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# THE EFFECT OF CLIMATE CONDITIONS ON COVID-19: A MODELLING STUDY IN THE INDONESIAN EPICENTER

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***Abstrak***

*Over 200 countries have experienced a further increase in COVID-19 cases and this has been considered to be influenced by climatic conditions. The most vulnerable countries to this increase are those with low vaccination rates. This study aims to determine the influence of climate on COVID-19 cases in Indonesia. Furthermore, an ecological study design based on time conducted in Jakarta was used to obtain secondary data from March to September 2020. These data include maximum, minimum and average temperature, humidity, precipitation, maximum, and average wind speed, and solar radiation. The multiple linear regression test results showed that high humidity significantly affects the decrease in COVID-19 cases and 66.5% of the variations can be explained by this factor. For every 1% increase in humidity, there will be a decrease of 4 cases per week. However, the high humidity environment was reported to have the ability to suppress cases since transmission is still possible. Therefore, SARS-CoV-2 can still survive in humid conditions but in a relatively short time.*

***Kata Kunci:*** *Climate, COVID-19, Epicenter, Humidity*.



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## INTRODUCTION

The COVID-19 pandemic poses a significant threat to health systems globally (Abbas, 2021). Over 200 countries have witnessed a rise in infections, particularly in those with low immunization rates, such as Indonesia (Gugus Tugas Percepatan Penanganan COVID-19, 2021; Kementerian Kesehatan RI, 2021; Worldometer, 2024). The most recent data indicates a total of 6,747,363 confirmed cases and 161,027 deaths (CFR 2.4%) across all provinces, with Jakarta contributing to 1,547,000 cases (Dinas Kesehatan Provinsi DKI Jakarta, 2024). Globally, Indonesia was positioned 20th due to the comparatively high incidence of cases and placed 2nd in Southeast Asia (Worldometer, 2024).

Meteorological parameters are one of the important factors influencing infectious diseases, which are partly caused by viruses (Şahin, 2020). Climatic conditions are considered as the top predictors of respiratory diseases such as SARS (Yuan et al., 2006). Viruses can remain alive and infectious in the air for hours and on surfaces for days, therefore enabling the transmission of aerosols and fomites to the host (Smither et al., 2020; Van Doremalen et al., 2020). Furthermore, the variables that determine the viability and transmission of infectious diseases such as the SARS virus include optimal temperature, humidity, precipitation, wind speed, and sunlight (Ratnesar-Shumate et al., 2020; Sobral et al., 2020; Yuan et al., 2006).

Several studies showed that there is an influence of climate on COVID-19 cases. A study from Brazil conducted under tropical Brazilian temperatures with annual averages of 16.8°C-27.4°C showed a negative linear relationship between temperature and the number of cases. Furthermore, each 1°C increase in temperature was associated with a 4.9% decrease in daily cases (Prata et al., 2020). A study in India also concluded that there is a significant relationship with a positive correlation between temperature, humidity, and COVID-19 cases. This showed that the number of cases can be increased by increasing temperature and humidity (Sharma et al., 2020). Additionally, a study covering all countries affected by the pandemic showed a negative correlation between average temperature and the number of SARS-CoV-2 infection cases, and a positive correlation between precipitation and virus transmission (Sobral et al., 2020). Chen et al. (2020) also analyzed the relationship between meteorological parameters and the severity of COVID-19 spread on a global scale. Wind speed, temperature, and relative humidity were reported to be the effective factors causing the spread of the virus (Chen et al., 2020). Moreover, a recent study stated that sunlight is capable of inactivating SARS-CoV-2 on the surface. It showed that simulated sunlight rapidly inactivates viruses suspended in saliva or culture media and dried with stainless steel coupons. About 90% of infectious viruses were inactivated every 6.8 minutes and 14.3 minutes in saliva and culture media when exposed to simulated sunlight representing the summer solstice at latitude 40°NL at sea level on a clear day (Ratnesar-Shumate et al., 2020).

However, most studies showed that high temperatures and sunlight are able to reduce COVID-19 while increased humidity, precipitation, and wind speed tend to increase cases. A study in Norway showed that an increase in maximum and normal temperature increase cases while an increase in precipitation reduces cases (Menebo, 2020). Furthermore, a study conducted in Bangladesh showed that high humidity significantly reduce virus transmission (Haque & Rahman, 2020). In Rio de Janeiro, Brazil, a study concluded that wind speed has a negative correlation with the incidence of COVID-19. This is because high wind speeds suppresses the spread of the virus (Rosario et al., 2020). Similarly, a study conducted in India showed different results from the conclusions of many studies regarding the effect of Solar radiation on the inactivation of SARS-CoV-2 (Carvalho et al., 2021; Ratnesar-Shumate et al., 2020; Rendell et al., 2021; Sloanid et al., 2021). A significant relationship was obtained with a positive correlation between Solar radiation and COVID-19. Therefore, the Solar radiation and the number of cases are directly proportional to one another (Gupta et al., 2020).

Based on the explanation above, it is reasonable to conclude that climate is one of the top predictors of COVID-19 cases. It is important to analyze the effect of climate in Jakarta since it is the epicenter for the spread of the virus in Indonesia. Therefore, this study aims to investigate the relationship between climate factors, especially humidity, and weekly cases in Jakarta.

## METHODS

A time-based observational descriptive ecological study design and statistical techniques were adopted. Furthermore, daily COVID-19 case data for the period of March-September 2020 was obtained from the Jakarta Provincial Health Office website and can be accessed freely at the link https://corona.jakarta.go.id/id/data-pemantauan.
Climatic data such as maximum temperature ($^oC$), minimum temperature ($^oC$), average temperature ($^oC$), humidity (%), precipitation (mm), maximum wind speed (m/s), average wind speed (m/s), and Solar radiation (hours) were obtained from the Meteorology, Climatology and Geophysics Agency website. This site can be accessed after registering an account at the link https://dataonline.bmkg.go.id/home. These daily data were entered into Ms. Excel and converted into weekly data (31 weeks). The final result was used as the parent variable on the computer of all the input formats and was transferred to SPSS 21 software to perform a multiple linear regression

test.

The first stage is the selection of bivariate variables included in the initial modeling in the form of COVID-19 cases. In the next stage, the modeling was conducted using a multiple linear regression test. Meanwhile, climate factors that have fulfilled the p-value < 0.25 were the independent variable used Table 2 showed the multiple linear regression test results with $R^2 = 0.667$, which is the basis for building the final model. The final modeling was determined by gradually removing the variables with a p-value in the initial modeling > 0.05. The variables to be excluded are average temperature, precipitation, average wind speed, and Solar radiation. Furthermore, it is necessary to check $R^2$ to prevent significant changes from the initial model and check the B coefficient for each variable and keep the changes within the limit of 10%. The largest p-value, namely Solar radiation was the first variable excluded. Additionally, there was no significant change in $R^2$ (0.665), and the change in coefficient does not exceed 10%. The multiple linear regression test results in the following model equation are given as $y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + e$; where $y$ is COVID-19 cases, and $X_1$, $X_2$, $X_3$, and $X_4$ are the average temperature, humidity, precipitation, and weekly wind speed respectively.

## RESULTS AND DISCUSSION

Figure 1 showed an increased number of COVID-19 cases in the period of March-September 2020 from the 1st to the 28th week and was decreased from the 29th to the 31st week. The highest and lowest occurred in the 28th and 1st weeks of 8,825 and 4 cases, respectively. Furthermore, the temperature ranged from 25.42°C-33.85°C, where the highest and lowest maximum at the 26th and 1st week was 33.85°C and 31.53°C, respectively. The highest and lowest minimum temperatures at the 28th and 22nd weeks were 27.24°C and 25.42°C, respectively. Furthermore, the highest and lowest average temperatures at the 13th and 22nd weeks were 29.94°C and 28.25°C, respectively. The average humidity ranged from 66.93%-82.14%, where the highest and lowest were 82.14% and 66.93% in the 3rd and 22nd weeks respectively. Meanwhile, the average precipitation ranged from 0 mm-29.32 mm where the highest occurred in the 24th week of 29.32 mm and the lowest occurred at the 22nd, 23rd, 26th, 28th-30th weeks of 0 mm. Wind speed ranged from 1.43 m/s-6.07 m/s, and the highest maximum of 6.07 m/s occurred in the 1st week while the lowest of 4.5 m/s was in the 9th and 15th weeks. Moreover, the highest and lowest average wind speed of 2.75 m/s and 1.43 m/s occurred in the 29th and 4th weeks respectively. The average Solar Radiation ranged from 3.29-7.66 hours, and the highest and lowest of 7.66 hours and 3.29 hours occurred in the 26th and 9th weeks respectively.

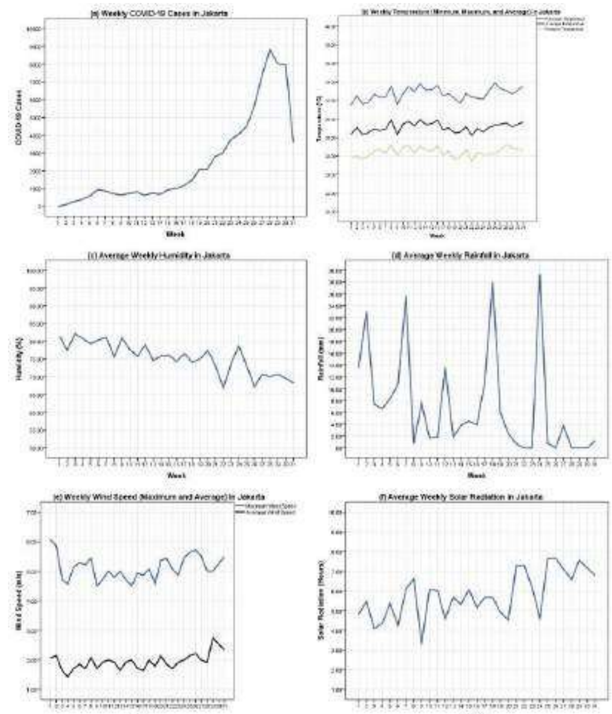


Figure 1. Climate Distribution (y axis) per week (x axis) which includes: (a) COVID-19 cases, (b) Temperature (°C), (c) Humidity (%), (d) Precipitation (mm), (e) Wind Speed (m/s), (f) Solar Radiation (Hours)

Table 1 showed the p-value of the correlation test results for each independent variable on the dependent. The included variables in the modeling of the multiple linear regression test are maximum temperature, minimum temperature, humidity, precipitation, average wind speed, and Solar radiation as shown in table 2.

Table 1. Significance Value (p-value) of Climate Factors on COVID-19 Cases

| Microclimate Factors | *p-value* |
|---|---|
| Minimum Temperature | 0.200 |
| Maximum Temperature | 0.076 |
| Average Temperature | 0.280 |
| Humidity | **0.000** |
| Precipitation | **0.001** |
| Maximum Wind Speed | 0.379 |
| Average Wind Speed | **0.002** |
| Solar Radiation | **0.000** |

Table 2 showed that the model's coefficient of determination is 0.665, meaning that the regression model obtained can explain 66.5% of the variation in COVID-19 cases. Furthermore, humidity is the only variable that significantly affects the cases. This is because every 1% increase decreases the cases by 4 after been controlled by average temperature, precipitation, and average wind speed.

The influence of climatic factors is comprehensively evaluated, encompassing temperature (maximum, minimum, and average), humidity, precipitation, wind speed (maximum and average), and solar radiation on COVID-19 cases. Most prior investigations utilized case and climate data from the same day. The case data does not

Table 2. Multiple Linear Regression Model for the Effect of Humidity on COVID-19 Cases

| | | | | Model | Non-Standardized Coefficient | Standardized Coefficient | |
|---|---|---|---|---|---|---|---|
| | B | SE | Beta | | | Lower | Upper |
| Constant | 508.530 | 224.091 | | 2.269 | 0.032 | 47.006 | 970.055 |
| Average Temperature | -9.609 | 6.642 | -0.191 | -1.447 | 0.160 | -23.289 | 4.071 |
| Humidity | -3.635 | 1.288 | -0.632 | -2.823 | 0.009 | -6.288 | -0.983 |
| Precipitation | -1.185 | 2.448 | -0.078 | -0.484 | 0.633 | -7.912 | 3.856 |
| Average Wind Speed | 58.715 | 35.728 | 0.226 | 1.643 | 0.113 | -6.226 | 132.298 |
| Solar Radiation | 1.523 | 4.581 | 0.072 | 0.332 | 0.742 | -14.869 | 10.958 |
| Model 1: $R^2$ = 0.667, F = 10.003, p < 0.05 | | | | | | | |
| Constant | 519.263 | 217.927 | | 2.383 | 0.025 | 71.307 | 967.219 |
| Average Temperature | -9.113 | 6.361 | -0.181 | -1.433 | 0.164 | -22.187 | 3.962 |
| Humidity | -3.899 | 0.997 | -0.678 | -3.909 | 0.001 | -5.949 | -1.849 |
| Precipitation | -1.269 | 2.392 | -0.084 | -0.530 | 0.600 | -6.187 | 3.649 |
| Average Wind Speed | 61.388 | 34.211 | 0.236 | 1.794 | 0.084 | -8.934 | 131.710 |
| Model 2 (Solar Radiation is excluded): $R^2$ = 0.665, F = 12.918, p < 0.05 | | | | | | | |

indicate the date of infection, as there is a latency period before symptoms manifest following transmission. The necessary duration for tracing and testing must also be taken into account, as it is exceedingly challenging to determine the precise date of a patient's initial COVID-19 infection. Daily COVID-19 case and climatic data ought to be aggregated weekly to reduce potential bias. This is predicated on the usual incubation time, characterized by symptom onset, of approximately 5-6 days, with a maximum duration of 14 days (Kementerian Kesehatan Republik Indonesia, 2020).

Humidity was the sole variable exhibiting a significant correlation with COVID-19 instances, accounting for 66.5% of the difference in cases. For each 1% increase, there will be a reduction of four cases every week. This finding aligns with other prior research indicating that elevated humidity can diminish the transmission of COVID-19 by affecting host and agent conditions (Haque & Rahman, 2020; Liu et al., 2020; Meo et al., 2020). Moreover, SARS-CoV-2 has greater stability at low (Biryukov et al., 2020) and intermediate (Smither et al., 2020) relative humidity levels, in contrast to elevated relative humidity, which might diminish virus vitality and expedite the decay process (Biryukov et al., 2020; Wang et al., 2021). Increased humidity contributes to the prevention of different illnesses in the host, including COVID-19. This is accomplished by maintaining moisture in the nasal and pharyngeal membranes to obstruct the entry of debris, bacteria, and viruses into the lungs (Haque & Rahman, 2020). In contrast, cold and arid conditions might diminish the host's immune response, rendering it more vulnerable to viruses (Kudo et al., 2019). No significant correlation was identified among temperature, precipitation, wind speed, and solar radiation.

Additional findings indicated that around 88% of cases in Jakarta transpired under high humidity (68-88%), (Smither et al., 2020) which should be detrimental to the survival of SARS-CoV-2. In a high-humidity environment, SARS-CoV-2 can persist with a half-life of 8.3 hours, which is shorter than its half-life of 15.3 hours in low humidity. The prolonged persistence of SARS-CoV-2 on surfaces or in the air can significantly elevate the risk of transmission to those who are not adhering to health measures. This may happen as around 26.46% of individuals still fail to adequately execute health protocols during outdoor activities (Badan Pusat Statistik, 2020). Individuals are urged to thoroughly cleanse their hands with soap, don masks, and maintain physical distance. Moreover, restrictions on communal activities can be implemented to minimize transmission to the fullest extent.

Certain limitations that may influence these results should be acknowledged. Further study was not performed because to the lack of data on COVID-19 cases and climate in smaller regions (sub-districts and administrative areas). The comprehensiveness of the climate factor variables has been evaluated in the multiple linear regression model. Other significant factors, including population size, density, mobility, immunity, and behaviors (such as handwashing, mask-wearing, and physical separation), were considered, while the characteristics of the virus were excluded. Moreover, analyses were not conducted considering time lag, so the most significant correlation between climate and COVID-19 cases within the same week, as well as one and two weeks thereafter, was not established. A comparison investigation of the correlation between climate and weekly, biweekly, and monthly case counts should be undertaken to identify the most relevant timeframe. This pertains to various factors, including the incubation period of 14 days and the uncertain interval between the original and proven infection dates. Consequently, additional research must be undertaken to thoroughly examine these aspects.

## CONCLUSION

The findings indicate that a high-humidity conditions can reduce COVID-19 cases, with each 1% increase correlating to a decrease of 4 cases per week. Nonetheless, transmission remains feasible as SARS-CoV-2 can endure in humid environments for a limited duration. Consequently, health protocols like handwashing with soap, mask-wearing, and physical separation should be diligently implemented. Restrictions on communal activities are also seen essential for minimizing transmission to the fullest extent.

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