

## A SYSTEMATIC REVIEW ON THE EFFECT OF ENVIRONMENTAL FACTORS ON COVID-19 CASES

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**Abstract:** A global pandemic known as COVID-19 now threatens public health systems worldwide. The COVID-19 virus is spread by many sources, including environmental factors. Infectious diseases are transmitted and are resistant to certain environmental factors, including temperature, humidity, wind speed and population density. Through preferred reporting items for systematic reviews and meta-analyses, a study on the effects of environmental factors on the spread of COVID-19 cases in Asia was carried out to provide evidence-based knowledge and serve as a basis for health care and preventative guidelines (PRISMA). Search databases like Web of Science (WoS), Scopus and PubMed were used to find the data. A total of 52 full-text papers, 1,780 abstracts and 16 systematic review articles were examined. The results indicate a clear correlation between environmental factors, population density and the occurrence of COVID-19. These findings suggest that environmental factors may play a role in the distribution of COVID-19 in Asia.

Keywords: Environmental factor, COVID-19, humidity, climate, temperature.

### Introduction

The World Health Organization (WHO) has declared Coronavirus 2019 (COVID-19) a worldwide health emergency, several weeks after the virus was first detected in late December 2019 in Wuhan, China (World Health Organisation, 2020). SARS-CoV-2 was transmitted most frequently by direct contact or droplets produced by sneezing, coughing or talking (Islam *et al.*, 2020; Li *et al.*, 2020; Wang *et al.*, 2020). The virus had spread to 216 nations, territories or areas by 1 January 2021, killing 1,814,461 individuals in 82,294,958 confirmed cases (WHO, 2020) and the figure is rapidly increasing. Identifying all elements contributing to COVID-19 spread in urban settings is critical. Influencing factors in the spread of infectious diseases include climate (humidity and temperature), population density and the quality of medical treatment available (Wang *et al.*, 2021). Wang *et al.* (2021) looked

at how temperature affected the spread of COVID-19 and found that it had a substantial influence. Their investigation revealed that a one-degree Celsius temperature increase significantly impacts the number of confirmed cases and the factors contributing to their spread. The survival and transmission of viruses are strongly influenced by environmental conditions such as temperature and humidity (Chan *et al.*, 2020; Morawska & Cao, 2020; Zhang *et al.*, 2020; Guo *et al.*, 2021; Kwon *et al.*, 2021).

For instance, climatic conditions are the only risk factor that can predict SARS with a high degree of accuracy. SARS-CoV and humans can interact biologically in response to climatic circumstances. This virus survived and propagated was influenced by environmental conditions such as temperature, humidity and wind speed (Yuan *et al.*, 2006). Based on these findings, it seems that environmental factors such as relative humidity (RH) and temperature,

among others, play a significant part in turning the virus inactive once it has been released from its host. It is believed that the meteorological conditions have a big effect on the continuance of the virus, as well as its potential to spread to new places and the degree to which it does so. This is in addition to the fact that the virus may be passed from person to person (Chan *et al.*, 2011; Van Doremalen *et al.*, 2013). Xie and Zhu (2020) investigated the association between temperature and COVID-19 infection rates in China. They discovered a positive linear connection between average temperature and COVID-19 infection rates when the temperature is below 3°C.

Additionally, they found this relationship is strongest in areas with a high population density. Tosepu *et al.* (2020) evaluated the COVID-19 pandemic in Indonesia and discovered a link between the outbreak and the average temperature. In the city of Kuala Lumpur, Malaysia, there was a link between COVID-19 and the relative humidity of the air ( $r=0.106$ ,  $p<0.001$ ) (Suhaimi *et al.*, 2020). According to Ma *et al.* (2020), relative humidity and temperature fluctuations are linked to COVID-19 mortality. Wind speed, temperature and humidity all impact the worldwide COVID-19 spread severity, according to research by Chen *et al.* (2020). Humidity significantly influenced the rapid spread of COVID-19 in New York City (Bashir *et al.*, 2020).

It is crucial to investigate the extent to which COVID-19 transmissibility changes with the seasons and the impact of meteorological and climatic factors on transmission patterns. COVID-19 has been shown to have an inverse connection with temperature and humidity in certain studies but not others; the same holds for solar UV radiation and average ambient temperature. There is much research on how environmental factors affect COVID-19 cases and other human coronaviruses but our major purpose was to present a synthesis of this research and explain how it pertains to the current pandemic.

## Materials and Methods

The publications were obtained from Web of Science (WoS), Scopus and PubMed. The systematic review was conducted following PRISMA guidelines which also applied to the study's resources, inclusion and exclusion criteria, review processes (identification, screening, eligibility) and data abstraction and analysis. The three main search terms were COVID-19, environmental issues and climate change. People with COVID-19 diagnoses made up the population. Comparisons were made between the nations, study parameters, climate variables, COVID-19 results and qualitative research methods.

### Search Strategy

The Web of Science search formula or string is  $TS = ("Climate\ change,\ environmental\ factor\ and\ COVID-19\ all\ fall\ under\ this\ category")$ .  $TITLE-ABS-KEY [("environmental\ factor*")\ AND\ ("climate\ change*")\ AND\ (COVID-19*)\ in\ Scopus])$ . Environmental factor AND  $[("Climate\ change")\ (All\ Fields)\ in\ PubMed\ ("COVID-19")\ (All\ Fields)]$ . The filter includes the following criteria: Full text, types of journal article, publication date within the last two years and English language.

### Resources

The research was conducted using the Web of Science, Scopus and PubMed, three significant journal databases. WoS is a sizable database with over 33,000 publications on over 256 topics such as environmental studies, transdisciplinary social sciences, social concerns and, development and planning. It ranks journals according to three criteria: Citations, articles and citations per article, and has over a century's worth of comprehensive backfile and citation data provided by Clarivate Analytics. The second database considered for this review is Scopus. With 22,800 articles from 5,000 publishers worldwide, Scopus is one of the largest databases of abstracts and citations of peer-reviewed literature. The environmental, social, agricultural and biological sciences are

among the many fields covered by Scopus. Over 33 million references to articles in the biological sciences are available in PubMed. Full-text journal articles are not included, although links to them are often supplied from other places like the publisher’s website or PubMed Central (PMC).

**Eligibility and Exclusion Criteria**

Several inclusion and exclusion criteria have been defined. First, non-English publications were excluded from the search attempts and only English-language content was considered to avoid confusion and translation difficulties. Second, only articles in peer-reviewed journals that contain empirical data are considered. This means that review articles and book series are excluded from the search. Third, there is no time restriction for the chronology as most articles were published in 2019. Since the analysis focused on the correlation of environmental elements (temperature, humidity, population density, precipitation and vegetation area), COVID-19 cases were included. This review conducted a literature search that evaluated the interaction between environmental characteristics and COVID-19 recovery and reproduction rates. Finally, in line with the journal’s aim of highlighting Asian cases, only publications related to Asian areas were selected (Table 1).

**Systematic Review Process**

The systematic review procedure included four steps. During the initial stage of the search process, we determined which keywords would be used. Based on prior research and the thesaurus, similar terms about environmental issues, climate change and COVID-19 were utilised. After rigorous examination, 685 duplicate items were eliminated at this level. The second phase involved screening. At this step, 1,044 articles were eliminated from 1,096 papers eligible for screening. The third phase is the selection phase during which entire articles are accessed. After a thorough analysis, 52 papers were deemed ineligible because they did not focus on environmental variables were not empirical or did not reference Asian countries and territories. The last review phase yielded 16 articles for qualitative examination (Figure 1).

**Data Extraction and Analysis**

This evaluation was based on a review of the relevant literature. Results from studies were prioritised since they addressed the main issues. In order to collect information, we first looked at the abstracts and then read through the complete articles (in great detail) to figure out which themes and subtopics were relevant. The impact of the environment affecting COVID-19 cases among Asians was identified by qualitative researchers using text analysis.

Table 1: The criterion used to include and exclude papers from systematic reviews

Criteria	Eligibility	Exclusion
Language	English	Non-English
Types of literature	Journal (research articles)	Book series, chapter in book, proceeding
Correlation between environmental factors	Temperature, humidity, population density, rainfall and vegetation area	Recovery rates and reproduction rates
Countries	Asian countries	Non-Asian countries

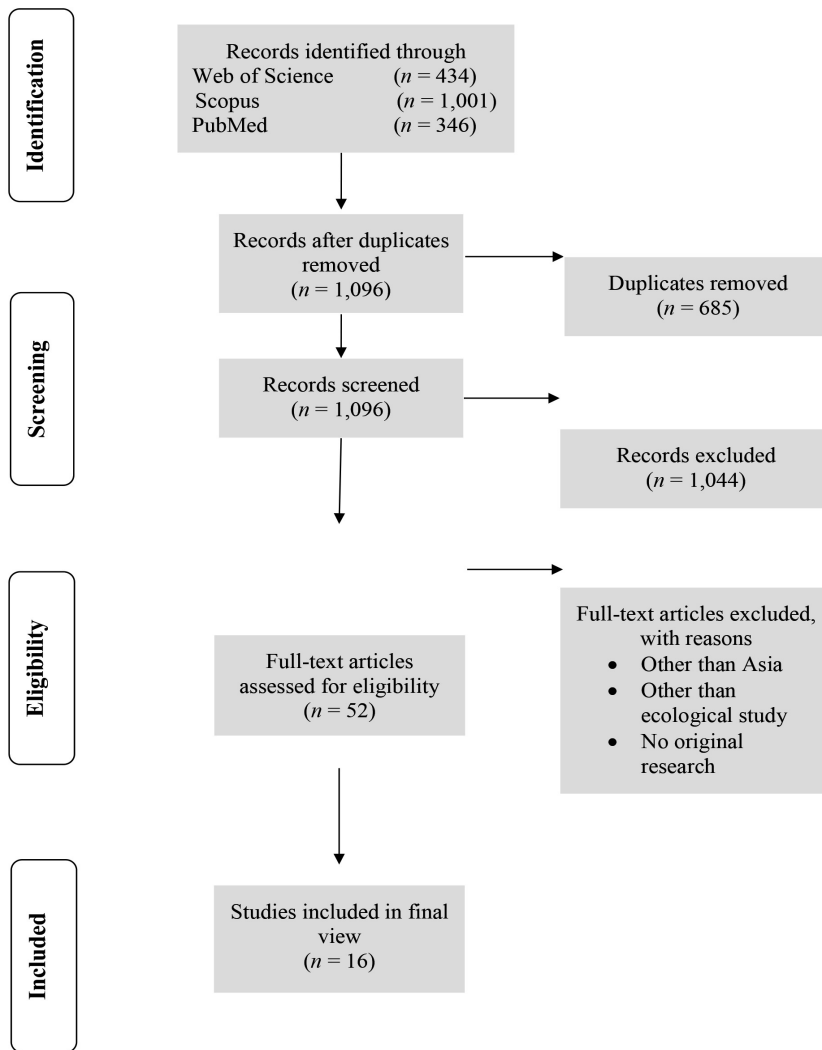


Figure 1: Flow diagram of the study selection for the review process

**Results**

Most research used daily meteorological data to determine the association between environmental conditions, events and mortality. Research findings, study locations, study designs and associated variables for studies examining environmental factors are all summarised in Table 2. In most publications, climate parameters included temperature (minimum and maximum temperatures), precipitation and humidity, wind velocity and population density. The following variables were evaluated based on the results: (i)

Ambient temperature, (ii) Average temperature, (iii) Maximum and minimum temperature, (iv) Relative humidity, (v) Solar radiation, (vi) Wind speed and (vii) Population density. According to the data shown in Table 3, researchers discovered that temperature, humidity, wind speed and population density all correlated with COVID-19. Wind and population density were discovered to be significant factors in the dissemination of COVID-19. Both variables explained 94% of the variance in viral dispersion.

Table 2: Characteristics of selected articles

Article ID	Title and Author(s)	Objective(s)	Location	Samples and Study Period	Types of Analysis	Variables	Main Results
ID 1	“Correlation between weather and COVID-19 pandemic in Jakarta” Tosepu <i>et al.</i> (2020)	To examine the relationship between weather and daily COVID-19	Jakarta, Indonesia	Data January to 29 March 2020	Spearman rank correlation	Minimum, maximum and average temperature, humidity, amount of rainfall	There is a statistically significant relationship between the average temperature and COVID-19. Other variables did not become significant
ID 2	“Investigation of effective climatology parameters on COVID-19 outbreak in Iran” Ahmadi <i>et al.</i> (2020)	To investigate the influence of statistical and climatological aspects in the transmission of the Coronavirus	Iran	Data 19 February to 22 March	The Partial Correlation Coefficient (PCC), Sobol Jansen methods, analysing the effect and correlation spreading rate	Infected cases, population density, average temperature, average rain, humidity, wind speed	Correlation between population density and COVID-19 is significant. Areas with low humidity and wind speed can support the viability of the virus, causing high infection rates. Provinces with a high population density and high humidity are more susceptible to infection
ID 3	“Impact of weather on COVID-19 pandemic in Turkey” Mehmet Sahin (2020)	To investigate the relationship between climatic conditions and the COVID-19 epidemic	Turkey	Data 10 March to 5 April 2020	Temperature, dew point, humidity, wind speed, population density	Spearman’s correlation	The impact of the humidity is at its peak in the middle of the day. The density of the population is an important indication
ID 4	“The spread of COVID-19 virus through population density and wind in Turkey cities” Coskun <i>et al.</i> (2021)	To determine the influence of climate and demographics on the propagation of the COVID-19 virus	Turkey	Data March 2020	Population density, rain, temperature, humidity, wind speed	Regression analysis, mediation analyses	The virus spread rapidly due to population density and wind. Temperature and humidity do not affect how often things happen
ID 5	“Effect of temperature on the infectivity of COVID-19” Ujjea <i>et al.</i> (2020)	To evaluate the influence of temperature on the infectivity of COVID-19	Japan	Data 15 January and 16 March 2020	Population density, average temperature	Poisson regression analysis	Possible association between low temperature and increased risk of COVID-19 infection
ID 6	“Association between temperature, humidity, and COVID-19 outbreaks in Bangladesh” Haque and Rahman (2020)	To investigate the relationship between the average temperature and relative humidity and the COVID-19 pandemic	Bangladesh	Data 8 March to 3 May 2020	Temperature average, humidity	Linear regression	High temperatures and relative humidity impede the transmission of COVID-19

ID 7	<p>“Association between environmental factors and COVID-19 in Shanghai, China” Ma <i>et al.</i> (2021)</p>	<p>Investigate the relationship between exposure and reaction among daily confirmed cases of COVID-19 and environmental factors</p>	<p>Shanghai, China</p>	<p>21 January 2020 to 29 February 2020</p>	<p>Temperature average, humidity, wind speed</p>	<p>Generalised Additive Model (GAM)</p>	<p>COVID-19 exposure response was positive at 5°C and negative between 5 and 15°C. COVID-19 transmission was negatively correlated with the temperature humidity index (THI) and wind impact index (K)</p>
ID 8	<p>“Significance of geographical factors to the COVID-19 outbreak in India” Gupta <i>et al.</i> (2020)</p>	<p>To investigate the associations between meteorological and topographical characteristics and the total number of infected cases in each state</p>	<p>India</p>	<p>Data 27 April 2020</p>	<p>Factors such as population density, wind speed and population evaporation rate</p>	<p>Moment correlation, square regression, Additive Model (GAM)</p>	<p>Maximum transmission is achieved under arid conditions. Wet and extremely wet provinces were less susceptible to infection. Bivariate analysis was inconclusive for the infected case. The Variable Importance of Projection (VIP) and Partial Least Square (PLS) techniques suggested that SR, T, R and AET were of larger significance</p>
ID 9	<p>“Association of temperature and relative humidity with the growth rate of the coronavirus disease 2019 epidemic” Qin <i>et al.</i> (2021)</p>	<p>Examining how different weather conditions affect the development of COVID-19 (GR)</p>	<p>China</p>	<p>Data 26 January to 25 February 2020</p>	<p>Average temperature, average humidity</p>	<p>Longitudinal model, fixed-effect models</p>	<p>High temperatures (-5°C to 15°C) and low relative humidity (&lt;72%) may reduce the GR of COVID-19 outbreaks</p>
ID 10	<p>“Effect of temperature and humidity on the dynamics of daily new cases and deaths due to COVID-19 outbreak in Gulf countries in Middle East Region” Meo <i>et al.</i> (2020)</p>	<p>Determine the influence of humidity and temperature on the daily number of new COVID-19 infections and deaths</p>	<p>Gulf countries (Saudi Arabia, United Arab Emirates, Bahrain, Kuwait, Qatar and Oman)</p>	<p>Data 29 January 2020 to 15 February 2020</p>	<p>Temperature, humidity</p>	<p>Mean and Standard Error of Mean (SEM), correlation coefficient, growth factor</p>	<p>During this period, the average daily temperature was 29.200.30°C and the humidity was 37.954.40%. The negative connection between cases and the humidity rise. However, as temperature increased, there was a link between instances</p>
ID 11	<p>“Influence of absolute humidity, temperature and population density on COVID-19 spread and decay durations: Multi-prefecture study in Japan” Rashed <i>et al.</i> (2020)</p>	<p>To analyse the spread and deterioration of the COVID-19 pandemic in many prefectures throughout Japan</p>	<p>Japan</p>	<p>Data 15 March to 25 May 2020</p>	<p>Spread and decay duration, population density, maximum temperature, absolute humidity</p>	<p>Spearman’s rank correlation, a correlation matrix with partial correlation. Linear regression</p>	<p>Maximum humidity affected decay duration. Population density influences the distribution and damage pattern. The anticipated duration is derived through multivariate analysis and used to plan interventions for a future pandemic</p>

ID 12	“Correlation between COVID-19 morbidity and mortality rates in Japan and local population density, temperature and absolute humidity” Kodera et al. (2020)	Examine relationships between mortality and morbidity rates and population density	Japan	Data 22 February to 25 May 2020	Population density, maximum temperature, humidity	Spearman’s rank correlation, correlation matrix with partial correlation probability, CI of correlation, regression analysis	Moisture-saturated air. Temperature, relative humidity and population cases were weakly correlated
ID 13	“Correlation between weather and COVID-19 pandemic in India: An empirical investigation” Sharma et al. (2020)	The purpose of this study is to isolate and investigate the COVID-19	India	Data 29 January 2020 to 30 April 2020	Maximum and minimum temperature, specific humidity, temperature	Pearson product moment correlation, Spearman’s rank correlation	There was a substantial association between each variable and the prevalence of COVID-19 patients
ID 14	“Association of environmental parameters with COVID-19 in Delhi, India” Ladha et al. (2020)	To forecast COVID-19 risk variables and provide a better pandemic response to policymakers regarding additional public health measures	Delhi, India	Data 1 April to 31 May 2020	Maximum temperature, average relative humidity on average	Linear regression	There was no significant relationship found between COVID-19 cases and maximum temperature, average temperature or average relative humidity
ID 15	“Impact of population density and weather on COVID-19 pandemic and SARS-CoV-2 mutation frequency in Bangladesh” Sharif and Dey (2020)	Determine the impact of weather on COVID-19 cases, mortality and mutation rate	Bangladesh	Data 7 March 2020 to 14 August 2020	Minimum, mean and maximum temperature, UV index, wind velocity, precipitation and relative humidity	Spearman’s rank correlation	The most important component associated with COVID-19 is temperature
ID 16	“Association of COVID-19 pandemic with meteorological parameters over Singapore” Pani et al. (2020)	To explore the function of Singapore’s transmission by examining the correlation between climatic characteristics and COVID-19 cases	Singapore	Data 23 January to 31 May 2020	Maximum, minimum and average temperature, relative humidity, surface pressure, dew point, wind speed	Spearman and Kendall rank correlation	The correlation between variables such as temperature, dew point, relative humidity and absolute humidity



There is evidence that environmental factors are connected to COVID-19 cases as reported in Table 3. Ten items were found to have a positive correlation with temperature while one was shown to have a positive correlation with both the lowest and maximum temperature. In addition, the researchers discovered a positive correlation between five articles and humidity, four articles and wind speed, and five articles and population density. Several articles, meanwhile, exhibit a negative association with temperature, precipitation, humidity and wind speed.

In addition, we uncovered a factor such as the vegetation index that has no link with COVID-19 instances. It is possible to use the connection between changes in climate and other environmental conditions and the occurrence of COVID-19 to make predictions regarding the spread of COVID-19. This systematic review analysed the various interaction between COVID-19 cases and a wide range of climate and environmental variables (including precipitation, relative humidity, temperature, wind speed and population density) to understand better the factors contributing to the spread of this disease.

**Discussion**

The most crucial climatic factor connected with the pandemic COVID-19 is temperature. Most of the research points to a correlation between weather patterns and the spread of COVID-19 (Gupta *et al.*, 2020; Haque & Rahman, 2020; Meo *et al.*, 2020; Pani *et al.*, 2020; Rashed *et al.*, 2020). According to the research carried out by Tosepu *et al.* (2020), there is a correlation between temperature and COVID-19. On the other hand, the degree of association is rather significant (with the lowest average temperature being 26.1°C and the highest average temperature being 28.6°C. The degree of connection established by Sharma *et al.* (2020) between temperature and COVID-19 was fairly substantial, even though they discovered a positive link between the two variables. There is a link between the frequency of illnesses and long-term temperature records, with relatively hot and dry places in low-lying Indian provinces being more vulnerable to COVID-19 infection (Gupta *et al.*, 2020). Increased temperatures in Gulf Cooperation Council (GCC) countries were linked to an increase in COVID-19 cases per day. There was a daily rise in fatalities

Table 3: Environmental factors and COVID-19 cases’ correlations

Factor	Significant Correlation		Non-significant Correlation	Additional Explanation
	Positive	Negative		
Temperature	1,5,6,8,10,11,13,15,16	3,7	4,9,12,14	Average temperature and COVID-19 were connected
Minimum temperature	13		1,14	
Maximum temperature	13		1	
Rainfall		8	1	Adverse correlation between rainfall
Humidity	6,11,13,15,16	3,7,8,10	1,2,4,9,12,14	High humidity reduces the transmission of COVID-19
Wind speed	3,4,15	16,7,2		The number of cases increases as wind speed increases
Population density	2,3,4,11,15			Highest infection rates when there is much provincial movement

Note: The number in the table refers to article ID



attributable to COVID-19 and a link between temperature and the number of daily cases (Meo *et al.*, 2020). Temperatures ranged from 32°C on average to 38°C on occasion. The minimum temperature in Bangladesh ranges from 18°C (low) to 26°C (high) (Sharif & Dey, 2020). An increase in reported cases of COVID-19 during warm periods may indicate a viral origin for the illness. Many issues must be investigated, including virus resistance, population migration and population resilience. Although the virus can only replicate inside live cells, it can survive on the surface of an infected environment for some time, dependent on the temperature (Chan *et al.*, 2020).

Several investigations have shown a correlation between low temperatures and higher COVID-19 infection rates, which is true (Ujiiea *et al.*, 2020). According to Ujiiea *et al.* (2020), cold temperatures can increase the infectivity of COVID-19. High temperatures and humidity have been demonstrated to hinder influenza transmission (Lowen *et al.*, 2008; Shaman, 2009) and this finding supports these findings. Furthermore, low temperatures have been linked to COVID-19 coronavirus pathogenicity (Haque & Rahman, 2020). First, the influenza virus can survive in low temperatures better, and respiratory droplets are more likely to remain airborne in dry conditions (Lowen *et al.*, 2008). Second, cold and dry environments may impair hosts' immune systems, making them more vulnerable. Higher humidity also helps to keep nasal and pharyngeal mucous membranes moist, making it easier for them to trap debris, bacteria and viruses. Using data daily from the weather station, Shi *et al.* (2020) found an inverse relationship between COVID-19 transmission and temperature. On a global scale, it has been demonstrated that the transmission rate is significantly greater in certain places located inside subtropical nations with significantly lower average air temperatures (Poole, 2020). On the other hand, Xie and Zhu (2020) found no evidence of a drop in COVID-19 in warmer temperatures. Liu *et al.* (2020) discovered that between 20 January and 2 March 2020, temperatures and humidity are anticipated

to be lower in 130 Chinese cities, favouring COVID-19 transmission (except in Wuhan). Further research is needed to bridge the gap between these two variables.

The relationships between maximum and minimum temperature and total cases were studied. We also looked at how average, maximum, and lowest temperatures correlated with the number of instances in each group. A relationship was also found between three different temperatures and the total number of deaths in each city. The average temperature on the day of the cases was shown to have the greatest correlation value, followed by the average temperature seven days earlier, the highest temperature that day, and the lowest temperature that day (Tosepu *et al.*, 2020). The overall number of fatalities and the maximum temperature of the day had a strong association. The number of reported cases of COVID-19 and the number of fatalities is inversely related, suggesting that as temperatures decrease, so do the incidence and mortality rates associated with this virus.

Most research discovered a link between humidity and COVID-19 instances. Relative humidity is another essential meteorological factor connected to infectious diseases. The relative humidity in Bangladesh varies on average from 55% to 86% of the total available moisture (Sharif & Dey, 2020). The number of deaths was more closely related to the day's relative humidity than the number of cases. The correlation between the COVID-19 epidemic and relative humidity deteriorates over time. Previous research has discovered a substantial link between coronavirus infections and various climatic variables (Rabenau *et al.*, 2005; Sajadi *et al.*, 2020). Coronaviruses in droplet nuclei may be unable to survive at high temperatures (Chan *et al.*, 2011). According to laboratory and field investigations, coronavirus survival is drastically reduced at temperatures above 38°C (Rabenau *et al.*, 2005; Chan *et al.*, 2011). According to the findings of another study, the temperature and the relative humidity both significantly influence the  $r_s$  value of

COVID-19 cases in China (Wang *et al.*, 2021). The COVID-19 pandemic was strongly linked to temperature and humidity. In Singapore, relative humidity was shown to be modestly but statistically substantially linked with COVID-19 instances (Pani *et al.*, 2020). Relative humidity was minimal (80%) in the early transmission phases.

Several studies have pointed to a connection between low humidity and increased COVID-19 infection rates and these findings are consistent. In New York, the number of cases of COVID-19 has a positive correlation with temperature but a negative correlation with relative humidity (Bashir *et al.*, 2020). In Germany, the relative humidity of the air has a negative correlation with the death toll from COVID-19 (Biktasheva, 2020). Relative humidity was connected with the daily death rate in Wuhan, China whereas the daily temperature range was associated with COVID-19 daily mortality rate. Average humidity affects virus propagation more than relative humidity (Gupta *et al.*, 2020; Ma *et al.*, 2020). Influenza and SARS-CoV-1 viruses were discovered to have a strong association with humidity (Chan *et al.*, 2011). After adjusting for population migrations, the researchers showed that environmental conditions, specifically absolute humidity had a significant independent effect on COVID-19 transmission. Low humidity and moderate diurnal temperature changes facilitate transmission in the immediate environment (Liu *et al.*, 2020).

It has been shown that there is a positive correlation between the amounts of COVID-19 instances and wind speed (Sharif & Dey, 2020; Sahin, 2020; Coskun *et al.*, 2021). When the wind blows faster, the infection rate rises. The virus-containing droplet nuclei scatter quicker as the wind speed increases. Wind speeds ranged between 3 and 19 kilometres per hour in this investigation. The number of cases was most closely connected with the average wind speed for the day in this study. With increasing wind speed, the number of cases and fatalities increased (Sharif & Dey, 2020).

Furthermore, the results demonstrate that a 14-day time frame is the most reasonable, implying that wind speed during this period should be considered when computing the correct connection (Sahin, 2020). Furthermore, this study discovered that wind substantially contributes to virus propagation. Wind speed was discovered responsible for 9% of the variation in the distribution or number of instances investigated. Wind, according to this argument, plays only a little role. The viruses stay in the air, which could explain why this is happening (Wang & Du, 2020). If the virus enters the atmosphere, it is unknown how long it will remain before it dies. The main issue is that measuring in the air is challenging. This shows that the virus may be airborne for a brief period when wind moderately influences outbreak frequency. Windy conditions make it difficult to keep the virus at bay. Depending on the strength and direction of the wind, the virus COVID-19 can be transmitted (Coskun *et al.*, 2021). Another study found that WS has been related to COVID-19 instances in Oslo, Norway (Menebo, 2020) and New York, USA (Bashir *et al.*, 2020). According to some articles, infection rates are higher when the wind blows at a lower speed. It has been established that there is a significant anti-correlation between wind speed and the number of COVID-19 instances in Singapore (Pani *et al.*, 2020). The correlation between COVID-19 and wind speed was shown to have a negative connection in Iran (Ahmadi *et al.*, 2020). The wind has the potential to alter the dynamics of several diseases and vectors, making it a significant factor in infectious disease transmission (Ellwanger & Chies, 2018).

Higher population densities and mobility between provinces result in higher infection rates, with the disease reaching up to 150 persons per day in high-population-density regions. According to our findings, high COVID-19 instances are connected with high population density (Ahmadi *et al.*, 2020; Sahin, 2020; Rashed *et al.*, 2020; Coskun *et al.*, 2021). According to the findings of this study, these provinces should make every effort to limit inter-provincial mobility to reduce infection rates.

Regardless of the weather, the large incidence of COVID-19 cases in Jakarta is attributed partly to the high pace of migration. Job seekers from all over Indonesia travel to Jakarta, the country's capital, in search of work. The high human density in Jakarta makes COVID-19 transmission exceedingly rapid (Tosepu *et al.*, 2020). In Turkey, Sahin (2020) discovered a connection between a large population size and an elevated prevalence of COVID-19 cases ( $r_s = 0.687$ ). While the previous study only looked at the density of COVID-19 cases and fatalities, this new analysis found a greater correlation between the total population and the number of cases ( $r_s = 0.645$ ) and deaths ( $r_s = 0.578$ ).

We found an inverse relationship between the amount of rainfall and the number of COVID-19 occurrences (Gupta *et al.*, 2020). Menebo (2020) discovered an inverse link between the amount of precipitation and the number of COVID-19 cases in Osla, Norway which supports the previous research. Thus, COVID-19 instances were lower in rainy weather and higher in sunny weather (high global radiation). In the US, daily COVID-19 cases climbed between 1.27 and 1.74 inches and declined from 1.77 inches of precipitation (0.0001) (Chien & Chen, 2020). This study can inform future interdiction and vaccine programmes to understand better how weather affects COVID-19 transmission. This technique can detect high-risk behaviours and outbreak locations. Climate change, weather patterns and socio-ecological factors can help us comprehend new diseases and pandemics.

### Major Gaps

The study determined that environmental factors like humidity, temperature, precipitation, wind speed and population density were inadequate. It is necessary to examine the relationship between urbanisation and climate change to prevent an increase in COVID-19 cases. In the COVID-19 control system, this information will be crucial for local authorities.

### Conclusion

In conclusion, most papers highlight the connection between COVID-19 occurrence and environmental characteristics such as relative humidity, temperature, wind speed, precipitation and people density. This proven relationship may be useful in anticipating the COVID -19 outbreak. On the other hand, population density can provide environmental variables that increase the transmission rate of the COVID-19 virus and the prevalence of COVID-19 cases. One of the meteorological elements recommended as a variable for this investigation is wind speed. The association between COVID-19 cases and environmental factors such as humidity, precipitation, temperature, wind speed and population density should be investigated in further research in the future.

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