Jurnal Kesehatan Lingkungan
Journal of Environmental Health
Vol. 15 No. 3
DOI: 10.20473/jkl.v15i3.2023.174-182
ISSN: 1829 - 7285 | E-ISSN: 2040 - 881X
Journal Home Page: https://e-journal.unair.ac.id/JKL
ORIGINAL RESEARCH Open Access

# CORRELATION BETWEEN CLIMATE VARIATIONS AND ROTAVIRUS DIARRHEA IN UNDER-FIVE CHILDREN IN SIDOARJO DISTRICT YEAR 2016 - 2019

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***Article Info***
Submitted : 30 April 2023
In reviewed : 18 May 2023
Accepted : 20 July 2023
Available Online : 31 July 2023

***Keywords :*** *Climate, Diarrhea, Rotavirus, Toddlers*

***Published by*** *Faculty of Public Health Universitas Airlangga*

## *Abstract*

***Introduction:*** *Rotavirus infection is one of the main causes of severe diarrhea and dehydration in toddlers. Climate variation is one of the factors that influence the outbreak of infectious diseases. This study aimed to clarify the relationship between climate variations and the incidence of rotavirus diarrhea among patients at the Soerya Mother and Child Hospital, Sidoarjo District in 2016 – 2019.* ***Methods:*** *This study used an ecological study with the Pearson correlation test. Rotavirus infection data was taken from the Viral Diarrhea Laboratory, Institute of Tropical Diseases, Universitas Airlangga, which was derived from fecal samples of patients with acute gastroenteritis with the unit of analysis at the individual level living in Sidoarjo district. Meanwhile, climate variation data were obtained from the Meteorology, Climatology, and Geophysics Agency Indonesia official website with units of analysis at the population level.* ***Results and Discussion:*** *The number of rotavirus diarrhea for 48 months as many as 149 cases with an average air temperature of 28.2°C, rainfall of 191.4 mm², humidity of 77.31%, and wind speed of 2.82 knots. There was a weak correlation between rainfall and the incidence of rotavirus diarrhea (p=0.01 r=0.367) and a weak correlation with humidity (p=0.016; r=0.347). Meanwhile, the air temperature (p=0.909 r=0.017) and wind speed (p=0.272 r=-0.162) had no relationship with the incidence.* ***Conclusion:*** *Rainfall and high humidity are factors associated with the prevalence of rotavirus diarrhea in children under-five years in the Sidoarjo District.*

## INTRODUCTION

One of the leading causes of morbidity and mortality in children globally, particularly in low- and middle-income nations, is diarrhea (1). Diarrhea caused the death of more than 500,000 children under the age of five worldwide in 2017, with South Asia and sub-Saharan Africa accounting for 88% of those deaths (2). In Indonesia, diarrhea is an endemic disease with the potential for extraordinary events which result in death. Diarrhea is defecation with more frequency than usual (>3 times a day) with more liquid stool consistency, except for neonates (infants <1 month) who only get breast milk is considered normal if the frequency of bowel movements is 5-6 times a day with good consistency (3). The prevalence of diarrhea in Indonesia in 2018 was quite high, namely 37.88% or around 1,516,438 cases in toddlers, and continued to increase in 2019 to 40% or around 1,591,944 cases in toddlers (4). In addition, the toddler group is the largest contributor to diarrhea, consisting of 11.4% or around 47,764 cases in males and 10.5% or around 45,855 cases in females (3).

Gastritis-related diarrhea is a serious health problem because it contributes significantly to death (5). Viruses are the most common pathogens that cause

***Cite this as :***
Amanda SV, Yamani LN, Dinana Z, Maharani AT, Astutik E, Noerfitri N. Correlation Between Climate Variations and Rotavirus Diarrhea in Under-Five Children in Sidoarjo District Year 2016 – 2019. *Jurnal Kesehatan Lingkungan*. 2023;15(3):174–182. https://doi.org/10.20473/jkl.v15i3.2023.174-182

acute diarrhea in children, with the highest prevalence at the age of 3 to 24 months because their immunity is still weak (6). The viruses astrovirus, adenovirus, Rotavirus A, and norovirus cause diarrhea in viral gastroenteritis (7). Rotavirus A infection has a high prevalence throughout the world which occurs all year round in tropical and temperate climates which have drier, hotter, and more humid air temperatures (5). Research on diarrhea in Southeast Asia from 2008 – 2018 reported that 40.78% of diarrhea was caused by rotavirus infection (8). Rotavirus infection is still the main cause of diarrhea in children in developing countries, including Indonesia (9). Even so, rotavirus vaccines with high efficacy (85 – 90%) have been found worldwide. In nations where rotavirus vaccination is mandatory, the number of rotavirus-related mortality has considerably decreased (10). The national immunization program in Indonesia does not contain the rotavirus vaccinations (Rotarix and RotaTeq), hence vaccination rates are still quite low (11). Because of that, the high infection rate of Rotavirus A is still a public health burden in Indonesia that must be evaluated systematically (11).

According to the National Basic Health Research of 2018 report, the prevalence of diarrhea cases in East Java Province is the second highest in Indonesia with a prevalence of 7.61% or as many as 151,878 people (3). Based on the Sidoarjo District Health Profile, in 2018 diarrhea was the disease with the sixth highest morbidity rate with a total of 45,213 cases (12). Meanwhile, the latest data from Sidoarjo District Health Profile diarrhea in children under five occurred in 38,724 cases in 2021 and then decreased in 2022 with incidents of 20,255 cases (13). Nevertheless, efforts are needed to reduce the morbidity and mortality of diarrhea in Sidoarjo District, with proper prevention and treatment.

Rotavirus diarrhea is a contagious infectious disease that is influenced by many factors. Recent advancements in lowering worldwide mortality from diarrheal disease among children are under concern due to climate change (14). In Indonesia, climatic factors are thought to have contributed to an increase in the incidence of diarrheal diseases, especially in toddlers, as a vulnerable group that can cause death (15). The impact of climate change is predicted to considerably raise the number of deaths (15). Several studies report that four diseases closely related to climate change must be of particular concern, namely acute respiratory infections (ARI), diarrhea, malnutrition, and malaria (16). Climate change can cause drought and water pollution which are positively correlated with the incidence of diarrhea (17). The likelihood of getting rotavirus infection seems to be increasing in chilly, dry conditions in temperate and tropical countries, according to the correlation between monthly rotavirus diarrhea incidence and climatic factors such as rainfall, temperature, relative humidity, and wind speed (18). On the other hand, in tropical areas, rotavirus epidemic peaks frequently coincide with the monsoon season. Previous research in East India reported that there was a positive relationship between the highest and lowest temperature, average rainfall, and average humidity, and the prevalence of rotavirus (19). Another study among children in Kathmandu, Nepal found a substantial correlation between the average monthly rainfall and the prevalence of diarrhea, with an estimated 0.9% rise in the prevalence of diarrhea for every 10 mm more rain in the same month (20). However, a study in Cheonan, Korea reported that only relative humidity was significantly associated with monthly cases of rotavirus (21). Therefore, this study was conducted to examine the association between climate variations (rainfall, air temperature, humidity, and wind speed) with the prevalence of diarrhea due to rotavirus in Sidoarjo District, in 2016-2019. The research hypothesis is that there is a relationship between climate variations (rainfall, air temperature, humidity, and wind speed) with the incidence of rotavirus diarrhea in the Sidoarjo district in 2016 – 2019.

## METHODS

An ecological time trend study had been used in this research. This study's observation period was 48 months, from 2016 – 2019. The data analyzed was monthly secondary data from the Viral Diarrhea Laboratory, Institute of Tropical Diseases, Universitas Airlangga, which had obtained informed consent and ethical approval to obtain stool samples from acute gastroenteritis patients with analysis units at the individual level domiciled in Sidoarjo who were being treated at Soerya Mother and Child Hospital, Sidoarjo District in January 2016 - December 2019. The data used were all patients diagnosed with acute diarrhea with positive rotavirus laboratory results of 149 samples. Acute gastroenteritis in a patient was defined as the occurrence of 3 bowel movements per day with stool consistency that was more watery than usual and lasted less than 14 days (22). Stool samples were obtained from patients registered at Soerya Mother and Child Hospital within 24 hours and stored at -80°C at the Viral Diarrhea Laboratory, Institute of Tropical Diseases, Universitas Airlangga which were then tested using the conventional PCR method. Polymerase Chain Reaction (PCR) is an in vitro DNA synthesis and amplification technique that can amplify DNA segments millions of times in just a few hours. In order to identify the presence of viral DNA,

traditional PCR was used to observe the results of DNA amplification on an agarose gel following electrophoresis. As for climate variation data such as relative humidity, rainfall, air temperature, and wind speed are obtained every month from the official website of the Meteorology, Climatology and Geophysics Agency. Univariate analysis was performed to determine the description of the distribution, average, and standard deviation of each variable. Meanwhile, bivariate analysis was carried out to determine the relationship between variables using the Pearson correlation test, because all variables were normally distributed with a value (p> 0.05). Variables were said to be significant and related if (p <0.05), which means the correlation coefficient was positive or had the opposite relationship if the correlation coefficient was negative.

## RESULTS

### Normality Test

The Kolmogorov-Smirnov test was employed as the normality test in this research, with an interpretation of the p-value > 0.05 the data was normally distributed. Based on the test results, all variables were normally distributed with a p-value for the temperature variable = 0.194 (p>0.05), rainfall = 0.913 (p>0.05), humidity = 0.773 (p>0.05), and wind speed = 0.647 (p>0.05).

### Univariate Analysis: Description of the Incidence of Rotavirus Diarrhea, Rainfall, Air Temperature, Humidity, and Wind Speed in Sidoarjo District in 2016 – 2019

Table 1 shows that in 48 months the number of cases of rotavirus diarrhea was 149 patients with an average of 3 patients each month (standard deviation 2.37). Then, based on Figure 1, it can be seen that cases of rotavirus diarrhea during 2016 - 2019 fluctuated greatly, with the highest incident occurring in January 2019, namely 10 cases, and the lowest cases of rotavirus diarrhea, namely 0 cases occurring in 2017, July, August, September, and 2018 in April, May, November, December, and 2019 in July and September.

**Table 1. Univariate Analysis of the Prevalence of Rotavirus Diarrhea, Rainfall, Air Temperature, Humidity, and Wind Speed in Sidoarjo District in 2016 – 2019**

| Variable | Amount (month) | Max | Min | Average | Standard Deviation |
|---|---|---|---|---|---|
| Prevalence of Rotavirus Diarrhea | 48 | 10 | 0 | 3 | 2.37 |
| Air Temperature | 48 | 34.02℃ | 22.91℃ | 28.2℃ | 0.61 |
| Rainfall | 48 | 534.3 mm² | 3.3 mm² | 191.4 mm² | 140.1 |
| Humidity | 48 | 82.58% | 69.74% | 77.3% | 3.53 |
| Wind Speed | 48 | 8.129 knot | 2.13 knot | 2.82 knot | 0.37 |

Then, the air temperature has an average of 28.2℃ with a standard deviation of 0.61. Based on Figure 2 it can be seen that the highest temperature in 4 years occurred in November 2019 with a temperature of 34.02℃, while the lowest temperature was in July 2019 with a temperature of 22.91℃. Then, the average temperature for 48 months (2016 – 2019) was 28.2℃, with an average maximum value of 29.5℃ in November 2019, and an average minimum value of 26.9℃ in July 2019. Furthermore, rainfall had an average of 191.4 mm² with a standard deviation of 140.1. Based on Figure 3, the month with the highest average rainfall was January 2019 with a rainfall of 534.3 mm². Meanwhile, the lowest average rainfall occurred in August 2017 with 3.3 mm² rainfall. Then, humidity had an average of 77.3% with a standard deviation of 3.53. Based on Figure 4 it is known that the highest average humidity occurred in January 2017 with a humidity level of 82.58%. Meanwhile, the lowest average humidity occurred in October 2018 with a humidity level of 69.74%. Based on Figure 5, the windiest month was January 2018, when it gusted to a speed of 8.12 knots. Then, the average wind speed for 48 months (2016 – 2019) is 2.82 knots, with an average maximum value of 3.71 knots in January 2018, and an average minimum value of 2.19 knots in March 2016.

**Bivariate Analysis: Correlation Between Climate Variations and Rotavirus Diarrhea in Children under 5 Years in Sidoarjo District Year 2016 - 2019**

According to Table 2, the temperature variable showed a p-value of 0.909 > 0.05, indicating that there was no significant correlation between temperature and the incidence of rotavirus diarrhea. Then, the results of the rainfall variable test yielded a p-value of 0.01 < 0.05, which means that there was a relationship with the incidence of rotavirus diarrhea and had a positive r-value of 0.367. A positive r value of 0.367 means that the more rainfall increased, the more rotavirus diarrhea occurred and vice versa. Furthermore, the humidity variable produced a p-value of 0.016 < 0.05, which means that there was a relationship with the incidence of rotavirus diarrhea and had a positive r-value of 0.347. The r value of 0.347 means that humidity had a weak correlation with the incidence of rotavirus, whereas the humidity increased, the incidence of rotavirus diarrhea also increased and vice versa. Then, the variable wind speed produced a p-value of 0.272 > 0.05, indicating no significant correlation between wind speed and the incidence of rotavirus diarrhea.

**Table 2. Bivariate Analysis of the Correlation Between Climate Variations and Rotavirus Diarrhea in Children under 5 Years in Sidoarjo District Year 2016 – 2019**

| Variable | Prevalence of Rotavirus Diarrhea | | |
|---|---|---|---|
| | p-value (sig 2-tailed) | Correlation Coefficient (r) | Explanation |
| Air Temperature | 0.909 | 0.017 | No Correlation |
| Rainfall | 0.01 | 0.367 | Weak Correlation |
| Humidity | 0.016 | 0.347 | Weak Correlation |
| Wind Speed | 0.272 | -0.162 | No Correlation |

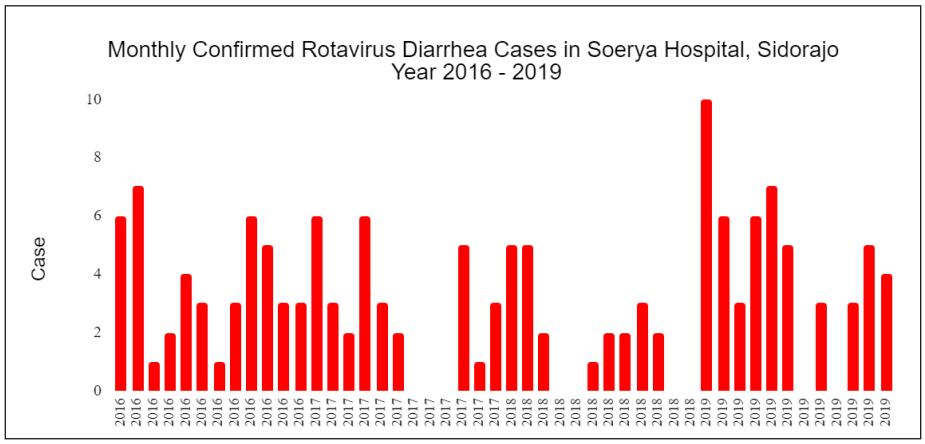


**Figure 1. Monthly Confirmed Rotavirus Diarrhea Cases in Soerya Hospital, Sidoarjo Year 2016 – 2019**

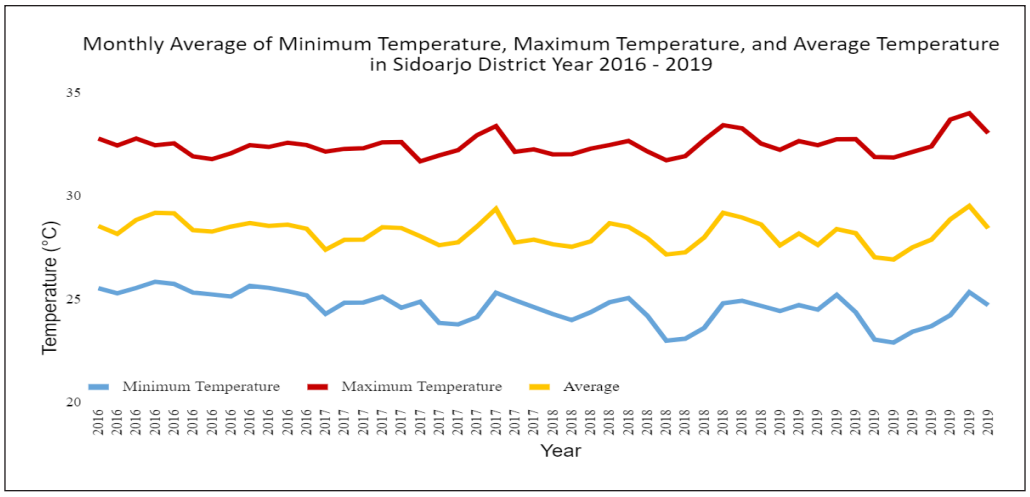


**Figure 2. Monthly Average of Minimum Temperature, Maximum Temperature, and Average Temperature in Sidoarjo District Year 2016 – 2019**

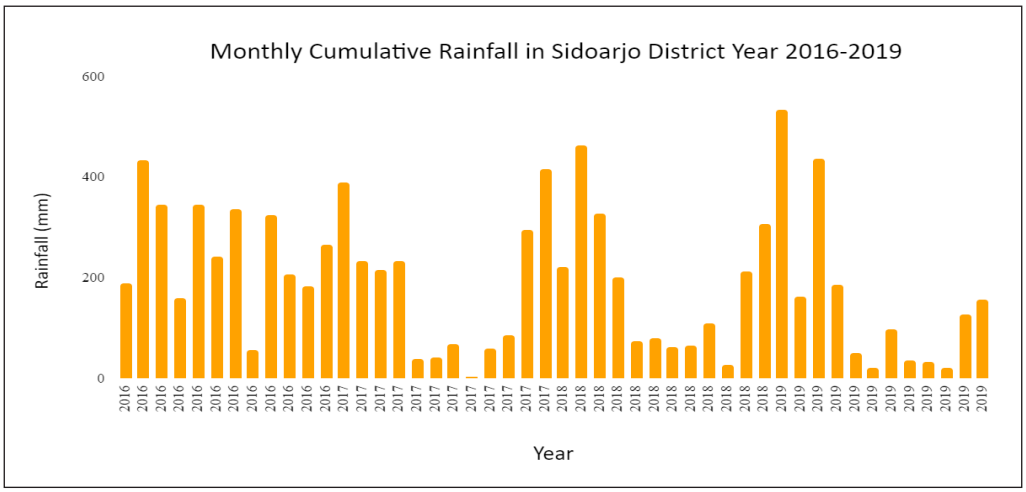


**Figure 3. Monthly Cumulative Rainfall in Sidoarjo District Year 2016 – 2019**

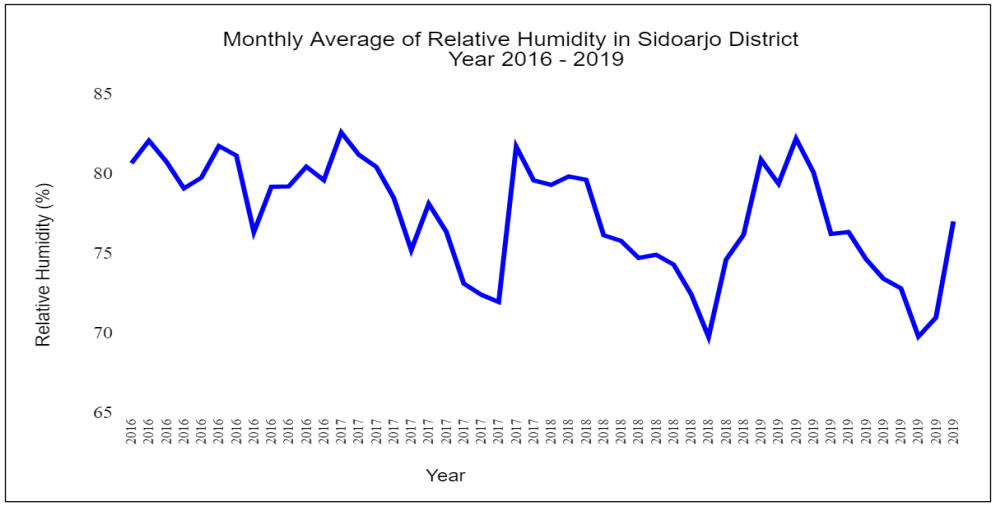


**Figure 4. Monthly Average of Relative Humidity in Sidoarjo District Year 2016 – 2019**

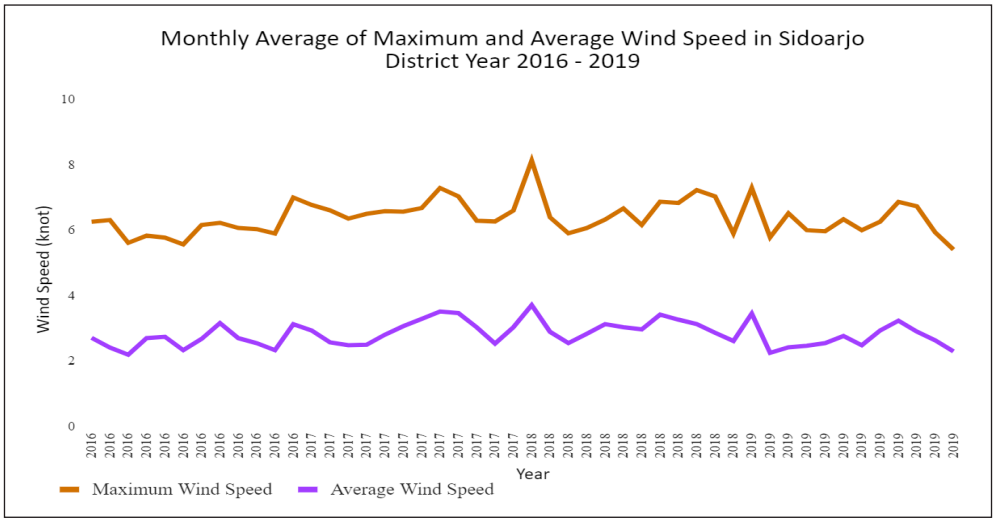


**Figure 5. Monthly of Maximum and Minimum Wind Speed in Sidoarjo District Year 2016 – 2019**

## DISCUSSION

Interpreting the outcomes of the Pearson correlation analysis test, it was known that the climate variables associated with the prevalence of rotavirus diarrhea in children under five years in Sidoarjo district in 2016 - 2019 were rainfall and humidity. The number of rotavirus diarrhea cases from stool examination in acute gastroenteritis patients at Soerya Mother and Child Hospital, Sidoarjo District increased and decreased from January to December every year from 2016 to 2019. As seen in Figure 1, the incidence of rotavirus diarrhea tended to peak at the start of the year, then dropped over the middle of the year before rising again towards the end. From January to November of 2016, there was a considerable spike and reduction in instances. In 2017, the graph of the incidence of rotavirus diarrhea decreased significantly to 0 cases from July to September. Then, in 2018, the highest cases of rotavirus diarrhea occurred at the beginning of the year, namely January and February, which decreased drastically to 0 cases in April, May, November, and December. Meanwhile, in 2019, the incidence of rotavirus diarrhea increased to 10 cases in January which was also the highest incidence for four years in the 2016-2019 period. The fluctuating cases of rotavirus diarrhea were caused by pathogenic microorganisms that were sensitive to climate change and variability, especially in extreme weather that has an impact on changes in environmental conditions such as water, clean air, food, shelter, and security (23).

In Figure 2, it can be seen that the highest temperature in 4 years occurred in November 2019 with a temperature of 34.02℃, while the lowest temperature was in July 2019 with a temperature of 22.91℃. The average temperature for 48 months (2016 – 2019) was 28.2℃, with an average maximum value of 29.5℃ in November 2019, and an average minimum value of 26.9℃ in July 2019. Then, the findings of the test for a relationship between air temperature and the occurrence of rotavirus diarrhea revealed that there was no significant relationship between air temperature and the incidence of rotavirus diarrhea that occurred in Sidoarjo Regency in 2016 - 2019 with a value of p = 0.909. A study carried out in East Jakarta revealed the same result in 2015-2019 which showed that found there was no significant relationship between air temperature and the incidence of diarrhea (p=0.732) (24). However, the results of this study were not consistent with Afghanistan research that found a strong correlation between air temperature and the incidence of diarrhea, where every 1℃ increase caused an increase in the relative risk of diarrhea by 0.7% (18). According to the study, higher air temperatures lead to drier weather which is associated with increased survival of viral and bacterial pathogens (17). According to a different study among the children under the age of 5 living in Kathmandu, Nepal, each 1°C increase in temperature over the monthly average recorded for the month leads to an 8.1% increase in diarrheal illnesses (20).

The following research findings in Figure 3 illustrate that the monthly rainfall intensity increased and decreased significantly during 2016 – 2019. The average monthly rainfall in Sidoarjo Regency was 191.4 mm²/month. The month with the highest average rainfall was January 2019 with 534.3 mm², while August 2017 had the lowest monthly average rainfall at 3.3 mm². The correlation test findings in Table 3 show that there was a significant correlation between rainfall and the incidence of rotavirus diarrhea that occurred in Sidoarjo Regency in 2016 - 2019 with a value of p = 0.01. The correlation between rainfall and the incidence of rotavirus diarrhea indicated a weak relationship (r = 0.367) and had a positive pattern, which means that if there was an increase in rainfall, there will also be an increase in the incidence of rotavirus diarrhea and vice versa. This finding in line with previous studies in Dhaka, Nepal which reported that there was an increase in the incidence of diarrhea by 0.9% for every 10 mm increase in rainfall in the same month (20). In addition, this study is also in line with research conducted in Bangladesh and Mozambique which found that there was an increase in diarrhea by 5.1% and 1.04% for 4 weeks during heavy rainfall (25). However, this study is not in line with research conducted in Bangui, the capital of the Central African Republic where the results of the study stated that low rainfall is associated with an increase in rotavirus cases (26). There are multiple factors that contribute to the incidence of diarrhea rather than just one, there was a discrepancy in the findings of this study. One of the causes of diarrhea is the availability of clean water, where rainfall directly or indirectly affects the quantity and quality of clean water. Heavy rain can cause water supplies to be contaminated as a result of the entry of disease-carrying agents through the rainwater medium accompanied by poor sanitation (23). In addition, high rainfall has the potential to cause flooding which results in contamination of the residents' clean water facilities (27).

Then, the humidity variable shown in Figure 4 can be seen that the humidity level in Sidoarjo Regency was very fluctuating, with the highest average humidity occurring in January 2017 with a humidity level of 82.58%. Meanwhile, the lowest average humidity occurred in October 2018 with a humidity level of 69.74%. The results of the correlation test revealed that there was a significant correlation between humidity

and the incidence of rotavirus diarrhea that occurred in Sidoarjo Regency in 2016 – 2019 with a p = 0.016. The relationship between humidity and the incidence of rotavirus diarrhea showed a weak relationship (r = 0.347) and had a positive pattern, which means that if there was an increase in humidity, there will also be an increase in the incidence of rotavirus diarrhea and vice versa. High humidity in the rainy season accompanied by a lack of sunlight causes microorganisms that caused diarrhea to reproduce well and faster for vectors such as rats, cockroaches, and flies. In addition, the environment's temperature and humidity can impact the virus's ability to survive, which in turn can impact how quickly an infection spreads (28). The results of this study were also supported by research conducted in Bangladesh which reported that high humidity correlated with the number of cases of diarrhea in toddlers with a p-value = 0.0001 (29). In addition, a study conducted at Dankook University Hospital in Cheonan, Korea that included 4009 patients with gastrointestinal illnesses resulted in similar research findings also showed that humidity was significantly correlated with Rotavirus A infection with a p-value = 0.02 (21). However, this study does not support previous studies among groups aged 0 – 5 years in Jiangsu, China which reported that rotavirus-positive cases were significantly related to relative humidity (30). The study found that among children 0 to 5 years old, the risk of illness increased when the relative humidity ranged between 67 and 78% and fell when it was either too high or too low. In line with other research, the GAM model indicated an increased risk of disease between 67 and 78% relative humidity (31). A favorable relative humidity encourages the development of pathogens and airborne transmission (30).

The results of the subsequent analysis in Figure 5 show that the wind speed level fluctuated greatly, increasing and decreasing throughout 2016 – 2019. The highest wind speed occurred in April 2018, with a wind speed of 8.13 knots, while the lowest wind speed occurred in March 2016 with a wind speed of 2.13 knots. The average wind speed for 48 months (2016 – 2019) was 2.82 knots, with an average maximum value of 3.71 knots occurring in January 2018, and an average minimum value of 2.13 knots occurring in March 2016. Then, the results of the correlation test between wind speed and the incidence of rotavirus diarrhea yielded a p-value = 0.272, which refers to the fact that there was no significant correlation between wind speed and the incidence of rotavirus diarrhea that occurred in Sidoarjo District in 2016 – 2019. The results of this study are supported by the results of research in Iran which found that there was no significant relationship between wind speed and rotavirus diarrhea in children under the age of five (32). In addition, the findings of this research align with studies done in Guangzhou, China which found a significant correlation between the incidence of infectious diarrhea and all meteorological factors except wind speed (33). However, the results of this study were not in line with a study conducted on acute diarrhea patients in 217 Chinese hospitals which reported that Rotavirus A, B, and C had a positive relationship with low wind speed (1). According to the study, high levels of wind speed can reduce the detection rate of the virus because transmission of rotavirus increases when aerosols can persist in slower moving air and are hindered by stronger winds that carry particles away from vulnerable individuals (34).

This research has several limitations. First, this study design is retrospective in nature, in which researchers lack important individual patient information including the exact home address, as well as other factors that are closely related to the incidence of viral infection such as socioeconomic status, water supply, and population density conditions (18). The results of the research can be useful for informing the design of an early warning system, prediction, and control of diarrhea in children under five years in Sidoarjo District based on the variations in climate patterns observed. The researcher believes that this study can serve as a resource for future researchers who will conduct relevant studies. Using daily or weekly data, additional research can be conducted in order to obtain more satisfying and fruitful results.

## ACKNOWLEDGMENTS

Lecturers from the Faculty of Public Health at Universitas Airlangga, and members of the research staff at the Laboratory of Viral Diarrhea, Institute of Tropical Diseases, Universitas Airlangga assisted in the completion of this research.

## CONCLUSION

Interpreting the results of the study, it can be concluded that rotavirus infection in acute gastroenteritis patients at Soerya Mother and Child Hospital has increased and decreased from January to December each year, with the results of the analysis that rotavirus infection has a positive correlation with rainfall (p = 0.01; r = 0.367) and humidity (p = 0.016; r = 0.347) variables. Meanwhile, the air temperature (p = 0.909; r = 0.017) and wind speed (p = 0.272; r = -0.162) variable has no relationship with the incidence of rotavirus infection.

Furthermore, Inadequate water availability, human immunity, social economic, and cultural factors can all have a direct impact on the prevalence of diarrhea. Besides that, due to poor human behavior, especially the cleanliness of dishes and washing hands before meals, diarrhea-causing organisms can be transmitted from dishes and unclean hands, contaminating the human body and causing diarrhea. It is necessary to improve health promotion activities in order to increase people's preventive behavior in order to reduce the incidence of rotavirus diarrhea, particularly through vaccination. Rotavirus vaccination is the most effective way to prevent rotavirus disease. Both monovalent and pentavalent rotavirus vaccines should be made available by the government for use in Indonesia's national immunization program. Therefore, it is essential to manage diarrhea in an integrated and focused way, including by making an effort to prevent, detect, and respond.

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