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The Relationship Between Climate Factors and Vector Density with the Incidence of Dengue Hemorrhagic Fever in East Jakarta

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ABSTRACT

Background: *Dengue fever is a vector-borne disease. The high incidence of DHF in an area is influenced by living things (vector density) and non-living things (air temperature, climate, humidity, and rainfall). The purpose of the study was to determine the relationship between air temperature, climate, vector density, rainfall, humidity, and the incidence of DHF in East Jakarta in 2022.*
Methods: *This research was an observational ecological study. This research was conducted in Cakung and Pasar Rebo sub-districts, East Jakarta. Secondary data sources were from the VBPP laboratory, BBTKL PP Jakarta, and BMKG Indonesia.*
Results: *The results showed that the container index (CI) correlated with the incidence of DHF (r = 0.118, p = 0.001), as well as the number of ownership-positive containers for larvae correlated with the incidence of DHF (r = 0.113, p = 0.001). Meanwhile, the variables of temperature, humidity, and the free number of larvae did not correlate with the incidence of DHF.*
Conclusion: *It is expected that the community actively drains regularly and closes water storage containers at home.*

INTRODUCTION

According to a 2019 report by the World Health Organization (WHO), outbreaks of dengue hemorrhagic fever (DHF) occurred in over 100 countries across the Americas, Southeast Asia, the Western Pacific, Africa, and the Eastern Mediterranean. Southeast Asia accounted for the highest proportion (70%)[1], followed by the Western Pacific and the Americas. DHF is prevalent in tropical and subtropical regions [1]. In 2020, Indonesia reported 108,303 cases of DHF with 747 deaths, a case fatality rate (CFR) of 0.7%, and an incidence rate (IR) of 40 per 100,000 population. A province is considered to have a high CFR if the rate exceeds 1% [2]. In 2020, Jakarta reported 4,760 cases with an almost equal proportion of male and female cases [3].

The Aedes aegypti mosquito is the primary vector and Aedes albopictus is the secondary vector responsible for transmitting the dengue virus [4]. This virus causes infections such as DHF, yellow fever, Zika, and chikungunya. The occurrence of DHF is influenced by climatic, environmental, and social factors [1,5].

A 2018 study conducted in the working area of Gunung Anyar Public Health Center, Surabaya, East Java, showed that rainfall and humidity had a significant relationship with DHF incidence. The climate, which supports the increase of dengue-carrying mosquitoes, led the Gunung Anyar community to be more alert during peak transmission seasons by conducting mosquito breeding site eradication at home and in the surrounding environment [6]. A 2021 study also confirmed that climate variability has a significant relationship with DHF [7].

Statistical analysis indicates that humidity and rainfall have a moderate and positive relationship with DHF, while temperature has a strong but negative relationship with DHF. A study in Yogyakarta in 2021 showed that humidity, rainfall, and the number of rainy days were positively correlated with DHF, but temperature was not [8]. Another factor associated with DHF is vector density, which includes adult mosquitoes and larval density. Larvae density is measured using the Larvae-Free Index (LFI), Container Index (CI), House Index (HI), and Breteau Index (BI) [9].

A 2016 study found that LFI had a weak but positive relationship with DHF incidence ($r = 0.078$), meaning that a lower ABJ was associated with an increased incidence of DHF [10]. In 2015, a study confirmed a relationship between CI and DHF incidence [11]. Widjaja's study found that the type of water container was associated with DHF incidence. Among ten containers examined, two buckets ($p = 0.00$) and clay jars ($p = 0.034$) were significantly associated with DHF ($p < 0.05$) [12].

East Jakarta, one of the municipalities in DKI Jakarta, reported the highest number of DHF cases: 3,014 cases with a CFR of 0.1% in 2019 [13], and 1,599 cases with a CFR of 0.02% (one death) in 2020 [3]. According to the Halim Perdanakusuma Meteorology Subdivision report in 2021, the average temperature was 27.8°C, humidity 78.3%, with an average of 17.5 rainy days and 287.3 mm of rainfall [14]. In May 2022, East Jakarta recorded an average temperature of 28.12°C, humidity of 79%, 19.6 rainy days, and 271.72 mm of rainfall [15].

East Jakarta spans an area of 188.03 km^2, consisting of 10 sub-districts and 65 urban villages [14]. In May 2022, the highest DHF incidence rate (IR) by sub-district was reported in Pasar Rebo with 166 cases (IR = 71.58 per 100,000 population) and an ABJ of 93.78%. Cakung ranked second with 158 cases (IR = 28.08 per 100,000 population) and an LFI of 92.25% [16].

Climate change and vector density are associated with the increase in DHF cases. Therefore, this study aims to examine the relationship between climatic factors and vector density with the incidence of DHF in East Jakarta in 2022. This effort is part of the Early Warning and Response System (EWARS) for DHF outbreaks in the region.

METHODS

This study is descriptive research using an ecological study approach. Ecological studies assess disease frequency across multiple populations and examine correlations with average exposure within those populations. These studies are unique because the analysis is not based on individual-level data. Instead, the data points represent the average exposure and disease frequency in a group or population. Therefore, the unit of analysis is not individuals, but entire populations or groups [17].

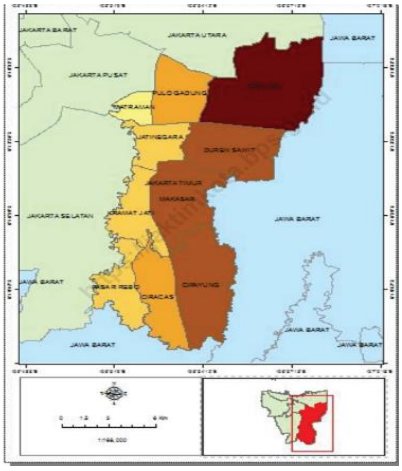
The dengue survey forms used in this study were obtained from the Jakarta Center for Environmental Health Engineering and Disease Control (BBTKL PP) and the Vector and Disease-Carrying Animal Laboratory (VBPP) in 2022, comprising 800 respondents. The sample size was the total population. The study was conducted in Cakung Sub-district (Jatinegara and Rawa Terate urban villages) and Pasar Rebo Sub-district (Kalisari and Cijantung urban villages) from May to July 2022.

The study variables include climate factors such as air temperature and humidity, as well as vector survey data from the VBPP Laboratory in March and June 2022. Rainfall and rainy days data were obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG). The incidence rate of DHF per urban village in East Jakarta for the year 2022 was also analyzed.

Univariate analysis (frequency distribution, proportion, mean, and standard deviation) was used to describe air temperature, rainfall, number of rainy days, air humidity, and vector density based on LFI, CI, container types, and DHF case counts. Bivariate analysis was conducted to assess the relationship between vector density and climatic factors with DHF incidence using the Spearman correlation test via SPSS version 20.

RESULTS

East Jakarta is located at 106°49'35" East Longitude and 06°10'37" South Latitude, covering an area of 188.03 km^2 (28.39% of the total area of DKI Jakarta Province), consisting of 10 sub-districts (Pasar Rebo, Ciracas, Duren Sawit, Makasar, Cipayung, Kramat Jati, Jatinegara, Matraman, Cakung, and Pulogadung) and 65 urban villages (Figure 1) [14]. The study was conducted in the urban villages of Jatinegara, Rawa Terate, Kalisari, and Cijantung.



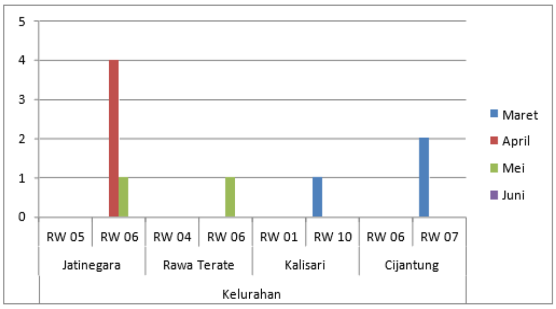


Figure 1. Map of Easth Jakarta City[14]

Figure 2. Distribution of Dengue Cases

The distribution of dengue cases in RW 06, Jatinegara urban village, shows four cases in April and one case in May. In RW 06, Rawaterate urban village, there was one dengue case in May. In RW 10, Kalisari urban village, there was one case in March. Meanwhile, RW 7, Cijantung urban village, recorded two cases in March (Figure 2).

Out of 800 respondents, 9 were infected with dengue. Table 1 shows that of the 9 dengue patients, 56% were male. Most of the cases occurred in the 20–60 years age group (56%), and the majority of cases were found in Jatinegara urban village.

Table 1. Characteristics of Dengue Cases in Cakung and Pasar Rebo Districts

Characteristic	Number	Proportion
Sex		
Female	4	44%
Male	5	56%
Age Group		
0-1 years	0	0%
2-10 years	2	22%
11-19 years	2	22%
20-60 years	5	56%
>60 years	0	0%
Urban village		
Jatinegara	5	55,6%
Rawa Terate	1	11,1%
Kalisari	1	11,1%
Cijantung	2	22,2%

Table 2 shows that in East Jakarta City from 21–24 March 2022 and 21–24 June 2022, the mean air temperature was 33.15°C (SD: 1.33), with a minimum of 27.9°C and a maximum of 36.8°C. The mean air humidity was 57.66% (SD: 6.01), ranging from 43% (lowest) to 80% (highest). The mean Larvae-Free Index (LFI) was 77% (SD: 4.42), with values between 72%

(lowest) and 86% (highest). The mean Container Index (CI) was 13.17% (SD: 28.07), varying from 0% to 100%. The average number of containers was 0.31 (SD: 0.68), with a minimum of 0 and a maximum of 5 containers.

Table 2. Descriptive Analysis of Air Temperature, Humidity, LFI, and Container Index

Variable	March	June
Rainfall	186,0	196,7
Rainy Days	19	19

Normality tests showed that only air temperature was normally distributed, while dengue cases, humidity, CI, and LFI were not, thus the Spearman correlation test (non-parametric) was used [18]. There is a statistically significant association between the Container Index and DHF ($p = 0.001$; $r = 0.118$). Similarly, the number of containers also shows a significant but weak positive correlation with dengue cases ($p = 0.001$, $r = 0.113$). Other variables (temperature, humidity, LFI) were not significantly correlated with dengue incidence ($p > 0.05$) (Table 3).

Table 3. Spearman Test Results (n = 800)

Variable	Correlation (r)	p-value
Air Temperature	0,047	0,180
Humidity	0,004	0,906
Larvae-Free Index (LFI)	-0,250	0,481
Container Index (CI)	0,118	0,001
Number of Positive Containers	0,113	0,001

DISCUSSION

Dengue Fever Incidence

Indonesia, a transcontinental unitary state in Southeast Asia, is a tropical country where the two primary mosquito vectors of DENV—*Aedes aegypti* and *Aedes albopictus*—are widespread in endemic areas [19]. Indonesia, part of the Southeast Asia Regional Office (SEARO), ranks first in dengue fever cases based on incidence (IR) and case fatality rate (CFR) [20]. Several provinces in Indonesia have experienced outbreaks, including Jakarta. Dengue is a priority health concern in East Jakarta. The Jakarta Health Profile reported that in 2019 and 2020, East Jakarta recorded the highest number of dengue cases in the province [3,13].

The first dengue cases in Indonesia were reported in 1968 in Surabaya and Jakarta. Over time, the dengue trend in Indonesia has undergone significant changes [21,22]. These changes include dengue outbreaks becoming more irregular with high inter-epidemic baselines [21], an increasing average age of dengue cases, rising annual incidence rates (IR), and decreasing fatality rates (CFR) [21,22].

Dengue is closely linked to the environment and is classified as an environmentally-based infectious disease [23]. Its rise is influenced by temperature, climate, humidity, rainfall, and vector density, with population mobility also contributing to its spread [4].

Air Temperature

Temperature is a quantitative measure of heat and cold, typically recorded using a thermometer [24]. Both indoor and outdoor temperatures influence mosquito breeding and dengue transmission [20]. Ambient air temperature significantly influences faunal conditions [25]. Animals or fauna exhibit varying levels of reaction to their surrounding environment.

The Asia-Pacific region, characterized as a tropical area with air temperatures ranging from 16–32°C, provides an ideal habitat for the breeding of *Aedes aegypti* and *Aedes albopictus*. The optimal temperature for these mosquitoes is between 25–27°C [26]. Temperatures between 20–30°C are suitable for sustaining their life cycle [27]. Meanwhile, research findings indicate that the average air temperature is 33.15°C. Temperature affects feeding behavior and blood-sucking activity, which are essential for the development of mosquito ovaries. Feeding activity ceases at temperatures below 15°C or above 36°C. Environmental temperature also influences the reproductive cycle of female mosquitoes, as fertilization may fail when the temperature drops below 20°C.

This study showed no correlation between air temperature and dengue incidence in East Jakarta ($p > 0.05$), aligning with similar findings from Pandeglang (2011–2016) (p value = 0,113) [28], and Bogor (2011–2014) [29]. However, a study in Tegal found a strong but negative correlation between temperature and dengue incidence [30]. Indoor and outdoor temperatures ranging from 25–30°C are associated with dengue transmission and increase the risk of outbreaks by 2 to 4 times, with 95% CI = 1.556–5.215 and 1.939–8.914. These temperature ranges create favorable conditions for mosquito breeding sites [20].

The optimal temperature for dengue transmission is 25–27°C. Temperatures outside this range show little impact on dengue incidence. This indicates no significant relationship between temperature and dengue cases, as the average temperature in East Jakarta from March 21–24, 2022 and June 21–24, 2022 was 33.15°C.

Humidity

According to Siswanto & Usnawati (2019), the Asia-Pacific region is a tropical area with humidity levels between 60–80%, which provides an ideal habitat for the breeding of *Aedes aegypti* and *Aedes albopictus* [23]. Humidity in a particular location influences the hatching process of *Aedes aegypti* eggs, as they tend to hatch more quickly in high humidity environments [9]. When humidity falls below 60%, the lifespan of mosquitoes shortens, reducing their potential as vectors[31].

This study found no correlation between air humidity and the incidence of DHF in East

Jakarta ($p > 0.05$), which is consistent with a study in Tegal Regency showing no significant relationship between humidity and dengue cases from 2012 to 2018 [30]. However, a study in Manado City found that humidity is associated with dengue incidence [7].

The average humidity recorded at the study site does not represent an ideal habitat for the breeding of dengue vector mosquitoes. However, the maximum humidity level observed at the study location, which reached 80%, does provide a suitable environment for the breeding of *Aedes aegypti* and *Aedes albopictus*.

High humidity extends the lifespan of mosquitoes, thereby increasing the risk of dengue transmission. However, this study indicates no correlation between humidity levels and dengue incidence, as the average humidity recorded in East Jakarta from March 21–24, 2022, and June 21–24, 2022, was 57.66%.

Rainfall

Rainfall can cause water puddles in and around homes. These puddles can become breeding habitats for *Aedes aegypti* mosquitoes [26]. During the rainy season, the mosquito population can increase as the eggs hatch once their habitat fills with rainwater [32]. This situation increases the mosquito population and consequently raises the risk of dengue virus transmission [9].

According to BMKG (Meteorology, Climatology, and Geophysics Agency of Indonesia), monthly rainfall in 2022 is classified into four categories: 0–100 mm/month (low rainfall), 100–300 mm/month (moderate rainfall), 300–500 mm/month (high rainfall), and >500 mm/month (very high rainfall). In this study, the monthly rainfall frequency distribution was higher in June 2022 (196.7 mm) than in March 2022 (186.0 mm) [15].

Based on the BMKG classification, the rainfall in March and June 2022 falls into the moderate category. Moderate but prolonged rainfall increases mosquito breeding sites, resulting in a higher vector population [31]. However, in this study, the researcher could not access daily rainfall data at the site, thus further analysis could not be conducted.

Rainy Days

Dengue outbreaks generally begin to increase in the middle of the rainy season due to more mosquito breeding sites caused by increased rainfall. BMKG data showed that the number of rainy days in both March and June 2022 was the same—19 days each [15]. However, in this study, the researcher could not access daily rainfall data at the site, thus further analysis could not be conducted.

Larvae-Free Index (LFI)

Vector density refers to the number of vectors in a given unit area. The Larvae-Free Index (LFI) is one indicator of immature mosquito vector density. The LFI can also be used to assess the quality of vector control programs. According to environmental health standards, the minimum acceptable LFI is 95% [9].

This study showed that the ABJ in East Jakarta on March 21–24 and June 21–24, 2022, had an average of 77%, with a minimum of 72% and a maximum of 86%. The correlation test between LFI and dengue cases in East Jakarta in 2022 was not significant ($p = 0.481$; $r = -0.25$), indicating that LFI was not correlated with dengue cases ($p > 0.05$).

These findings differ from a study at Putat Jaya Public Health Center, which found a weak but positive relationship between ABJ and dengue cases [10]. However, it is consistent with studies in Jambi City and Medan City, which reported no significant relationship between ABJ and dengue incidence [33][34].

The LFI in this study was below the environmental health quality standard (<95%). Nonetheless, statistical analysis showed no correlation between LFI and dengue cases, indicating that dengue incidence in East Jakarta is not influenced by high or low LFI values.

Container Index (CI)

The Container Index (CI) indicates the proportion of water containers found to have mosquito larvae. A CI <5% means that many containers are potential breeding habitats [35]. CI is calculated by dividing the number of containers with larvae by the number of inspected houses, multiplied by 100% [36].

Larval density is measured using the CI. The study showed that the average CI in East Jakarta on March 21–24 and June 21–24, 2022, was categorized as moderate, though some areas had high densities. A CI value of 13.17% means that 13.17% of containers were positive for larvae, indicating a high risk of dengue transmission. The correlation test showed a positive but weak relationship between CI and dengue cases ($p = 0.001$; $r = 0.118$), meaning higher CI values are associated with more dengue cases.

This finding aligns with a study in Manado City that found a strong relationship between larval density and dengue cases [37]. However, it differs from a study at Rowosari Public Health Center, Semarang, which found no significant correlation ($p = 0.494$) [38]. A high CI is associated with greater dengue risk compared to houses with a low CI [39].

Types and Quantity of Container Ownership

Containers affect the presence of A. aegypti larvae inside homes, primarily due to the habit of storing water in open containers indoors. Adult mosquitoes are attracted to lay eggs in these containers. Additionally, A. aegypti tends to prefer biting humans (anthropophilic), resting in dark, damp, and hidden places [40] and around hanging clothes [41] making it likely to stay near its host.

Buckets were the most common container type found to contain larvae, consistent with findings in Jayapura City [35] Buckets were the most common container type found to contain larvae, consistent with findings in Jayapura City. The most frequently used water source in these buckets was groundwater. The total number of positive-larvae containers was 13.4%, indicating moderate larval density [42]. The correlation test between the number of larva-positive containers and dengue cases was significant (p = 0.001; r = 0.11), though the relationship was weak and positive—meaning that an increase in CI and larva-positive container ownership was associated with an increase in dengue cases.

Larvae survey data were secondary data, limited to the information written on the larvae survey forms from the VBPP Laboratory at BBTKLPP Jakarta. The dengue case data were limited to individual cases from the research area, not aggregated data from the wider region. Dengue data were based on public health center records and did not include hospital reports. Researchers could not access daily rainfall and rainy day data, preventing further analysis.

CONCLUSION

This study concludes that average temperature, humidity, rainfall, rainy days, and House Index (HI) are not correlated with dengue incidence. However, Container Index (CI) and the number of positive containers were positively associated with dengue incidence. Buckets were the most common containers with larvae. Community involvement in regular vector control activities such as covering, draining, and modifying containers is crucial. Regular draining and tightly covering buckets can reduce mosquito breeding.

Local government support through regular larval inspections and community-led vector control efforts is essential. Establishing sanitation clinics at health centers can also provide public consultation spaces with environmental health officers.

DECLARATIONS

Ethics approval

This study was approved by Ethical approval obtained from the Research Ethics Committee of Respati Indonesia University, No. 282/SK_KEPK/UNR/2022.

Conflict of interest.

The authors declare no conflict of interest.

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