-19 transmission for the sake of human survival and well-being. Coskun et al. (2021) discovered a near link between COVID-19 widespread and wind speed. Wind or air circulation can spread COVID-19. Wind and population density were significant determinants in virus propagation, accounting for 94% of the variation. Population density completely mediated the wind effect on virus propagation according to author findings.

According to some studies, the SARS virus was also transmitted by weather conditions (Tan et al., 2005; Yip et al., 2007; Yuan et al., 2006). Cai et al. (2007) used logistic regression analysis to investigate the relationship between meteorological factors and human health (average temperature, sunshine, humidity, and air pressure).

The transmission of the SARS virus is discovered to be inextricably connected to meteorological influences, according to the authors. SARS spread quickly, according to Yuan et al. (2006), due to three main meteorological factors: temperature, wind velocity, and relative humidity. At this point, it was discovered that certain climatic and weather factors could affect influenza transmission (Chen et al., 2017; Bai et al., 2019; Kalhori et al., 2019).

Liu et al. (2019) investigated the effects of environmental factors on influenza. Their findings show that the winter and spring seasons are the peak seasons for influenza, and that temperature and relative humidity are inversely related to influenza cases. Lau et al. (2018) discovered that meteorological conditions have nonlinear and lagged effects on the influenza virus. The authors' results indicate that rainfall between 60.3mm and 200.3mm is favorable for influenza virus infection.

SARS-CoV-2 has recently been reported to be spreadable through airborne transmission (Prather et al., 2020; Hadei et al., 2020; Allen et al., 2020; Klompass et al., 2020; Greenhalgh et al., 2021; Ahlawat et al., 2020; Ueki et al., 2020). Morawska and Cao (2020) discovered a close connection between SARS-CoV-2 transmission and airborne transmission. COVID-19 will spread through the air, according to Yao et al. (2020), and it is negatively correlated with higher ozone levels.

They also suggest that environmental factors and social isolation could be contributing to the pandemic's spread. SARS-CoV-2 could spread through airborne transmission, according to Correia et al. (2020).

Weather conditions, temperature, and relative humidity have been linked to COVID-19 in some studies (Briz-Redón et al., 2020; Adhikari et al., 2020; Chien et al., 2020). COVID-19 transmission is caused by comparatively dry and cold weather, according to Fu et al., (2021). Tosepu et al., (2020) assume that climatic parameters and COVID-19 spread are inextricably linked. According to Pan et al. (2021), there is no connection between weather factors and COVID-19 transmissions, and that warm weather can reduce COVID-19 transmission. Wu et al. (2020) used the GAM model to investigate the relationship between COVID-19 and meteorological influences, finding that relative humidity, wind speed, and temperature have nonlinear effects on COVID-19 regular new cases when temperature, relative humidity and wind speed were below 20°C, 70% and 7 m/s respectively.

Liu et al. (2020) used correlation analysis and multiple regression analysis to investigate the pattern of COVID-19 in relation to climatic conditions, and discovered a strong and negative relationship between humidity and COVID-19 new cases. According to De Angelis et al. (2021), socioeconomic and meteorological variables are linked to COVID-19 new cases and mortality. According to Leal and Hernández (2020), temperature has a negative relationship with COVID-19, and COVID-19 cases with carbon monoxide have a clear positive relationship with PM 2.5.

Temperature, wind speed, and high solar radiation were found to minimize the spread of COVID-19 cases by Rosario et al. (2020). Air quality, NO₂, and PM 2.5 have positive effects on COVID-19 new events, while temperature has negative effects, according to Li et al. (2020). According to Pei et al. (2021), COVID-19 cases have a clear positive relationship with AQI.

COVID-19 cases have also clear positive relationship with PM 10, and PM 2.5, as well as a negative relationship with temperature, carbon monoxide, and COVID-19.

Bangladesh's situation is extremely dangerous and disturbing, and the number of infected humans is growing by the day. The number of deaths has been rising in recent days, causing concern among the public. In order to administer and take useful connotations, it is important to predict the pattern of COVID-19 transmission. Unfortunately, there is still a lack of research into the relationship between meteorological influences and COVID-19. The results of some research findings on the relationship between meteorological factors and COVID-19 were mixed. Furthermore, research findings revealed that the relationship between climatic variables and COVID-19 cases is time and area dependent.

This study used correlation analysis to analyze the strength and direction of the relationship between climatic variables such as temperature, wind speed, humidity, and PM 2.5 in order to arrive at new conclusions and recommendations. Pearson correlation analysis, Spearman correlation analysis, and Kendall's correlation analysis were all used in this phase. The ARDL model was used to look at the lagged impact of climatic variables on COVID-19 in conjunction with certain non-climatic variables.

2. Overview of Bangladesh

Bangladesh is a beautiful country in South Asia with a middle-income economy. Bangladesh is the eighth most populous nation in the world. Bangladesh has a very high population density as compared to other developing countries. Bangladesh's population is projected to be 166,078,786

people as of May 8, 2021 (United Nation data). Middle-aged people account for 164,689,383 people out of the total population. Bangladesh's population accounts for 2.11 percent of the world's total population. Bangladesh has a land area of 56980 square miles. Bangladesh has a population density of 3277 people per square mile and a median age of 27.6 years. Dhaka is Bangladesh's largest city and capital in terms of national, political, economic, and cultural importance.

Bangladesh has a tropical monsoon climate. The overall climate is divided into three distinct seasons: hot and summer months last from March to June, rainy months last from June to October, and winter months last from October to March. Bangladesh's average temperature ranges from 10°C to 40°C, with average humidity ranging from 30% to 80% and average wind speeds ranging from 7km/h to 24km/h.

Bangladesh's economy was the hardest hit by the COVID-19 pandemic. Bangladesh is the third country in South Asia to be impacted, after India and Pakistan. On March 8, 2020, Bangladesh reported the first COVID-19 cases (IEDCR). Till May 10, 2021, Bangladesh has recorded 775027 new cases, 11972 deaths, and 712277 cases that have been recovered (DGHS). Dhaka, Bangladesh's capital was hit by 78 percent of the total (DGHS).

3. Materials and methods

3.1 Data description

The time series data used in this analysis ranged from May 1, 2020 to April 14, 2021. The Directorate General of Health Services (DGHS) website (<https://www.dghs.gov.bd>) provided data on COVID-19 daily-confirmed new cases. The Bangladesh Meteorological Department (BMD) and <https://en.climate-data.org/asia/bangladesh/dhaka-division/dhaka-1062098/> provided meteorological variables such as average temperature, average humidity, and average wind speed. The temperature (temp) is expressed in degrees Celsius, the humidity (hum) in percentages, and the wind speed (ws) in kilometers per hour. We used the most current and comprehensive data available. <https://aqicn.org/city/bangladesh/dhaka/us-consulate/> provided the data for PM 2.5 (a proxy for air quality). The population density (pd) were collected from Bangladesh Bureau of statistics (BBS) and <https://www.worldometers.info/world-population/bangladesh-population/>. The data for the human development index was collected from <https://globaldatalab.org/shdi/shdi/>. IBM SPSS and Eviews 10 were utilized for statistical analysis.

3.2 Methodology

Three-correlation analysis, such as Pearson correlation, Spearman correlation, and Kendall's rank correlation, were used in the empirical study. The results of the normality check revealed that the data in our study is not normally distributed (Dogan et al., 2020). As a result, three forms of correlation analysis may describe all circumstances.

Pearson correlation is the greatest way for measuring the relationship between two variables because it checks for a linear association between them. The Pearson correlation coefficient is the covariance of two variables divided by multiplication of their standard deviation. As a result, Pearson correlation is based on calculating covariance. The correlation coefficient's range is -1 to +1, and it can be calculated as follows:

$$r = \frac{\text{cov}(x,y)}{\sqrt{\nu(x)*\nu(y)}} \quad (1)$$

The non-parametric Spearman correlation evaluates the monotonic statistical dependence of two variables. If the correlations between the variables are linear, the Pearson and Spearman correlation coefficients are equivalent. The spearman correlation coefficient has a range of -1 to +1. If the dependent variable grows as the independent variables rise, the Spearman correlation coefficient is positive. If the dependent variable drops as the independent variable grows, the Spearman correlation coefficient is negative. When variables are not linearly connected, the Spearman correlation coefficient is zero. The Spearman correlation coefficient is calculated using the formula below:

$$r_s = 1 - \frac{6 \sum_i d_i^2}{n(n^2-1)} \quad (2)$$

Where, the total number of observations is indicated by the number n.; d_i = rank of X_i – rank of Y_i .

Kendall's rank correlation coefficient is another non-parametric correlation coefficient. It can be used to check the ordinal relationship between variables and analyze the similarity of the

orderings. Kendall's correlation coefficient is referred to as' tau '(τ), and its range is from -1 to +1.

This is how the Kendall's coefficient is defined:

$$\tau = \frac{\text{No.of concordant} - \text{No.of discordant}}{0.5 * n(n-1)} \quad (3)$$

The number of pairs is denoted by n.

Finally, the ARDL model was used to examine the lag effect of climatic and non-climatic factors on COVID-19 in this study. COVID-19 infection and transmission requires 2 to 15 days, according to Wu et al. (2020), Wang et al. (2020), and Ma at al. (2020). As a result, the ARDL model was used to examine the delayed effects in this study. We employed four climatic variables including average temperature, average humidity, PM 2.5 averages, as well as average wind speed, as well as two non-climatic variables, population density and human development index as a control variable. The resilience of climatic and non-climatic elements was tested using the individual ARDL equation. The ARDL equation is formulated as follows when population density is a control variable:

$$\Delta logcovid_t = \alpha_0 + \sum_{i=1}^p a_{1i} \Delta logcovid_{t-i} + \sum_{i=1}^q a_{2i} \Delta logtemp_{t-i} + \sum_{i=1}^r a_{3i} \Delta loghum_{t-i} + \sum_{i=1}^s a_{4i} \Delta logpm2.5_{t-i} + \sum_{i=1}^t a_{5i} \Delta logwind_{t-i} + \sum_{i=1}^u a_{6i} \Delta logpd_{t-i} + \mu_t \quad (4)$$

Where, COVID stands for COVID-19 daily cases, temp stands for average temperature, hum stands for average humidity, wind stands for average wind speed, and pd is for population density.

The ARDL equation looks like this when the human development index is used as a control variable:

$$\Delta \logcovid_t = \beta_0 + \sum_{i=1}^p b_{1i} \Delta \logcovid_{t-i} + \sum_{i=1}^q b_{2i} \Delta \logtemp_{t-i} + \sum_{i=1}^r b_{3i} \Delta \loghum_{t-i} + \sum_{i=1}^s b_{4i} \Delta \logpm{2.5}_{t-i} + \sum_{i=1}^t b_{5i} \Delta \logwind_{t-i} + \sum_{i=1}^u b_{6i} \Delta \loghuman_{t-i} + e_t \quad (5)$$

Where, COVID indicates COVID-19 daily cases, temp indicates average temperature, hum indicates average humidity, wind indicates average wind speed and human indicates human development index.

The ARDL model was used to investigate the lagged impacts of meteorological factors and COVID-19 broad spread. As a result, the following is our fundamental ARDL equation:

$$\Delta \logcovid_t = \gamma_0 + \sum_{i=1}^p \theta_{1i} \Delta \logcovid_{t-i} + \sum_{i=1}^q \theta_{2i} \Delta \logtemp_{t-i} + \sum_{i=1}^r \theta_{3i} \Delta \loghum_{t-i} + \sum_{i=1}^s \theta_{4i} \Delta \logpm{2.5}_{t-i} + \sum_{i=1}^t \theta_{5i} \Delta \logwind_{t-i} + \epsilon_t \quad (6)$$

Where, COVID indicates COVID-19 daily cases, temp indicates average temperature, hum indicates average humidity and wind indicates average wind speed.

Two methods are used to calculate the ARDL equation (6): 6a. with no covariate lag and 6b. with a covariate lag of 12 days. The ideal lag orders were chosen using the Akaike Information Criterion (AIC) and the Schwartz Information Criterion (SIC). In their investigations, Dogan et al. (2020) and Wu et al. (2020) used a similar methodology.

4. Results and discussion

4.1. Daily adaptation of COVID-19 and climatic variables

Throughout the research time, Bangladesh had the highest average temperature of 35°C on April 14, 2021, and the maximum number of daily new confirmed cases of 7626. The average humidity on that day was 63%, the average wind speed was 22.1 km/h, and PM 2.5 was 203. The lowest average temperature observed during the study was 10°C on January 25, 2021, with 603 daily new confirmed cases. The daily fresh confirmed cases of COVID-19 are plotted against climatic conditions in **Figure 1**. Climate conditions and COVID-19 prevalence are highly connected, as seen in Figure 3.

The descriptive statistics of climatic parameters and COVID-19 regular cases are presented in **Table 1**. The average COVID-19 case was 1998.54, and the median COVID-19 case was 1719, as shown in Table 1. During the study period, there were maximum 7626 COVID-19 instances with a minimum of 291 instances. The greatest temperature was 35 degrees Celsius, while the lowest temperature was 10 degrees Celsius. The average and median temperatures, for example, were 26.25°C and 29°C, respectively. Humidity levels were recorded to be as low as 31% and as high as 80%. In addition, the average and median humidity levels were 60.48 percent and 68 percent, respectively. PM 2.5 concentrations were found to be as low as 28 and as high as 365. Furthermore, the average and median PM 2.5 concentrations were 154.68 and 142, respectively. The maximum wind speed was 23.4 km/h, while the lowest wind speed was 7.6 km/h. The average and median wind speeds, respectively, were 14.89 and 14.8 kilometers per hour. COVID-19's Skewness is 1.615, which is not between -0.5 and 0.5, according to the calculations. It implies that the COVID-19 data is not symmetrical, and that Kurtosis (6.56) is more than 3,

indicating that the distribution is wider than the normal distribution. All environmental parameters (excluding temperature) have skewness values between -0.5 and 0.5. The data for all climatic components are symmetrical, and the kurtosis for all climatic factors is less than three, indicating a narrower distribution than the normal distribution, according to the findings.

4.2. Correlation between climatic factors and COVID-19

Table 2 has reported the results of Pearson correlation test results. Results revealed that correlation between daily-confirmed COVID-19 cases and temperature is positive and significant. $r = 0.600$; $p < 0.01$ indicates the existence of strong, positive and significant association between temperature and COVID-19 confirmed cases. The empirical outcome is consistent with prior Bangladeshi investigations (Hridoy et al., 2021; Islam et al., 2020).

COVID-19 transmission is reduced at low ambient temperatures, according to several research (Dogan et al., 2020; Ma et al., 2020; Shahzad et al., 2020). On the other hand, some international research has found a link between temperature and COVID-19 that is both positive and substantial (S.K. Pani et al., 2020; S.Kumar 2020; Xie and Zhu 2020). Table 2 also reported a positive and significant association between COVID-19 and humidity ($r = 0.523$; $p < 0.01$) and wind speed ($r = 0.785$; $p < 0.01$). The findings are similar to those of recent Bangladeshi studies (Hridoy et al., 2021; Islam et al., 2020), Chinese studies (Sajadi et al., 2020), and Indian studies (Goswami et al., 2020).

The study has found a negative, weak and significant association between COVID-19 and PM 2.5 ($r = -0.306$; $p < 0.01$). Ma et al. (2020) reached the same conclusion as this report in Wuhan,

China. On the contrary, COVID-19 and PM 2.5 have a positive association, according to Bashir et al. (2020).

Table 2 has also shown the results of the spearman correlation test. The results show the existence of a positive and significant association between COVID-19 and temperature ($r= 0.723; p < 0.01$), humidity ($r= 0.635; p < 0.01$) and wind speed ($r= 0.855; p < 0.01$) respectively. The finding of this study is in line with Hridoy et al. (2021) and Islam et al. (2020). The study has found a negative, weak and significant association between COVID-19 and PM 2.5 ($r=-0.489; p < 0.01$).

The results of Kendall's rank correlation test are presented in **Table 2** also. The Pearson and Spearman rank correlations demonstrated a similar pattern of connection between COVID-19 and meteorological conditions. The results show the existence of a positive and significant association between COVID-19 and temperature ($r= 0.537; p < 0.01$), humidity ($r= 0.467; p < 0.01$) and wind speed ($r= 0.673; p < 0.01$) respectively. Bangladeshi researchers Hridoy et al. (2021) and Islam et al. (2020) support the conclusions of their investigation. COVID-19 and PM 2.5 had a negative, weak, and significant relationship ($r=-0.336; p < 0.01$), according to the study. In general, the results of three different types of correlation tests are consistent.

4.3. ARDL method result and COVID-19

The basic need for time series data to study the order of integration of variables is the unit root test, often known as the stationary test. The Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) tests were used to conduct our empirical research. **Table 3** presents a summary of

the findings. For an ideal lag structure involving intercept and linear time trend at level but excluding time trend from initial difference, the Akaike Information Criterion (AIC) was used. Only the log COVID-19 cases are stationary at level for the ADF test and stationary for both level and first difference, showing that the variable is I (0) and I (1), respectively; nevertheless, the series log temperature, log humidity, log PM 2.5, and log wind speed are stationary at first difference. This indicates that the variables are I (1). Next, with the absence of I (2) variables, we can perform the bounds testing procedure to estimate equation (4). Our investigation began with estimating equation (4), and the final specification of the ARDL model was determined using a general to specific methodology. Furthermore, for optimal lag structure, the Akaike Information Criterion (1981) was adopted.

The results of the symmetric ARDL model for equation (4), which included one non-climatic element, population density, are shown in **Table 4**. COVID-19 is strongly and positively linked with temperature, wind speed, and PM 2.5, according to empirical estimates. Humidity, on the other hand, is both insignificantly and positively associated with COVID-19. According to the findings, a 1% increase in temperature resulted in a 2.39 percent rise in COVID-19 new cases. In addition of 0.96 percent and 1.35 percent in COVID-19 new instances, respectively, resulted in a 1% rise in PM 2.5 and wind speed. Furthermore, COVID-19 new cases fell by 1.72 percent because of a 1% increase in population density. The findings that population density is taken into account are consistent with Dogan et al. (2020).

Because the F-statistic result of 5.3992 is greater than the required upper constraint of 3.79 at 5%, the limits test confirms co-integration for linear fashion. In addition, diagnostic tests were carried out to prove the ARDL model's reliability. For error normality, we utilized the Jarque-Bera (J-B) test, the Ramsey RESET test for model specification, the Autocorrelation Conditional Heteroskedasticity (ARCH) up to order 2 for Heteroskedasticity, and the LM test up to order 2 for serial autocorrelation. **Table 4**'s bottom panel displays the results of all tests. The results indicate that the ARDL model passes all diagnostic tests, implying that our model is trustworthy. In addition, the model's stability was tested using the CUSUM and CUSUM Square tests. The results of these experiments are shown in **Figure 2**, confirming that the model is extremely stable.

Table 4 also shows the results of the ARDL model for equation (5) after including the human development index. Temperature, wind speed, and PM 2.5 are all significantly and positively linked with COVID-19, according to the empirical findings. In COVID-19 new cases, a 1% increase in temperature, PM 2.5, and wind speed was found, with additions of 2.30 percent, 0.98 percent, and 1.135 percent, respectively. In addition, 6.07 percent of COVID-19 new cases had a 1% accession of the human development index. Additionally, residual analysis was used to assess the ARDL model's reliability. The results of all tests are listed in Table 7's lower panel. The CUSUM and CUSUM Square tests are shown in **Figure 3** to assess the model's stability and indicate that it is highly stable.

Table 5 summarizes the results of our main ARDL equation (6). We can estimate equation (6) in two ways: (6a) by altering the auto lag covariate and (6b) by altering, the 12 days lag of

covariates. COVID-19 verified instances will result in a 0.59 percent to 1% rise in the daily lag value 1, and COVID-19 confirmed cases will contribute significantly to 0.12 percent, 0.38 percent, 0.14 percent to 1% increases in the daily lag values 6, 7, and 8, respectively, of auto-lag covariate, according to 6a's findings. COVID-19 confirmed cases, on the other hand, will contribute to a drop in the current number of cases by increasing the daily lag values of 9 and 12 by 0.14 percent and 0.122 percent to 1 percent, respectively. Temperature, PM 2.5, and wind speed all rises by 1% in COVID-19 new instances, with increases of 2.40 percent, 0.98 percent, and 1.20 percent, respectively. Furthermore, residual analysis was used to test the ARDL model's reliability. Table 5's bottom panel displays the results of all tests. The CUSUM and CUSUM Square tests are illustrated in **Figure 4a** to assess the model's stability and indicate that it is extremely stable.

COVID-19 confirmed cases would lead to an increase in the current number of cases by 0.58 percent, 0.13 percent, 0.39 percent, and 0.14 percent to 1 percent in the daily lag values of 1, 6, 7, and 8, respectively, for 12 days lag covariates, according to 6b findings. Due to a 12-day covariate lag, COVID-19 confirmed cases would contribute to a 0.12% decline in the current number of cases. Temperature, PM 2.5, and wind speed all rose by 1% in COVID-19 new instances, with increases of 2.59 percent, 0.89 percent, and 1.14 percent, respectively. The ARDL model's dependability was also evaluated using residual analysis. Table 5's lower column contains the results of all testing. **Figure 4b** shows the CUSUM and CUSUM Square tests, which check the model's stability and confirm that it is highly stable.

4.4. Discussion

We may conclude from non-meteorological measures that health-policy initiatives that work, protection programs, standard of education and understanding, and population age all play a role in avoiding pandemics and disease crises. The authors recommend that, in order to reduce COVID-19 transmission, the Bangladesh should change policies to take into account Protecting one's health, ensuring one's safety, educating oneself, and aging the population are all factors to consider.

The three statistical correlations for Bangladesh have revealed a substantial relationship between the variables COVID-19, temperature, PM 2.5, wind speed, and humidity. COVID-19 is, in reality, a virus have a strong positive relationship with the temperature, wind speed, and humidity and negative association with PM 2.5. The fact that all of these weather variables have the potential to affect the number of COVID-19 events reported can help to explain this result. The findings could back up the idea that COVID-19 infection is linked to air pollution.

According to the findings of the ARDL, temperature, wind speed, and PM 2.5 influenced the daily number of COVID-19 verified cases. Indeed, at various degrees of statistical significance, COVID-19 is affected by temperature (or PM 2.5) in a positive (or negative) way (1 percent). The delayed findings, in particular, back up previous research findings that imply a time lag between previous infections, temperature, wind speed, PM 2.5, and COVID-19 daily-confirmed cases. The incubation phase may be seen as required while developing travel policies and regulations (Xie and Zhu 2020). As a result, those countries that used quarantine and smart lockdown methods to govern movement were able to be successful at managing the COVID-19 situation. These discoveries can be viewed as a contribution to the field of study and they may

help Bangladesh develop new disease control implications. As a result, intoxication and the weather may be considered COVID-19 defining criteria.

Since South Asian countries have low incomes and a dense population, and people are less aware of the transmission, on sunny days, people crack the lockdown for safety reasons. Moreover, it's possible that one explanation is that there's a connection between temperature and the number of cases registered. One of the most significant indirect factors for COVID-19 transmission in this case is temperature. According to some recent studies, Maximum temperature was found to have a COVID-19 transmission is significantly affected (Shao et al., 2021; Hridoy et al., 2021; 2021; Singh et al., 2020; Islam et al., 2020; S.K. Pani et al., 2020; S.Kumar 2020; Xie and Zhu 2020). Unlike some recent studies that found a negative relationship between temperature and the ability to transmit of COVID-19, this discovery was made (Dogan et al., 2020; Liu et al., 2020; Sahoo et al., 2020; Shahzad et al., 2020).

The effect of moisture in the air can be blamed for the overall effects. Exhaled bio-aerosols evaporate quickly in low-humidity conditions, forming nuclei of droplets that can remain in the air and on the ground for extended periods. These nuclei are referred to as persistent nuclei. As a result, virus transmission can be accelerated. Respiratory droplets can pass SARS-CoV-1 from person to person. Because its genetics are similar to SARS-CoV-2, it is thought to be capable of infecting droplets in the lungs. SARS-CoV-2 is a virus that can live for a long time. On plastic, stainless steel, iron, cardboard, and glass, it can last for 3 hours in aerosol form (5 m) and 72 hours in droplet form (> 5 m) according to the World Health Organization (WHO).

The occurrence of COVID-19 has no significant association with relative humidity, according to Bashir et al. (2020). Other studies have observed the similar findings (Hridoy et al., 2021; Islam et al., 2020; Li et al., 2020; Sajadi et al., 2020; Ma et al., 2020; Runkle et al., 2020; Wang et al., 2020;), suggesting that COVID-19 is linked to relative humidity.

Dbouk and Drikakis (2020) demonstrated the role of wind speed in SARS-CoV-2 airborne transmission using a computational fluid dynamics simulation. At wind speeds ranging from 4 to 15 km/h, respiratory droplets can travel up to 6 meters, implying that a social distance of 2 meters may not be sufficient. The rising number of incidences of high temperatures and humidity in the southern United States, Brazil, India, and Bangladesh, however, refutes the impact of these conditions.

Maximum wind speed was found to have a major effect on the transmission of COVID-19; this is in line with preceding findings (Hridoy et al., 2021; Ahmadi et al., 2020; Kulkarni et al., 2021; Singh et al., 2020; Islam et al., 2020; Sahin M. 2020). Unlike some recent studies that found no relationship between wind speed and the ability to transmit of COVID-19, this discovery was made (Li et al., 2020), while a negative association was found by Islam et al. (2020). Furthermore, during previous influenza virus outbreaks or extreme acute respiratory syndrome, the wind speed was taken into consideration as one of the primary factors that aided SARS, MERS, and influenza transmission (SARS). The probability of COVID-19 virus transmission can be increased in confined areas with high wind speeds because infectious droplets have a much larger particle density.

Despite its many benefits, this research is not without flaws. We've discussed the importance of wind speed, but determining it can be challenging. It's also possible that the direction of the wind plays a role, but we can't investigate its impact on virus transmission due to a lack of data. Furthermore, our findings are focused on data from the outdoor weather system, which is one of our study's major limitations. Indoor conditions, on the other hand, may have a profound impact on SARS-CoV-2 transmission. When evaluating the relationship between meteorological variables and COVID-19 in Bangladesh, future studies should consider these factors.

5. Conclusion

The Corona virus (COVID-19) has spread to all individuals, regardless of ethnicity, religion, or age. For researchers, health professionals, politicians, and others, the fast death rate caused by COVID-19 in various affluent countries has become a huge concern. Meteorological and non-meteorological elements are underlined as major contributors in influencing COVID-19's rapid spread in Bangladesh in this study. The findings show that local COVID-19 transmission in Bangladesh is strongly linked to climatic factors. The association between temperature, wind speed, PM 2.5, humidity, and COVID-19 in Bangladesh is revealed in this study, with interesting and mixed results. The coupling effects of mean temperature, relative humidity, and wind speed were found to increase COVID-19 transmission. Meanwhile, there was a negative correlation between COVID-19 incidence and PM 2.5.

Overall, we believe that high temperature, PM 2.5, high wind speed, high humidity, and past COVID-19 incidences in Bangladesh may contribute to the virus's transmission. Temperature,

PM 2.5, and wind speed have immediate, significant, and delayed impact (0 to 12 days) in Bangladesh on COVID-19 dispersal, according to the findings, which back up prior study. The data also shows that future COVID-19 transmission in Bangladesh will be mediated by weather conditions. However, as stated in the previous section, this does not imply that meteorological conditions are the sole determinants of transmission.

The study's main strength is that it was conducted over a lengthy period and that it took into account various confounding factors. Only four meteorological variables were evaluated in this investigation. Focusing on developing immediate methods and policies to tackle the COVID-19 outbreak in Bangladesh is important considering all influencing factors, such as the climate. The findings could help determine how seasonality influences COVID-19 transmission in Bangladesh. To improve accuracy, future studies should incorporate more variables. Furthermore, the results of this study may be useful for future studies in countries. Virus resistance, number of people, urban volume, mobility, cleanliness, use of masks and sanitizers, and other aspects associated with the COVID-19 virus, for example, all of this has to be investigated.

Author contributions

Conceptualization and approval: Rehana Parvin; methodology: Rehana Parvin; software: Rehana Parvin; analysis: Rehana Parvin; data curation: Rehana Parvin; validation: Rehana Parvin; draft preparation: Rehana Parvin; visualization: Rehana Parvin; review and editing: Rehana Parvin; supervision: Rehana Parvin.

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Code availability

IBM SPSS and Eviews 10 were utilized for statistical analysis and code will provide to the corresponding author upon reasonable request.

Data accessibility

The data has been provided in the form of a zip file for online submission as a supplementary file.

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

Not applicable.

Consent to participants

Informed consent was obtained from all individual participants included in the study.

Consent to publish

The participant has consented to the submission of the case report to the journal.

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References

- Adhikari, A., & Yin, J. (2020). Short-term effects of ambient ozone, PM2. 5, and meteorological factors on COVID-19 confirmed cases and deaths in Queens, New York. *International journal of environmental research and public health*, 17(11), 4047. <https://doi.org/10.3390/ijerph17114047>
- Ahlawat, A., Wiedensohler, A., & Mishra, S. K. (2020). An Overview on the role of relative humidity in airborne transmission of SARS-CoV-2 in indoor environments. *Aerosol and Air Quality Research*, 20(9), 1856-1861. <https://doi.org/10.4209/aaqr.2020.06.0302>
- Ahmadi, M., Sharifi, A., Dorosti, S., Ghoushchi, S. J., & Ghanbari, N. (2020). Investigation of effective climatology parameters on COVID-19 outbreak in Iran. *Science of the Total Environment*, 729, 138705. <https://doi.org/10.1016/j.scitotenv.2020.138705>
- Allen, J. G., & Marr, L. C. (2020). Recognizing and controlling airborne transmission of SARS-CoV-2 in indoor environments. *Indoor air*, 30(4), 557. [10.1111/ina.12697](https://doi.org/10.1111/ina.12697)
- Bai, Y. L., Huang, D. S., Liu, J., Li, D. Q., & Guan, P. (2019). Effect of meteorological factors

on influenza-like illness from 2012 to 2015 in Huludao, a northeastern city in China. *PeerJ*, 7, e6919. <https://doi.org/10.7717/peerj.6919>

Bashir, M. F., Jiang, B., Komal, B., Bashir, M. A., Farooq, T. H., Iqbal, N., & Bashir, M. (2020). Correlation between environmental pollution indicators and COVID-19 pandemic: a brief study in Californian context. *Environmental research*, 187, 109652. <https://doi.org/10.1016/j.envres.2020.109652>

Bashir, M. F., Ma, B., Komal, B., Bashir, M. A., Tan, D., & Bashir, M. (2020). Correlation between climate indicators and COVID-19 pandemic in New York, USA. *Science of the Total Environment*, 728, 138835. <https://doi.org/10.1016/j.scitotenv.2020.138835>

Briz-Redón, Á., & Serrano-Aroca, Á. (2020). A spatio-temporal analysis for exploring the effect of temperature on COVID-19 early evolution in Spain. *Science of the total environment*, 728, 138811. <https://doi.org/10.1016/j.scitotenv.2020.138811>

Cai, Q. C., Lu, J., Xu, Q. F., Guo, Q., Xu, D. Z., Sun, Q. W., ... & Jiang, Q. W. (2007). Influence of meteorological factors and air pollution on the outbreak of severe acute respiratory syndrome. *Public Health*, 121(4), 258-265. <https://doi.org/10.1016/j.puhe.2006.09.023>

Cai, Y., Huang, T., Liu, X., & Xu, G. (2020). The Effects of "Fangcang", Huoshenshan, and Leishenshan" Makeshift Hospitals and Temperature on the Mortality of COVID-19. *MedRxiv*. <https://doi.org/10.1101/2020.02.26.20028472>

Chen, G., Zhang, W., Li, S., Zhang, Y., Williams, G., Huxley, R., ... & Guo, Y. (2017). The impact of ambient fine particles on influenza transmission and the modification effects of

temperature in China: a multi-city study. *Environment international*, 98, 82-88.

<https://doi.org/10.1016/j.envint.2016.10.004>

Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., ... & Zhang, L. (2020).

Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *The lancet*, 395(10223), 507-513.

[https://doi.org/10.1016/S0140-6736\(20\)30211-7](https://doi.org/10.1016/S0140-6736(20)30211-7)

Chien, Lung-Chang, and Lung-Wen Chen. "Meteorological impacts on the incidence of COVID-19 in the US." *Stochastic Environmental Research and Risk Assessment* 34.10 (2020):

1675-1680. <https://doi.org/10.1007/s00477-020-01835-8>

Correia, G., Rodrigues, L., Da Silva, M. G., & Gonçalves, T. (2020). Airborne route and bad use

of ventilation systems as non-negligible factors in SARS-CoV-2 transmission. *Medical hypotheses*, 141, 109781. <https://doi.org/10.1016/j.mehy.2020.109781>

Coşkun, H., Yıldırım, N., & Gündüz, S. (2021). The spread of COVID-19 virus through

population density and wind in Turkey cities. *Science of the Total Environment*, 751, 141663. <https://doi.org/10.1016/j.scitotenv.2020.141663>

Dbouk, T., & Drikakis, D. (2020). On coughing and airborne droplet transmission to

humans. *Physics of Fluids*, 32(5), 053310. <https://doi.org/10.1063/5.0011960>

De Angelis, E., Renzetti, S., Volta, M., Donato, F., Calza, S., Placidi, D., ... & Rota, M. (2021).

COVID-19 incidence and mortality in Lombardy, Italy: An ecological study on the role of air pollution, meteorological factors, demographic and socioeconomic

variables. *Environmental research*, 195, 110777.

<https://doi.org/10.1016/j.envres.2021.110777>

Doğan, B., Jebli, M. B., Shahzad, K., Farooq, T. H., & Shahzad, U. (2020). Investigating the effects of meteorological parameters on COVID-19: case study of New Jersey, United States. *Environmental Research*, 191, 110148.

<https://doi.org/10.1016/j.envres.2020.110148>

Duhon, J., Bragazzi, N., & Kong, J. D. (2021). The impact of non-pharmaceutical interventions, demographic, social, and climatic factors on the initial growth rate of COVID-19: A cross-country study. *Science of The Total Environment*, 760, 144325.

<https://doi.org/10.1016/j.scitotenv.2020.144325>

Espejo, W., Celis, J. E., Chiang, G., & Bahamonde, P. (2020). Environment and COVID-19: Pollutants, impacts, dissemination, management and recommendations for facing future epidemic threats. *Science of The Total Environment*, 747, 141314.

<https://doi.org/10.1016/j.scitotenv.2020.141314>

Fu, S., Wang, B., Zhou, J., Xu, X., Liu, J., Ma, Y., ... & Zhang, K. (2021). Meteorological factors, governmental responses and COVID-19: Evidence from four European countries. *Environmental research*, 194, 110596.

<https://doi.org/10.1016/j.envres.2020.110596>

Goswami, K., Bharali, S., & Hazarika, J. (2020). Projections for COVID-19 pandemic in India and effect of temperature and humidity. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, 14(5), 801-805. <https://doi.org/10.1016/j.dsx.2020.05.045>

Greenhalgh, T., Jimenez, J. L., Prather, K. A., Tufekci, Z., Fisman, D., & Schooley, R. (2021). Ten scientific reasons in support of airborne transmission of SARS-CoV-2. *The Lancet*, 397(10285), 1603-1605. [https://doi.org/10.1016/S0140-6736\(21\)00869-2](https://doi.org/10.1016/S0140-6736(21)00869-2)

Gupta, S., Raghuwanshi, G. S., & Chanda, A., (2020). Effect of weather on COVID-19 spread in the US: A prediction model for India in 2020. *Science of the total environment*, 728, 138860. <https://doi.org/10.1016/j.scitotenv.2020.138860>

Hadei, M., Hopke, P. K., Jonidi, A., & Shahsavani, A. (2020). A letter about the airborne transmission of SARS-CoV-2 based on the current evidence. *Aerosol and Air Quality Research*, 20(5), 911-914. <https://doi.org/10.4209/aaqr.2020.04.0158>

Hridoy, A. E. E., Mohiman, M. A., Tusher, S. M. S. H., Nowraj, S. Z. A., & Rahman, M. A. (2021). Impact of meteorological parameters on COVID-19 transmission in Bangladesh: a spatiotemporal approach. *Theoretical and Applied Climatology*, 144(1), 273-285. <https://doi.org/10.1007/s00704-021-03535-x>

Islam, A. R. M. T., Hasanuzzaman, M., Azad, M. A. K., Salam, R., Toshi, F. Z., Khan, M. S. I., ... & Ibrahim, S. M. (2020). Effect of meteorological factors on COVID-19 cases in Bangladesh. *Environment, Development and Sustainability*, 1-24. <https://doi.org/10.1007/s10668-020-01016-1>

Islam, A. T., Shen, S., Yang, S., Hu, Z., & Chu, R., (2019). Assessing recent impacts of climate change on design water requirement of Boro rice season in Bangladesh. *Theoretical and Applied Climatology*, 138(1), 97-113. <https://doi.org/10.1007/s00704-019-02818-8>

Islam, N., Bukhari, Q., Jameel, Y., Shabnam, S., Erzurumluoglu, A. M., Siddique, M. A., ... &

D'Agostino Sr, R. B. (2021). COVID-19 and climatic factors: A global analysis. *Environmental research*, 193, 110355.

<https://doi.org/10.1016/j.envres.2020.110355>

Jamil, T., Alam, I., Gojobori, T., & Duarte, C. M. (2020). No evidence for temperature-dependence of the COVID-19 epidemic. *Frontiers in public health*, 8, 436.

<https://doi.org/10.3389/fpubh.2020.00436>

Kalhori, S. N., Ghazisaeedi, M., Azizi, R., & Naserpour, A. (2019). Studying the influence of mass media and environmental factors on influenza virus transmission in the US Midwest. *Public health*, 170, 17-22. <https://doi.org/10.1016/j.puhe.2019.02.006>

Klompas, M., Baker, M. A., & Rhee, C. (2020). Airborne transmission of SARS-CoV-2: theoretical considerations and available evidence. *Jama*. [10.1001/jama.2020.12458](https://doi.org/10.1001/jama.2020.12458)

Kulkarni, H., Khandait, H., Narlawar, U. W., Rathod, P., & Mamtani, M. (2021). Independent association of meteorological characteristics with initial spread of Covid-19 in India. *Science of the Total Environment*, 764, 142801.

<https://doi.org/10.1016/j.scitotenv.2020.142801>

Kumar, S. (2020). Effect of meteorological parameters on spread of COVID-19 in India and air quality during lockdown. *Science of the Total Environment*, 745, 141021.

<https://doi.org/10.1016/j.scitotenv.2020.141021>

- Lau, S. Y. F., Wang, X., Wang, M., Liu, S., Zee, B. C. Y., Han, X., ... & Chen, E. (2018). Identification of meteorological factors associated with human infection with avian influenza A H7N9 virus in Zhejiang Province, China. *Science of the total environment*, 644, 696-709. <https://doi.org/10.1016/j.scitotenv.2018.06.390>
- Li, H., Xu, X. L., Dai, D. W., Huang, Z. Y., Ma, Z., & Guan, Y. J. (2020). Air pollution and temperature are associated with increased COVID-19 incidence: a time series study. *International journal of infectious diseases*, 97, 278-282. <https://doi.org/10.1016/j.ijid.2020.05.076>
- Liu, J., Zhou, J., Yao, J., Zhang, X., Li, L., Xu, X., ... & Zhang, K. (2020). Impact of meteorological factors on the COVID-19 transmission: A multi-city study in China. *Science of the total environment*, 726, 138513. <https://doi.org/10.1016/j.scitotenv.2020.138513>
- Liu, Z., Zhang, J., Zhang, Y., Lao, J., Liu, Y., Wang, H., & Jiang, B. (2019). Effects and interaction of meteorological factors on influenza: based on the surveillance data in Shaoyang, China. *Environmental research*, 172, 326-332. <https://doi.org/10.1016/j.envres.2019.01.053>
- Lorenzo, J. S. L., San Tam, W. W., & Seow, W. J. (2021). Association between air quality, meteorological factors and COVID-19 infection case numbers. *Environmental Research*, 197, 111024. <https://doi.org/10.1016/j.envres.2021.111024>

Ma, Y., Zhao, Y., Liu, J., He, X., Wang, B., Fu, S., ... & Luo, B., (2020). Effects of temperature variation and humidity on the death of COVID-19 in Wuhan, China. *Science of the total environment*, 724, 138226. <https://doi.org/10.1016/j.scitotenv.2020.138226>

Morawska, L., & Cao, J. (2020). Airborne transmission of SARS-CoV-2: The world should face the reality. *Environment international*, 139, 105730. <https://doi.org/10.1016/j.envint.2020.105730>

Notari, A. (2021). Temperature dependence of COVID-19 transmission. *Science of The Total Environment*, 763, 144390. <https://doi.org/10.1016/j.scitotenv.2020.144390>

Pan, J., Yao, Y., Liu, Z., Meng, X., Ji, J. S., Qiu, Y., ... & Kan, H. (2021). Warmer weather unlikely to reduce the COVID-19 transmission: An ecological study in 202 locations in 8 countries. *Science of The Total Environment*, 753, 142272. <https://doi.org/10.1016/j.scitotenv.2020.142272>

Pani, S. K., Lin, N. H., & RavindraBabu, S. (2020). Association of COVID-19 pandemic with meteorological parameters over Singapore. *Science of the Total Environment*, 740, 140112. <https://doi.org/10.1016/j.scitotenv.2020.140112>

Pei, L., Wang, X., Guo, B., Guo, H., & Yu, Y. (2021). Do air pollutants as well as meteorological factors impact Corona Virus Disease 2019 (COVID-19)? Evidence from China based on the geographical perspective. *Environmental Science and Pollution Research*, 1-13. <https://doi.org/10.1007/s11356-021-12934-6>

Pramanik, M., Udmale, P., Bisht, P., Chowdhury, K., Szabo, S., & Pal, I., (2020). Climatic factors influence the spread of COVID-19 in Russia. *International journal of environmental health research*, 1-15. <https://doi.org/10.1080/09603123.2020.1793921>

Prata, D. N., Rodrigues, W., & Bermejo, P. H. (2020). Temperature significantly changes COVID-19 transmission in (sub) tropical cities of Brazil. *Science of the Total Environment*, 729, 138862. <https://doi.org/10.1016/j.scitotenv.2020.138862>

Prather, K. A., Marr, L. C., Schooley, R. T., McDiarmid, M. A., Wilson, M. E., & Milton, D. K. (2020). Airborne transmission of SARS-CoV-2. *Science*, 370(6514), 303-304. [10.1126/science.abc6197](https://doi.org/10.1126/science.abc6197)

Qi, H., Xiao, S., Shi, R., Ward, M. P., Chen, Y., Tu, W., ... & Zhang, Z. (2020). COVID-19 transmission in Mainland China is associated with temperature and humidity: a time-series analysis. *Science of the total environment*, 728, 138778. <https://doi.org/10.1016/j.scitotenv.2020.138778>

Rosario, D. K., Mutz, Y. S., Bernardes, P. C., & Conte-Junior, C. A. (2020). Relationship between COVID-19 and weather: Case study in a tropical country. *International Journal of Hygiene and Environmental Health*, 229, 113587. <https://doi.org/10.1016/j.ijheh.2020.113587>

Runkle, J. D., Sugg, M. M., Leeper, R. D., Rao, Y., Matthews, J. L., & Rennie, J. J. (2020). Short-term effects of specific humidity and temperature on COVID-19 morbidity in select US cities. *Science of the Total Environment*, 740, 140093. <https://doi.org/10.1016/j.scitotenv.2020.140093>

Şahin, M. (2020). Impact of weather on COVID-19 pandemic in Turkey. *Science of The Total Environment*, 728, 138810. <https://doi.org/10.1016/j.scitotenv.2020.138810>

Sahoo, P. K., Powell, M. A., Mittal, S., & Garg, V. K. (2020). Is the transmission of novel coronavirus disease (COVID-19) weather dependent? *Journal of the Air & Waste Management Association*, 70(11), 1061-1064.

<https://doi.org/10.1080/10962247.2020.1823763>

Sajadi, M. M., Habibzadeh, P., Vintzileos, A., Shokouhi, S., Miralles-Wilhelm, F., & Amoroso, A. (2020). Temperature, humidity, and latitude analysis to estimate potential spread and seasonality of coronavirus disease 2019 (COVID-19). *JAMA network open*, 3(6), e2011834-e2011834. [10.1001/jamanetworkopen.2020.11834](https://doi.org/10.1001/jamanetworkopen.2020.11834)

Shahzad, K., Shahzad, U., Iqbal, N., Shahzad, F., & Fareed, Z. (2020). Effects of climatological parameters on the outbreak spread of COVID-19 in highly affected regions of Spain. *Environmental Science and Pollution Research*, 27(31), 39657-39666. <https://doi.org/10.1007/s11356-020-10551-3>

Shakil, M. H., Munim, Z. H., Tasnia, M., & Sarowar, S. (2020). COVID-19 and the environment: A critical review and research agenda. *Science of the Total Environment*, 141022. <https://doi.org/10.1016/j.scitotenv.2020.141022>

Shao, W., Xie, J., & Zhu, Y. (2021). Mediation by human mobility of the association between temperature and COVID-19 transmission rate. *Environmental research*, 194, 110608.

<https://doi.org/10.1016/j.envres.2020.110608>

Shi, P., Dong, Y., Yan, H., Zhao, C., Li, X., Liu, W., ... & Xi, S. (2020). Impact of temperature on the dynamics of the COVID-19 outbreak in China. *Science of the total environment*, 728, 138890. <https://doi.org/10.1016/j.scitotenv.2020.138890>

Singh, O., Bhardwaj, P., & Kumar, D. (2020). Association between climatic variables and COVID-19 pandemic in National Capital Territory of Delhi, India. *Environment, Development and Sustainability*, 1-15. <https://doi.org/10.1007/s10668-020-01003-6>

Sobral, M. F. F., Duarte, G. B., da Penha Sobral, A. I. G., Marinho, M. L. M., & de Souza Melo, A. (2020). Association between climate variables and global transmission oF SARS-CoV-2. *Science of The Total Environment*, 729, 138997.

<https://doi.org/10.1016/j.scitotenv.2020.138997>

Suhaimi, N. F., Jalaludin, J., & Latif, M. T. (2020). Demystifying a possible relationship between COVID-19, air quality and meteorological factors: evidence from Kuala Lumpur, Malaysia. *Aerosol and Air Quality Research*, 20(7), 1520-1529. <https://doi.org/10.4209/aaqr.2020.05.0218>

Tan, J., Mu, L., Huang, J., Yu, S., Chen, B., & Yin, J. (2005). An initial investigation of the association between the SARS outbreak and weather: with the view of the environmental

temperature and its variation. *Journal of Epidemiology & Community Health*, 59(3), 186-192. <http://dx.doi.org/10.1136/jech.2004.020180>

Tello-Leal, E., & Macías-Hernández, B. A. (2020). Association of environmental and meteorological factors on the spread of COVID-19 in Victoria, Mexico, and air quality during the lockdown. *Environmental Research*, 110442.

<https://doi.org/10.1016/j.envres.2020.110442>

Tosepu, R., Gunawan, J., Effendy, D. S., Lestari, H., Bahar, H., & Asfian, P. (2020). Correlation between weather and Covid-19 pandemic in Jakarta, Indonesia. *Science of The Total Environment*, 725, 138436. <https://doi.org/10.1016/j.scitotenv.2020.138436>

Ueki, H., Furusawa, Y., Iwatsuki-Horimoto, K., Imai, M., Kabata, H., Nishimura, H., & Kawaoka, Y. (2020). Effectiveness of face masks in preventing airborne transmission of SARS-CoV-2. *MSphere*, 5(5). [10.1128/mSphere.00637-20](https://doi.org/10.1128/mSphere.00637-20)

Wang, M., Jiang, A., Gong, L., Luo, L., Guo, W., Li, C., ... & Li, H. (2020). Temperature significant change COVID-19 Transmission in 429 cities. *medrxiv*. <https://doi.org/10.1101/2020.02.22.20025791>

Wu, Y., Jing, W., Liu, J., Ma, Q., Yuan, J., Wang, Y., ... & Liu, M. (2020). Effects of temperature and humidity on the daily new cases and new deaths of COVID-19 in 166 countries. *Science of the Total Environment*, 729, 139051. <https://doi.org/10.1016/j.scitotenv.2020.139051>

Xie, J., & Zhu, Y. (2020). Association between ambient temperature and COVID-19 infection in 122 cities from China. *Science of the Total Environment*, 724, 138201.
<https://doi.org/10.1016/j.scitotenv.2020.138201>

Yao, M., Zhang, L., Ma, J., & Zhou, L. (2020). On airborne transmission and control of SARS-CoV-2. *Science of the Total Environment*, 731, 139178.
<https://doi.org/10.1016/j.scitotenv.2020.139178>

Yip, C., Chang, W. L., Yeung, K. H., & Yu, I. T. (2007). Possible meteorological influence on the severe acute respiratory syndrome (SARS) community outbreak at Amoy Gardens, Hong Kong. *Journal of environmental health*, 70(3), 39-47.
<https://www.jstor.org/stable/26327426>

Yuan, J., Wu, Y., Jing, W., Liu, J., Du, M., Wang, Y., & Liu, M. (2021). Non-linear correlation between daily new cases of COVID-19 and meteorological factors in 127 countries. *Environmental research*, 193, 110521.
<https://doi.org/10.1016/j.envres.2020.110521>

Yuan, J., Yun, H., Lan, W., Wang, W., Sullivan, S. G., Jia, S., & Bittles, A. H. (2006). A climatologic investigation of the SARS-CoV outbreak in Beijing, China. *American journal of infection control*, 34(4), 234-236. <https://doi.org/10.1016/j.ajic.2005.12.006>

Figures

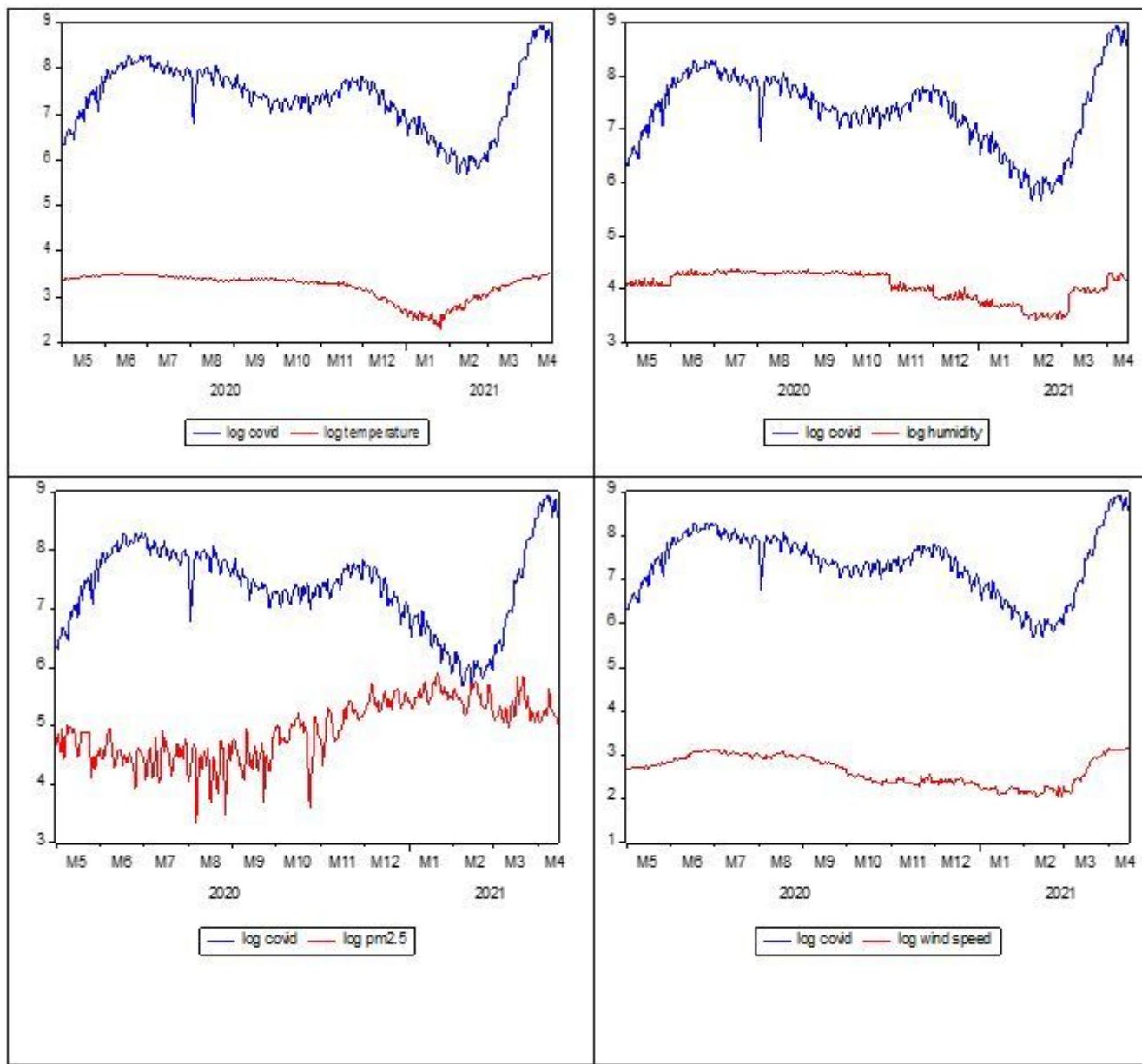


Figure 1

Meteorological factors versus COVID -19 confirmed cases in Bangladesh

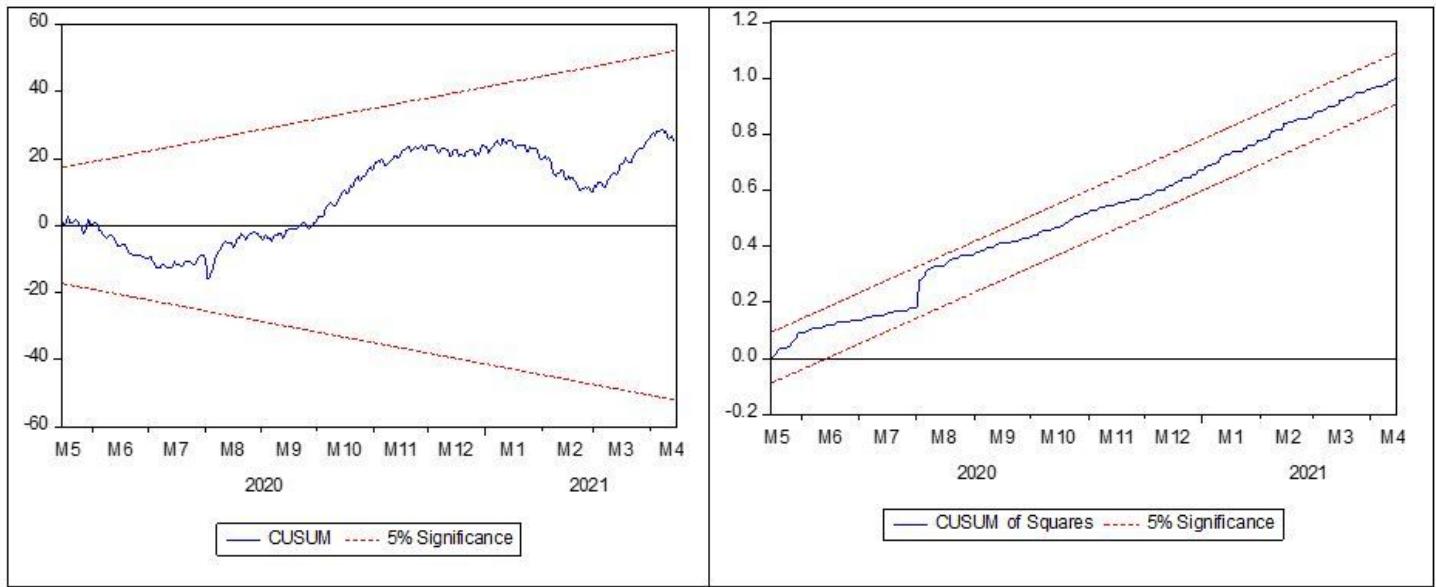


Figure 2

Model stability check using the Cumulative Sum (CUSUM) test and the CUSUM square test for equation 4

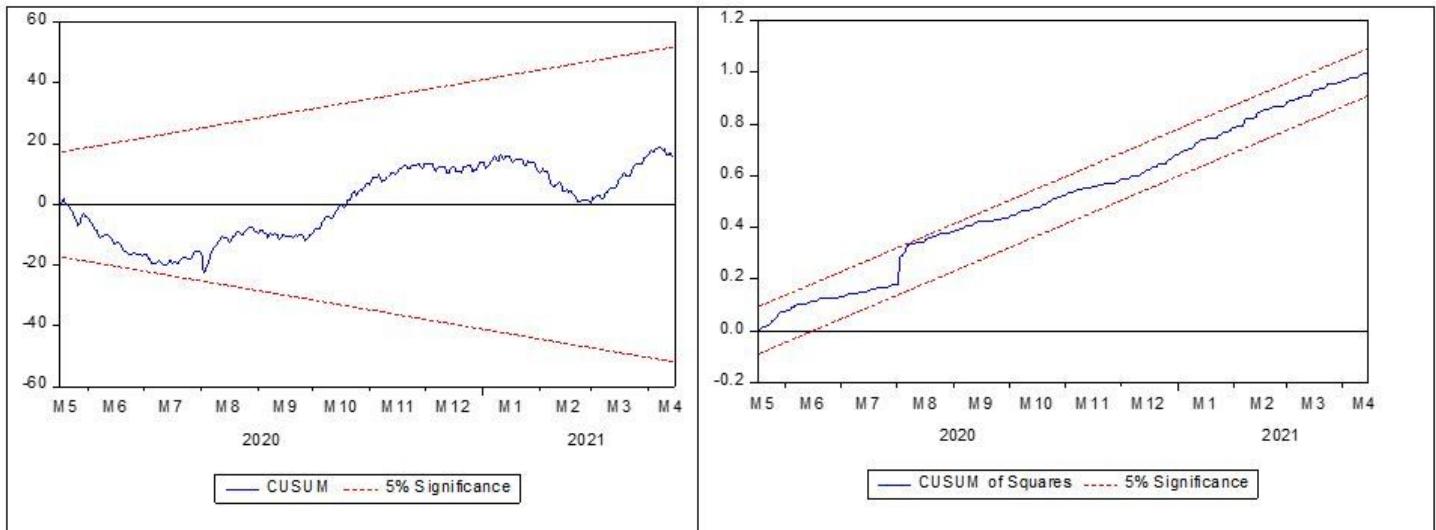


Figure 3

Model stability check using the Cumulative Sum (CUSUM) test and the CUSUM square test for equation 5

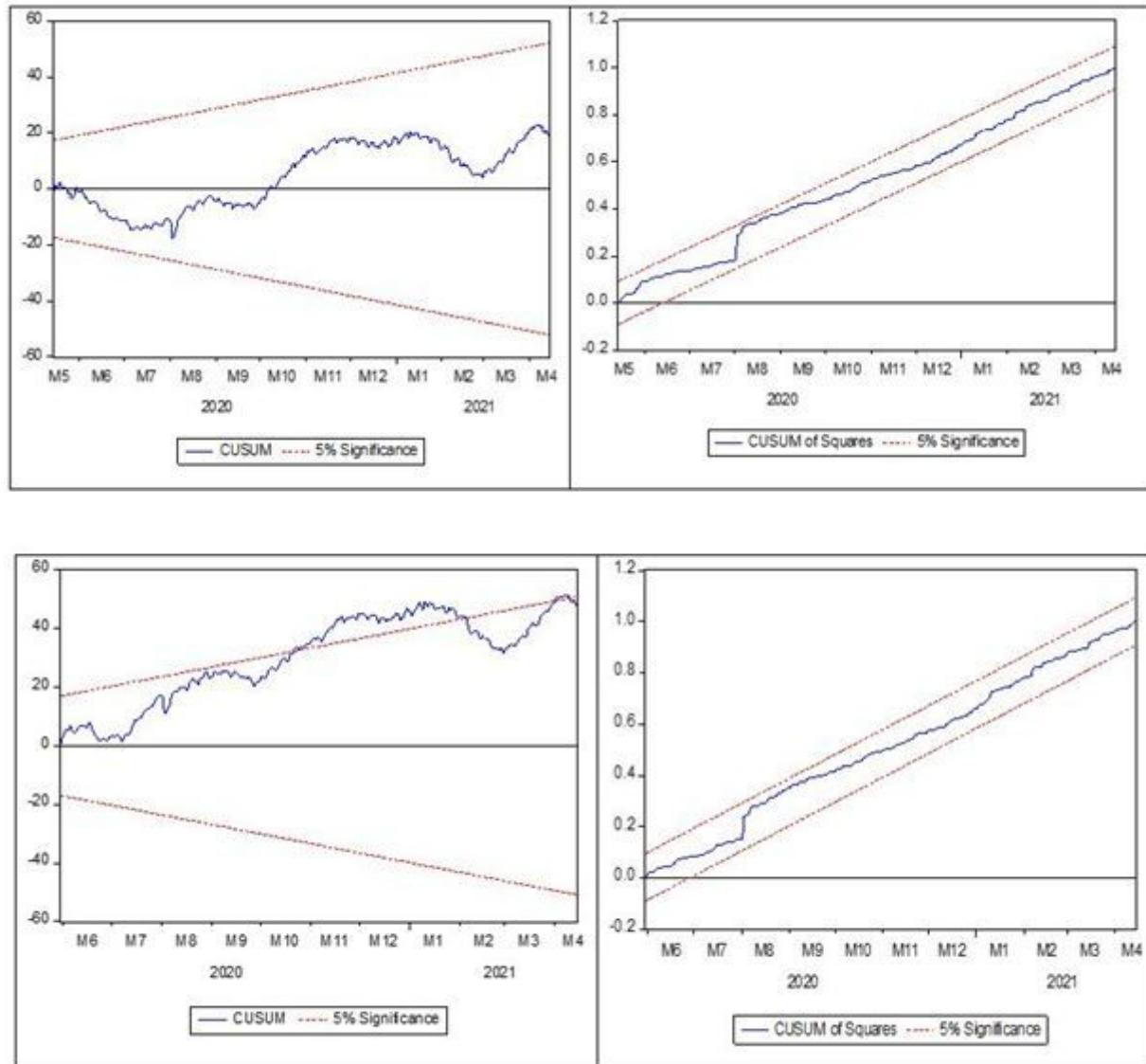


Figure 4

4a: Model stability check using the Cumulative Sum (CUSUM) test and the CUSUM square test for equation 6 (auto-lag covariates)
 4b: Model stability check using the Cumulative Sum (CUSUM) test and the CUSUM square test for equation 6 (12 days lag covariates)

Supplementary Files

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