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# Impact of Climate Variability and Incidence on Dengue Hemorrhagic Fever in Palembang City, South Sumatra, Indonesia

Minarti Minarti[1], Chairil Anwar[2]*, Irfannuddin Irfannuddin[3], Chandra Irsan[4], Ramzi Amin[5], Ahmad Ghiffari[1,6]

*[1]Department of Environmental Science, Graduate School, Universitas Sriwijaya, Palembang, Indonesia; [2]Department of Parasitology, Faculty of Medicine, Universitas Sriwijaya, Ogan Ilir, South Sumatra, Indonesia; [3]Department of Physiology, Faculty of Medicine, Universitas Sriwijaya, Indralaya, South Sumatra, Indonesia; [4]Department of Plant Protection, Faculty of Agriculture, Universitas Sriwijaya, Ogan Ilir, South Sumatra, Indonesia; [5]Department of Ophthalmology, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia; [6]Department of Parasitology, Faculty of Medicine, University of Muhammadiyah Palembang, Palembang, Indonesia*

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***Correspondence:** Chairil Anwar, Department of Parasitology, Faculty of Medicine, Universitas Sriwijaya, Ogan Ilir 30662, South Sumatra, Indonesia. E-mail: chairil53@fk.unsri.ac.id
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**Abstract**

**BACKGROUND:** Dengue hemorrhagic fever (DHF) is a dengue virus infection transmitted by Aedes spp. Climate has a profound influence on mosquito breeding. Palembang has the highest rate of DHF in South Sumatra.

**AIM:** This study aimed to investigate the relationship between the components of climate factors and the incidence of DHF in Palembang.

**METHODS:** This study was cross sectional, with an observational analytic approach. The Palembang City Health Office compiled data on DHF incidence rates from 2016 to 2020. Climatic factor data (rainfall, number of rainy days, temperature, humidity, wind speed, and sun irradiance) were collected from the Climatology Station Class I Palembang – BMKG Station and Task Force that same year. The Spearman test was used to conduct the correlation test.

**RESULTS:** Between 2016 and 2020, there were 3398 DHF patients. From January to May, DHF increased. There was a significant correlation between rainfall ($r = 0.320$; $p = 0.005$), number of rainy days ($r = 0.295$; $p = 0.020$), temperature ($r = 0.371$; $p = 0.040$), and humidity ($r = 0.221$; $p = 0.024$), wind speed ($r = 0.76$; $p = 0.492$), and sunlight ($r = 0.008$; $p = 0.865$).

**CONCLUSION:** Rainfall, the number of rainy days, and temperature were three climatic factors determining the increase in dengue incidence. Vector control approach must start around October, 2 months before the high DHF cases in Palembang.

## Introduction

Dengue fever affects about 400 million individuals globally each year [1]. There are four serotypes of dengue, which are transmitted by *Aedes* mosquitoes [2]; *Aedes aegypti* is more prevalent indoors, as a container breeder, while *Aedes albopictus* is more common outside, at city's outskirts. There is a tetravalent dengue vaccine; however, it is not widely utilized [3]. Concerns regarding the safety of the dengue vaccine have hampered its use. Children who had never been exposed to dengue before getting the vaccine had 50% increased risk of hospitalization [4]. The most effective method to reduce dengue transmission is to control vectors [5].

Transmission occurs across various biological zones and environmental circumstances [6], [7], [8]. The connection between vector density and disease transmission is complex and unpredictable [6], [7]. Incomplete coverage and improper application, pesticide resistance, high labor costs, and community apathy make comprehensive vector control challenging to establish and maintain [9]. Some research shows that vector management methods have little impact on entomological indicators [5], [10], [11]. Most vector control technique assessments utilize entomological data rather than disease incidence rates. The human disease was unaffected by substantial decreases in vector indices [12], [13], [14], [15], [16]. The optimal timing of insecticide fogging and its impact on reducing dengue cases were greatly influenced by seasonality and the level of transmission intensity [16].

The Ministry of Health (MoH) used a three-pronged coordinated vector approach since the 1980s. An eradication campaign led by 3 million families got underway. Through television, radio, and the internet, the general population was regularly taught how to detect *Aedes* larvae and administer larvicide. Second, Abate® was employed to destroy larvae by both residents and MoH personnel. Abate was made accessible at local clinics for use with larvae in water containers; for these methods to be effective, community involvement is required. Finally, in impacted regions, the MoH employed reactive outdoor pesticide fogging. The plan was to spray 100 m around the home of a dengue sufferer who had been hospitalized for a week. However, the trend of outbreaks in Palembang in 1998 showed the increase in dengue cases reached three doubled between January and April [17]. These vector control did not result in a significant reduction in dengue incidence. We hypothesized that climatic factors should be considered when planning a control strategy against dengue vectors. There is a need to understand better and predict dengue outbreaks and transmission risk based on the temporal data so that vector control resources can be allocated optimally.

## Materials and Methods

A cross-sectional study was used in this research. The Palembang Health Office provided data on the incidence of dengue hemorrhagic fever (DHF), and Climatology Class I Palembang – Station and UPT BMKG provided climate data (rainfall, number of rainy days, temperature, humidity, wind speed, and duration of sunshine). Due to the coronavirus disease (COVID-19) pandemic, it was obligated to follow health protocols such as wearing masks, washing hands, and keeping a safe distance during data collection. SPSS was used to gather, process, and calculate all data. The Kolmogorov–Smirnov and Spearman correlation tests were used in a bivariate analysis, with p = 0.05 considered statistically significant.

## Results and Discussion

### *The incidence rate of DHF based on temporal analysis and subdistrict categories*

Data of DHF incidence immensely varied every year and also in months. The number of DHF patients in 2020 decreased compared to the previous year (Figure 1). DHF incidence rose from January to May, then fell sharply from June to September. In this regard, it is noteworthy that the pattern of DHF patients has remained relatively consistent over the past 5 years. A general description of DHF incidence and climate over 5 years (2016–2020) is depicted in Figure 2. Seasonality and the degree of transmission intensity significantly affected the optimum timing of pesticide fogging and its impact on decreasing dengue incidence. The best time to fog insecticides to decrease dengue incidence is between the start of the rainy season and the peak of a large epidemic, rather than waiting

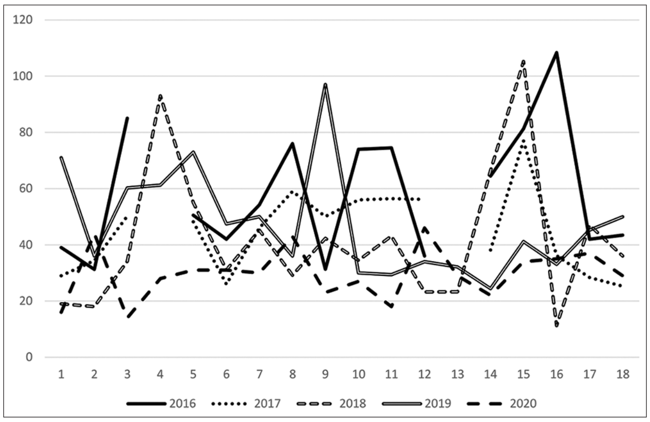


*Figure 1: The incidence rate of dengue hemorrhagic fever by subdistrict in Palembang city*

until the peak of a significant outbreak happens [16]. Dengue incidence was shown to be associated with several meteorological factors in Binh Thuan Province, Vietnam. A look at dengue population transmission patterns from 1996 to 2001 found a robust annual oscillation mode with a substantial multi-annual cycle. When it comes to developing early warning systems, the presence of these plausible climatic factors may be especially relevant since accurate predictors of dengue epidemics may help reduce the risk of dengue outbreaks [18]. Predictions of dengue season based on climate variability have led to early warning systems. Preemptive countermeasures innovative control approach for *A. aegypti* to reduce populations during periods of rapid population increase resulted in the first 2 months of the rainy season being sufficient to reduce *A. aegypti* numbers associated with the onset of dengue transmission [13]. There is no clear evidence for recommending peridomestic space spraying as a single, effective control intervention. Thus, peridomestic space spraying is more likely best applied as part of an integrated vector management strategy. The effectiveness of this intervention should be measured in terms of impact on both adult and immature mosquito populations and disease transmission [14]

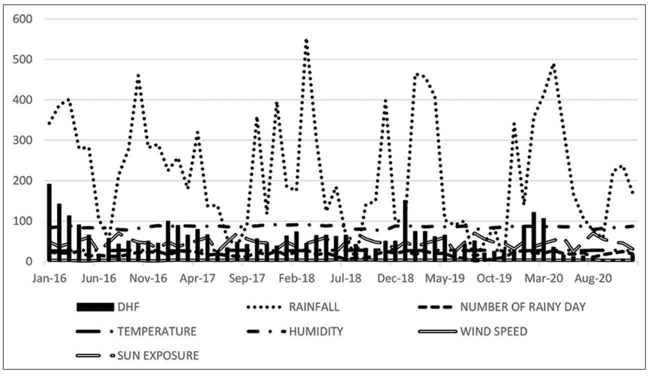


*Figure 2: Monthly distribution of dengue virus infection patients based on climatic factors*

Figure 1 illustrates that all 18 Palembang subdistricts reported a decline in dengue cases by 2020; however, from 2016 to 2019, three subdistricts, Sukarami, Seberang Ulu 1, and Ilir Barat 1, had a high incidence trend. Whereas the Sematang Borang, Gandus, and Kalidoni subdistricts are classified as sporadic yet located on the city's outskirts, others are classified as endemic and are located in the city center [19], [20]. *A. aegypti* mosquito is mainly found in houses in the city center. In contrast, *A. albopictus* is found outdoors in the city's outskirts [21]. Despite good public knowledge, the behavior of preventing and controlling mosquito nests must be improved to break the chain of transmission through the elimination of breeding of *A. aegypti* mosquito's site [22]. The community effectiveness of temephos depended on factors such as quality of delivery, water turnover rate, type of water, and environmental factors such as organic debris, temperature, and exposure to sunlight. As a single intervention, temephos effectively suppressed entomological indices; however, the same effect has not been observed when temephos was applied in combination with other interventions. There is no evidence to suggest that temephos use is associated with reductions in dengue transmission [15].

### *The incidence rate of DHF based on climatic factors*

Over 5 years, 3398 cases of DHF have been reported. Every year, the distribution of dengue cases follows a cyclical pattern. The Spearman correlation test reveals that rainfall, the number of rainy days, and temperature all impact the occurrence of DHF rainfall ($r = 0.320$; $p = 0.005$). The relative number of rainy days correlated with DHF ($r = 0.295$; $p = 0.020$). The incidence of DHF was also affected by temperature ($r = 0.371$; $p = 0.040$), whereas humidity, wind speed, and sunlight do not affect the incidence of DHF (Figure 3). Data on the weather in Palembang from 2016 to 2020. In Palembang, monthly rainfall peaked in January and then declined rapidly until April. The lowest monthly rainfall (2.0 mm) was in 2019. In 2018, March had the rainiest days (29/month), while August had the least (2/ month). Temperature fluctuations every month as the daily average temperature in 5 years did not show a significant increase and tended to fluctuate relatively low, as the highest temperature in 2020 was 33.9°C and a minimum of 24.2°C. Every month, the humidity level rises. In 2018, the highest average air humidity was 91.4%, and the lowest was 77.6%. Weather in Palembang ranged from 4.2 to 2.5 knots from 2016 to 2020. The sun's irradiance was 50.2%.

Rainfall in Palembang ranged from 0.0 to 45.84 mm from 2016 to 2020. These conditions are ideal for the development and survival of *Aedes* mosquito. More puddles in the house or yard from around the house can result from light rain. Rainfall serves to enhance the availability of *A. aegypti* vector habitat. The *Aedes* mosquito's eggs can survive and keep conditions secure. When the rainy season arrives, and the eggs of this type of mosquito are exposed to just a little water, they hatch promptly. DHF transmission is sensitive to fluctuations in rainfall [23]. Vector abundance and population will be affected by climate change, such as rainfall, thus affecting the transmission of DHF [24]. In India, rainfall is the single factor in the increase in the incidence of DHF [25]. Rainfall in the Philippines is associated with an increased incidence of DHF [26]. The study results were inversely proportional in Sri Lanka, which showed no relationship between rainfall and an increase in DHF [27]. Nonetheless, excess rain can also throw away mosquito eggs, larvae, pupae, and mosquito breeding grounds [28]. In South Taiwan, mosquito density and rainfall have a negative relationship when it rains heavily. In recent years, it has been noticed that many mosquito eggs and larvae are drifting away from breeding sites [29].

The number of rainy days in Palembang was <3 mm/day and <15 mm/day on 50 and 75% of days, respectively. The number of consecutive rainy days in the previous 2 months, increasing the probability of at least one case of DHF occurring 2 months later, increased by 17%. The number of rainy days is a robust predictor [30]. The number of days of rainfall plays an essential role in the dengue epidemic [31], [32].

The average humidity in Palembang was 87.7%, and the analysis discovered that it was not associated with the incidence of DHF. Humidity 60–70% affects mosquitoes' lives; mosquitoes cannot breed when humidity is <60%. It can interfere with the respiratory system, so mosquitoes' lifespan is short [33]. A study from 1983 through 2001, collecting monthly case numbers, temperature, humidity, and rainfall, characterizes seasonal dengue virus transmission cycles and identified seasonal transmission cycle structural variations. Larger epidemics are affected by temperature and humidity. Dualistic transmission 80% of 1.2 million severe dengue cases occurred at 27–29°C and 75% humidity [6]. It is better to act early to reduce epidemic size. Examining the relationship between weather, vector dynamics, and viral transmission help enhance human-to-human virus transmission models, dynamic risk assessment, and early epidemic.

The temperature range in Palembang was between 33.6°C and 24.6°C. The temperature was the most significant contributor to the occurrence of DHF in Nepal, accounting for nearly 90% of the influence [34]. An average temperature of 25–30°C provides an ideal environment for mosquito vector breeding and development [35]. Temperature influences the virus's extrinsic incubation period and mosquitoes' biting activity [36]. In the mosquito body, the development of extrinsic incubation is <9 and 5 days, at temperatures of 28°C and 30°C, respectively. Female mosquitoes' reproductive cycle is affected by the temperature of their environment, with female mosquito fertilization being reduced at temperatures below 20°C [37]. Biting female mosquitoes is influenced by their environment's temperature, which will increase the spread of dengue

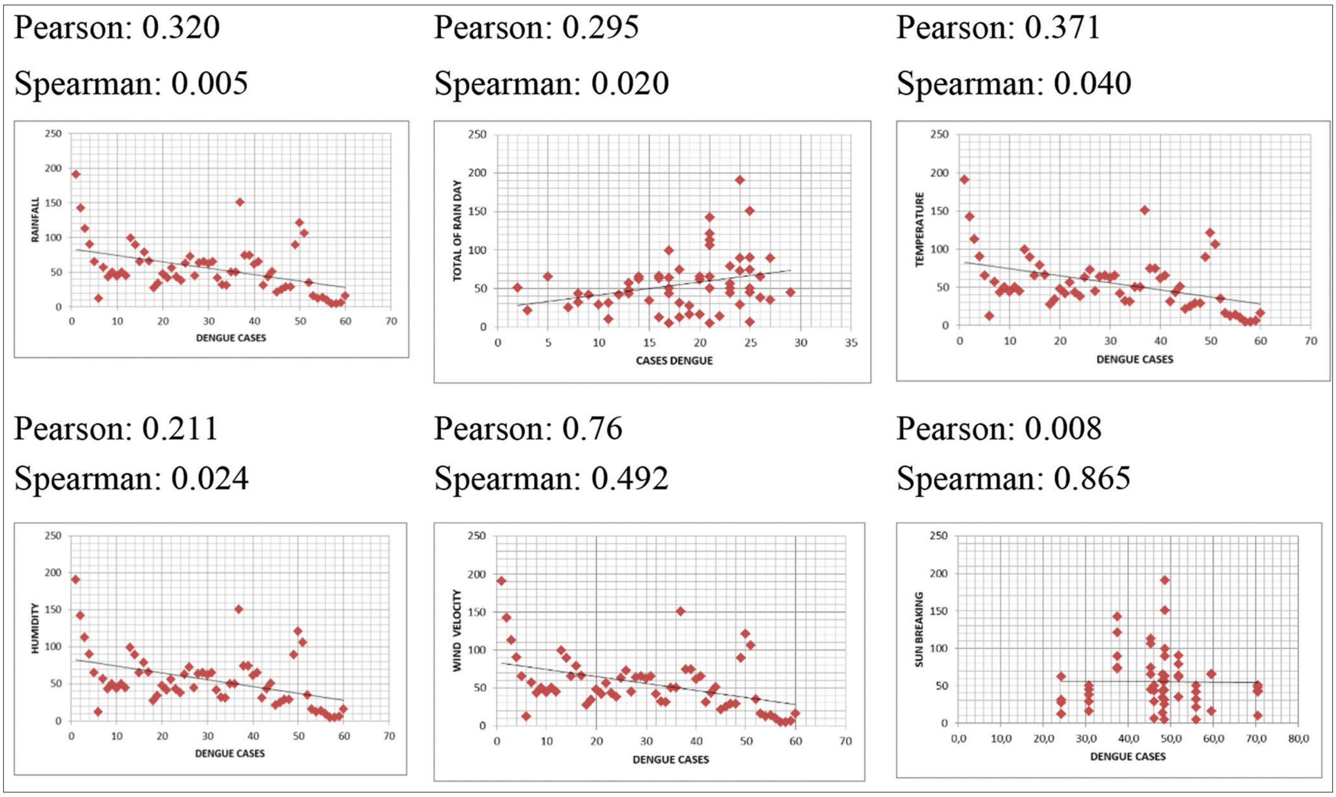


*Figure 3: Scatter plots of the relationship between climatic factors and dengue hemorrhagic fever cases in Palembang using Spearman correlation*

disease. There is a non-linear relationship between temperature rise and changes in the incidence of dengue cases [38], and temperature plays an essential role in influencing the population dynamics of *Aedes* mosquitoes [39]. Increase in DHF incidence ratio as the weekly average increase from 1℃ [38]. A large number of cases of DHF can be attributed to temperature [40], [41], [42]. Climatic factors such as temperature, humidity, and rainfall [43], [44], [45] [46] can prolong the transmission period of DHF [47]. Temperatures of 24–39°C play a significant role in mosquitoes' development, survival, and feeding behavior to promote viral replication in vectors [48]; thus, DHF will increase by 35% per 1°C [49].

The increase in wind speed in Palembang has a weak and negative correlation strength and did not affect the incidence of DHF. Although wind speed reduces the flying ability of mosquitoes, the results are similar, where there is no decrease in dengue transmission [50]. Different results where wind speed decreases dengue transmission, obtained from correlation and regression analysis of the relationship in Malaysia [51]. Dengue transmission in Malaysia is reduced by high wind speeds. There was a significant link between DHF incidence and exposure to mosquito flying activities and human interaction in Malaysian urban areas between 2012 and 2016 [51]. Wind speed contributes to exposure due to mosquitoes flying in or out of the house [52]. Wind speed affects or inhibits mosquito flight distance, thereby determining human-mosquito contact [53].

In Palembang, the duration of sun exposure had no significant relationship with dengue cases. The movement of mosquitos in search of food or a place to rest is greatly affected by sunlight. The female mosquito *Ae. aegypti* hunts for prey during the day when sunlight directly influences it. High levels of sunlight cause the air temperature to rise and the percentage of humidity to fall, interfering with mosquito survival. As a result, one of the factors that can influence mosquito productivity is sun exposure [54].

The DHF case in Palembang was caused by several determinants, besides the climate change factor. The public health issue such as locals' knowledge, attitude, and practice toward DHF control has impacted the disease control [19]. Fully enclosed mosquito breeding sites will increase awareness to create good environmental sanitation [55]. Another factor, such as community activity, has been implemented to prevent DHF incidence. Whereas ecological conditions and community behavior are factors, community behavior has a more significant influence on increasing the risk of DHF incidence [56].

This study has limitations because it uses secondary data. As a result, predicting dengue incidence increases when different weather and other factors are considered. Furthermore, it is essential to concentrate on vector population reduction and the limitation of human-vector contact when developing predictions. It is necessary to do that during climate change anomalies.

## Conclusions

Palembang has the highest incidence of DHF in 5 years in 2019. In terms of the early warning system, rainfall, the frequency of rainy episodes, and temperature were the three main climatic factors that influenced dengue incidence. Peridomestic spraying and temephos application were most effective beginning in October, 2 months before the incidence of DHF increased.

## Acknowledgment

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