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RELATIONSHIP BETWEEN CLIMATE VARIABLES AND DENGUE INCIDENCE IN WEST INDONESIA

Ahmad Ghiffari[1,2]*, Ratika Febriani[1], Galuh Pratama Mynanda[1], Thia Prameswarie[1]
[1]Faculty of Medicine, Universitas Muhammadiyah Palembang, Palembang, Indonesia
[2]Research Group of Chronic Disease, Universitas Muhammadiyah Palembang, Palembang Indonesia
*Corresponding Author : E-mail: ahmad_ghiffari@um-palembang.ac.id

ABSTRACT

Background: Dengue fever is a major public health problem, especially in heavily populated metropolitan areas like Palembang City, Indonesia. Gaining insight into the impact of climatic conditions on the dynamics of dengue transmission is essential for guiding specific public health actions. **Objective:** The objective of this study is to examine the correlation between temperature, rainfall, wind speed, air humidity, and the occurrence of dengue disease in Palembang City. **Methods:** Using observational data collected from 2016 to 2019 and 2022, we applied bivariate analytic approaches to evaluate the associations between meteorological factors and the incidence of dengue disease. **Results:** The findings demonstrate a notable inverse relationship between temperature and the occurrence of dengue disease, although rainfall displayed a favorable relationship. The relationships between wind speed, air humidity, air pressure, and dengue fever incidence were shown to be weaker. **Conclusion:** These findings highlight the significance of utilizing meteorological factors in early warning systems to enhance disease surveillance and control measures in metropolitan environments. This work helps to the creation of evidence-based strategies for reducing the burden of dengue fever in locations where it is common by explaining the intricate connections between climatic conditions and the dynamics of dengue transmission.

Keywords: *Dengue Fever, Disease Transmission, High Temperature, Observational Design, Urban City*

INTRODUCTION

Dengue fever has emerged as a serious worldwide health concern, with its occurrence increasing notably, particularly in highly populated cities. Dengue is a disease caused by one of four dengue viruses carried by *Aedes* spp. mosquitoes mostly affect tropical and subtropical countries. The Americas, Southeast Asia, and South Asia are severely impacted by this disease.[1,2] *Aedes aegypti* is synanthropic and lives in tropical areas, where weather factors like temperature and humidity are crucial for vector growth and dengue transmission.[3] Architectural and geographic factors are very important in determining the presence of *Aedes aegypti*, the dengue vectors in cities.[4] Urbanization creates favorable conditions for the breeding of vector mosquitoes in gutters and drains, leading to a higher density of mosquitoes in these regions.[4] Moreover, the implementation of the Dengvaxia® vaccination for children residing in regions with high dengue prevalence marks a noteworthy advancement in the field of dengue prevention.[5,6] The environmental factors, vector biology, and human behavior all interact in many different ways.

The complex relationship between climate and dengue fever transmission is crucial to investigate. Climate change favors vector species like *Aedes aegypti* and *Aedes albopictus*, which spread dengue fever.[7,8] The dengue-spreading *Aedes albopictus* mosquito is affected by weather.[9,10] Temperature and rainfall control mosquitoes,[11] while higher temperatures increase dengue virus transmission because mosquitoes can carry the virus more easily and infect more people fast.[12,13] Predictive models that account for temperature and DENV serotype vulnerability can also predict outbreaks.[14] Identifying dengue cases shows how temperature, rainfall, and relative humidity spread dengue.[15] Meteorological data-based machine learning models can identify dengue cases, demonstrating the importance of weather.[16]

Palembang South Sumatra in Western Indonesia, has the region's highest DHF rate.[17] Between 2016 and 2020, Palembang reported 3,398 DHF cases, with a significant increase from January to May, which correlated with climate factors such as rainfall, rainy days, and temperature.[18] The Mosquito Nest Eradication Program (PSN) reduces Aedes mosquitos, the primary vector of DHF, but budget constraints, a lack of SOPs, and low community participation make it challenging.[19] Community-based larval surveys and lethal ovitraps have increased the Sukarami Health Center's larvae-free (ABJ) rate.[20] However, the PSN program's planning and implementation, particularly community involvement and larval checks, are still insufficient.[21] Education,

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knowledge, and community behaviors, such as 3M Plus (drying, capping, and recycling), all have an impact on DHF incidence.[22] Environmental factors, such as extreme climate change, can exacerbate DHF cases.[23] Despite these efforts, some areas' larvae-free rates remain below targets, emphasizing the importance of community DHF prevention awareness and participation.[20] Geographic Information System (GIS) mapping reveals that vector-borne disease vulnerability varies throughout South Sumatra, necessitating targeted interventions.[24] With climate change, understanding the complex relationship between climate and dengue is critical for developing and implementing public health interventions. This study addresses that gap by using observational data analysis to demonstrate how intricate weather conditions spread dengue fever across major cities. It will also aid in targeted public health interventions to reduce disease and strengthen communities during weather changes.

METHODS

This study utilized an observational analytic research methodology. The study focused on persons who live in Palembang City, consisting of 18 subdistricts, which is a highly crowded urban region. A thorough sampling approach was employed to collect data from every reported case of dengue fever that was accessible to the Palembang City Health Service, composed of 41 public health centers and 23 hospitals. The permission clearance number, 800.2/9466/DINKES/2023, has been received from the Palembang city health service. In addition, climatic data such as temperature, rainfall, wind speed, and air humidity were acquired from the Provincial meteorological office and central statistical agency, with the permission clearance number, e.B/KL.01.00/202/KPLG/XII/2023.

Dengue fever incidence data were obtained from the records kept by the Palembang City Health Service, covering a certain period for the study 2016-2019, and 2022. The acquired data was analyzed using univariate and bivariate analytic approaches. Univariate analysis was used to independently characterize the distribution of dengue fever incidence and meteorological factors. Bivariate analysis was performed to examine the connections between the prevalence of dengue fever and several meteorological conditions, to evaluate their possible linkages. Non-parametric analysis employs Spearman's rank correlation coefficient to determine the relationship between two variables, assuming that their data scales are ordinal and the data is not normally distributed.

RESULTS

The ultimate results indicated a substantial negative correlation between temperature and the occurrence of dengue fever, while rainfall exhibited a positive correlation. The correlations between wind speed, air humidity, air pressure, and dengue fever incidence were shown to be less significant.

An examination of dengue fever occurrence data from 2016 to 2019 and 2022 demonstrated a regular seasonal trend, with the highest number of cases seen in January, followed by a progressive decrease until June and July. In 2022, there was a [22] noticeable pattern where the number of cases reached its maximum point in January. However, there was a modest increase in occurrences from May to July before gradually decreasing until October. The temperature data exhibited little fluctuations over the duration of the research. The lowest recorded temperatures were seen in February of both 2017 and 2018, measuring 26.5°C. Conversely, the greatest peak temperature was recorded in October 2019, reaching 28.8°C. These findings closely correspond to the average temperature of Palembang City, which stands at 26.96°C (figure 1). The data on rainfall patterns shows a significant overall rise in precipitation from October to March, with the highest amount of rainfall seen in March and October. In August 2019, the lowest level of rainfall was recorded, measuring only 1 millimeter (figure 2). The wind speed consistently decreased from November to April and increased from May to September (figure 3), whereas the air humidity indicated a repeating fall from July to August and a rise from September to June (figure 4). In December 2022, the air pressure in Palembang City reached its lowest frequency, measuring 1008 MB. The maximum atmospheric pressure occurred in September 2019, reaching a value of 1012.2 millibars. The mean atmospheric pressure is 1010.04 millibars. The atmospheric pressure in Palembang City experienced a decline from March to June, followed by a rebound from July to September. The air pressure in Palembang City had a decline from October to January (figure 5).

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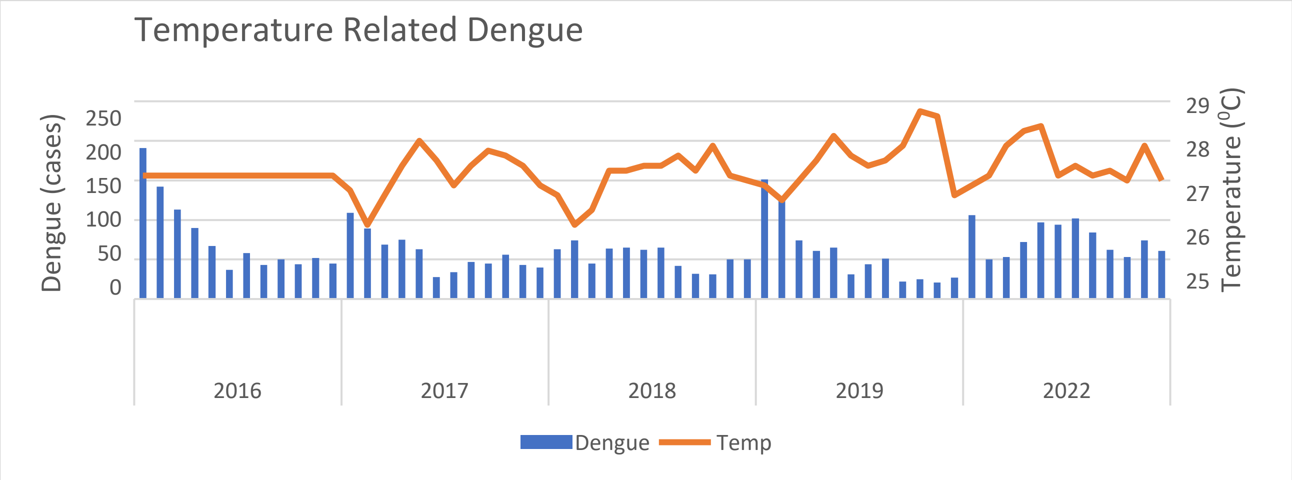

Figure 1. Temperature-related dengue incidence. The lowest recorded temperatures were seen in February of both 2017 and 2018, measuring 26.5°C.

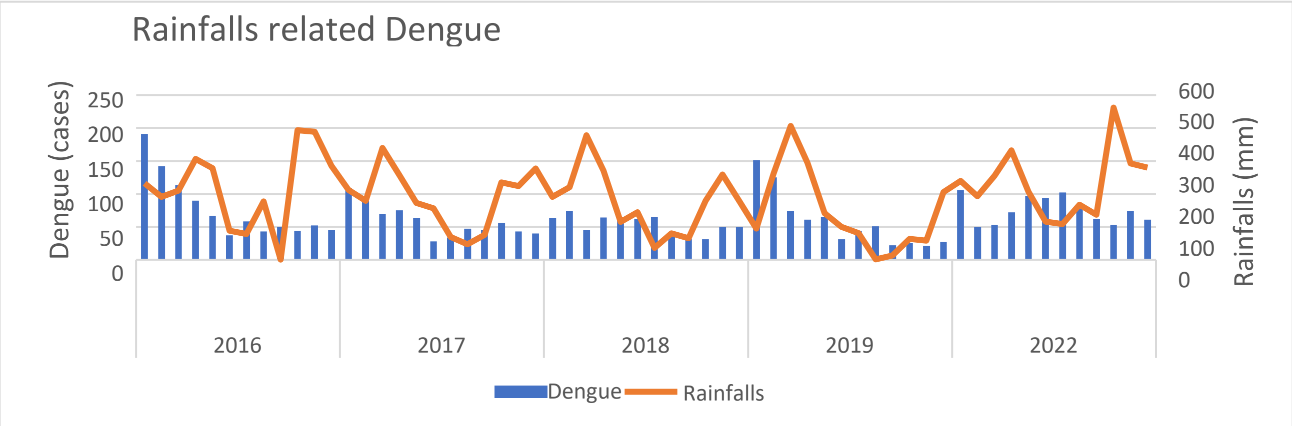

Figure 2. Rainfalls related to dengue incidence. The highest amount of rainfall was seen in March and October. In August 2019, the lowest level of rainfall was recorded.

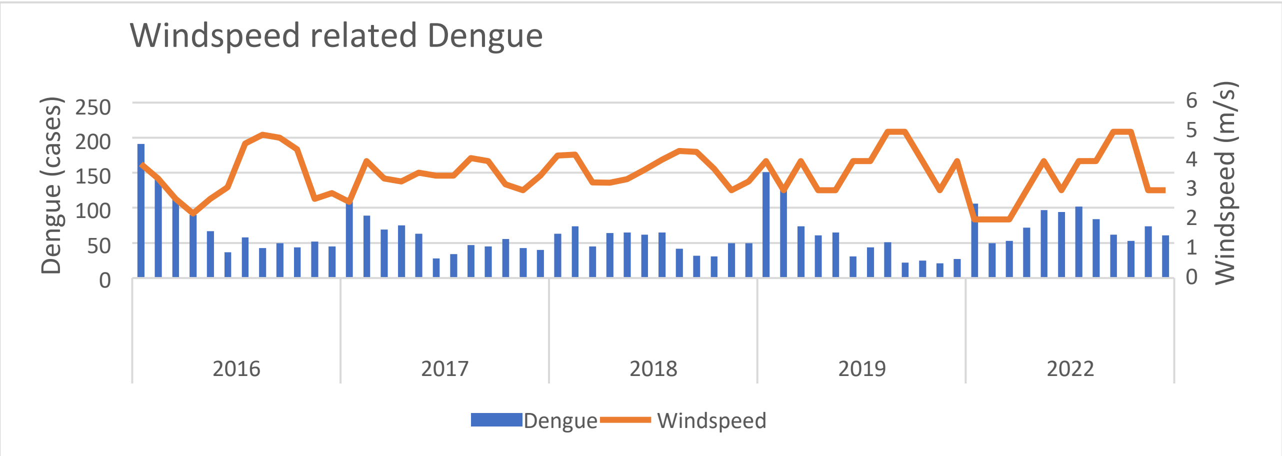

Figure 3. Windspeed-related dengue incidence. The wind speed consistently decreased from November to April and increased from May to September.

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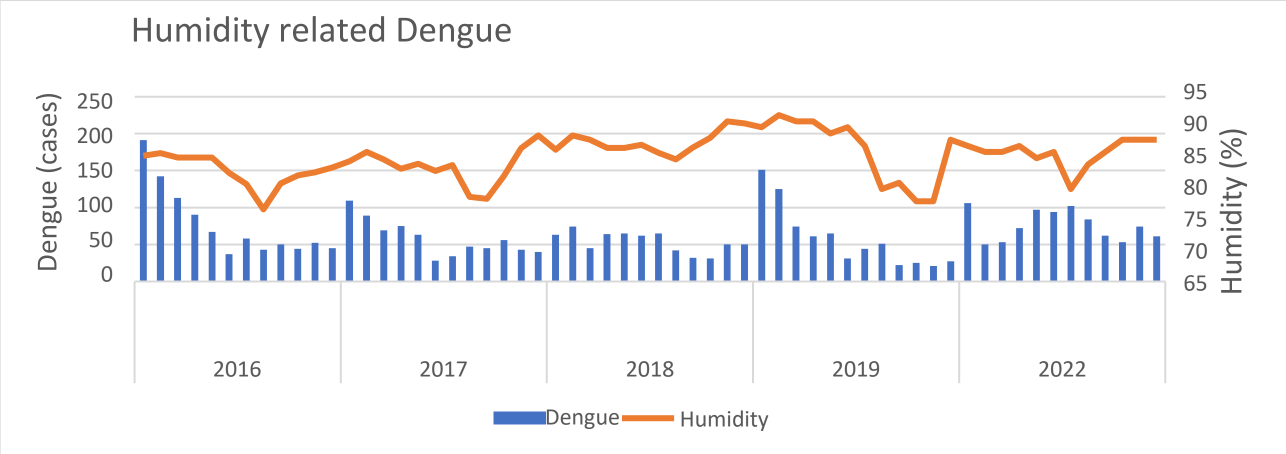

Figure 4. Humidity-related dengue incidence. The air humidity indicated a repeating fall from July to August and a rise from September to June.

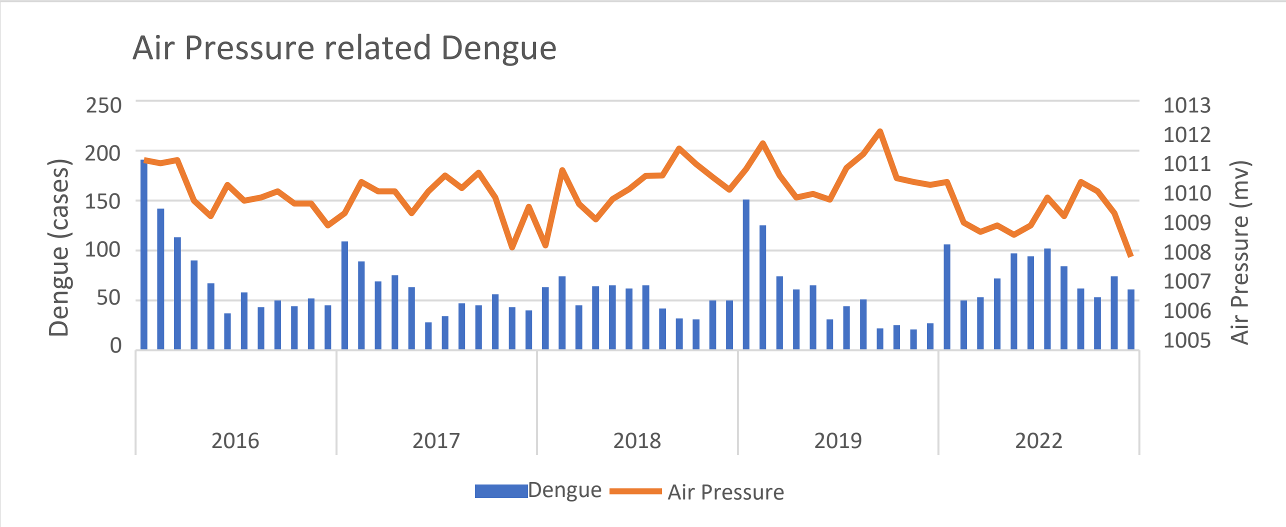

Figure 5. Air Pressure-related dengue incidence. The atmospheric pressure experiences a decline from March to June, followed by a rebound from July to September. The air pressure in Palembang City had a decline from October 2017 to January 2018.

Table 1. Factors that most influence the incidence of Dengue in Palembang, 2016-2020, 2022 (n=60 months), using the analysis with Spearman's rho

Climatic Variables	Dengue Incidence	
	p-value	r
Temperature	0,032	-0,277
Rainfalls	0,011	0,325
Windspeed	0,049	-0,255
Humidity	0,649	0,060
Air Pressure	0,559	-0,077

Through bivariate analysis utilizing Spearman correlation, it was shown that there are substantial connections between the occurrence of dengue fever and meteorological parameters. Specifically, temperature exhibited a negative correlation ($r = -0.277$, $p < 0.005$), whereas rainfall demonstrated a positive link ($r = 0.325$, $p = 0.011$). Wind speed ($r = -0.255$, $p = 0.49$), air humidity ($r = 0.060$, $p = 0.649$), and air pressure ($r = -0.077$, $p = 0.559$) showed modest relationships with dengue fever incidence (see table 1).

DISCUSSION

The relationship between environmental conditions and disease transmission dynamics has been extensively studied in various research, although the specific seasonal variations of dengue fever incidence in Palembang City have not been directly investigated in the given contexts. However, a comprehensive understanding of this complex relationship can provide insights into the inferred seasonal variations of dengue fever incidence in the city.[25] Dengue fever, a quickly spreading illness transmitted by vectors, is greatly impacted by environmental conditions such as temperature, rainfall, and humidity. These factors directly affect the number of vectors and the spread of the disease.[26] Temperature, in particular, has been demonstrated to have a direct proportional relationship with dengue's basic reproduction number, implying that higher temperatures might enhance mosquito life expectancy and hence the virus's incidence.[13] This is supported by studies that used temperature-based models to investigate the relationship between climate variability and dengue fever incidence, which found that areas with higher mosquito survival probabilities and shorter extrinsic incubation periods (EIPs) are more likely to report dengue cases.[27] Weather conditions, such as low temperatures and elevated air pollutants, can modify the risk of dengue fever by impacting the behavior and health of mosquitoes.[28] Mosquito biology, virus incubation, and environmental factors all contribute to dengue fever transmission at lower temperatures, albeit in varying degrees.

The observed trend of a peak in cases in January, followed by a fall in June and July, is consistent with previous research demonstrating the considerable effect of temperature on vector biology and virus replication rates. Temperature significantly influences vector competency, life history features, and arbovirus transmission dynamics. It has been regularly demonstrated that vector competence rises with rising temperatures, albeit the effect varies depending on the vector species, population, and virus strain.[29] This is because arthropod vectors are ectothermic, which means that ambient temperatures have a direct impact on their body temperature and, as a result, their biological processes, including virus replication rates.[30] Warmer temperatures allow for faster viral multiplication within vectors, resulting in shorter extrinsic incubation times, according to research on certain viruses such as the Mayaro virus (MAYV)[31] and epizootic hemorrhagic disease virus (EHDV).[32] This is congruent with studies from a variety of vector-pathogen pairings, which show that transmission is most efficient at intermediate temperatures ranging from 23 to 26°C.[33] However, it is vital to highlight that the link between temperature and viral transmission is nonlinear and can vary significantly. For example, whereas greater temperatures can speed up viral replication, they can also reduce vector quantity and activity.[34] Furthermore, temperature-dependent effects on virus-vector interactions can have a considerable impact on the epidemiology of arboviral illnesses, with climate change likely to alter their distribution and transmission dynamics.[35] This is corroborated by modeling studies that demonstrate temperature forcing increases prediction accuracy for West Nile virus (WNV) transmission, implying that temperature impacts WNV transmission rates.[36]

The well-documented positive relationship between rainfall and dengue fever incidence shows the importance of rainfall in providing optimal breeding sites for mosquito vectors, hence facilitating disease transmission.[9] Rainfall has been demonstrated in studies to have a direct impact on the population density of *Aedes aegypti* and *Aedes albopictus*, the principal dengue fever vectors, by providing sufficient breeding grounds for their larvae.[10] For instance, research in Guangdong Province, China, found that rainfall, particularly peak rainfall during the summer, is the strongest predictor of mosquito population development.[37] Similarly, in the metropolitan region of Rio de Janeiro, Brazil, temperature and rainfall were found as macro-factors influencing dengue incidence, with mathematical modeling proving their significance.[38] Furthermore, the time and amount of rainfall have been demonstrated to affect dengue fever transmission dynamics, with certain patterns of rainfall resulting in enhanced effective disease reproduction numbers.[39] Research in India also confirms the relationship between rainfall and dengue fever incidence, demonstrating that the risk of dengue transmission rises with particular levels of precipitation during specified periods.[40] Global climatic phenomena like the El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) have been linked to variations in

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dengue cases in India, highlighting the global impact of climatic factors on dengue fever incidence.[41] The correlation between rainfall and dengue fever incidence is crucial for understanding the disease's transmission mechanisms.[42]

Meteorological conditions have a complicated and diverse impact on dengue fever incidence, particularly in terms of vector behavior and virus transmission. While wind speed, air humidity, and air pressure have smaller connections with dengue fever incidence than other elements such as temperature and rainfall, their roles remain important in the larger context of disease transmission dynamics. Although wind speed was not directly related to dengue cases in the Guangzhou research, it may alter the dispersion and flying behavior of *Aedes* mosquitoes, which may influence the spatial distribution of dengue outbreaks.[10] Air humidity has been discovered as a major determinant in the occurrence of dengue infections in Alagoinhas, Bahia, Brazil, indicating that, while the association appears low, it has a considerable influence on vector survival and virus replication.[12] Air pressure, while not expressly stated in the presented scenarios, might be assumed to have an indirect influence via altering weather patterns that affect mosquito population dynamics. The complex interaction of these meteorological parameters with dengue transmission is exacerbated by the presence of air pollution, which can alter the relationship between meteorological exposures and dengue incidence.[7] Predictive models that include a variety of environmental indicators, such as temperature difference, cumulative rainfall, and relative humidity, have demonstrated substantial promise in forecasting dengue incidence, underlining the relevance of these variables in vector control strategies.[38] In a nutshell while wind speed, air humidity, and air pressure have weaker direct correlations with dengue fever incidence, their impact on vector behavior, environmental suitability for mosquito populations, and viral transmission dynamics is undeniable and warrants further investigation for better dengue prevention and control measures.[43,44]

While these studies provide strong insights into tropical ecosystems, their results are constrained by the meteorological and biological conditions under which they were conducted. The study's restriction to a single tropical locale raises questions about the findings' application to other areas with varying climatic circumstances. This complexity is further complicated by the interaction of many elements like as human behavior, urbanization, and healthcare infrastructure. As a result, caution must be clarified in the complex nexus of meteorological conditions and dengue transmission dynamics.

CONCLUSION

In conclusion, this study gives us useful information about the complex link between weather conditions and the spread of dengue fever in Palembang City, Indonesia. The seasonal trends of dengue fever cases the strong links between temperature and rainfall and how the disease spreads show how important climate factors are in shaping vector biology and the speed at which viruses replicate. Our results make it clear how important early warning systems based on weather conditions are for keeping an eye on diseases and controlling them, especially in cities where dengue fever is most common. But it's important to be aware of the study's flaws, like the fact that it only used observational data and confounding factors could have had an effect.

In the future, researchers should try to get around these problems by doing continuous studies that use multidimensional datasets and advanced modeling methods to learn more about the complicated relationships that control how dengue spreads. Targeted public health strategies, like vector control measures and community information programs, are also needed to lessen the impact of dengue fever in places where it is common. Researchers and healthcare workers can use what they've learned from this study to come up with evidence-based plans to fight dengue fever and protect public health as weather conditions change.

ETHICAL APPROVAL

The ethical clearance number, 075/EC/KBHKI/FK-UMP/XI/2023, was granted by the Faculty of Medicine at Universitas Muhammadiyah Palembang.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

The following contributions by the authors: conceptualization, AGC; methodology, RF; software, GPM; validation, TP; formal analysis, RF; investigation, GPM; resources, AGC; data curation, TP; writing—original draft preparation, AGC; writing—review and editing, AGC; visualization, GPM; supervision, RF; project administration, GPM; funding acquisition, TP.

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