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The Phenomenon of Dengue Fever in Climate Change

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Abstract

Dengue fever is a health challenge in tropical and subtropical countries. The increase in dengue cases in Indonesia is attributed to urbanization, climate change, increased population mobility, and community behavior. This study aims to describe the climate factors, including temperature, humidity, rainfall, and wind speed, as well as dengue fever cases from 2022 to 2024. This study uses a descriptive observational design with an ecological study approach. The data collection technique used in this study was secondary data in the form of documentation studies by analyzing records of dengue fever case numbers and climate data. The average of temperature are 28.10C (2022), 28.90C (2023), and 29.50C (2024); the average of humidity are 80.3% (2022), 75,2% (2023), and 74.3% (2024); the average of rainfall are 13.7mm (2022), 13.8mm (2023), and 8,2mm (2024); the average of wind speed are 2.1m/s (2022, 2023, and 2024); and the number of DHF are 260 (2022), 541 (2023), and 321 (2024). The monthly temperature ranges from 26.8 to 31.3°C, the average monthly humidity ranges from 65.1 to 85.7%, and rainfall fluctuates significantly, with the highest intensity reaching 28.7 mm. Dengue fever cases show a fluctuating trend, with the highest number in 2023 at 541 cases. Climate factors play a role in the dynamics of dengue cases in Semarang City. Temperature and humidity are within the optimal range that supports mosquito breeding and dengue virus transmission. High rainfall allows for puddles of water to form, which serve as breeding grounds for mosquitoes. Low wind speeds also facilitate mosquito flight activity

Introduction

Dengue fever is an arboviral infectious disease caused by the dengue virus from the flaviviridae family, which is carried by Aedes aegypti and Aedes albopictus (WHO, 2022). Dengue fever is transmitted to humans by female Aedes mosquitoes infected with the dengue virus. Four serotypes of virus can cause dengue fever, including DENV-1, DENV-2, DENV-3, and DENV-4. This disease has become a global concern due to the increasing trend of cases year after year, which has a significant impact on public health and the burden on healthcare systems. According to the World Health Organization (WHO), approximately 50% of the world's population is currently at risk of dengue fever, with more than 390 million dengue infections occurring annually. This phenomenon not only impacts developing countries but is also beginning to threaten countries with subtropical and temperate climates that were previously free of dengue. In recent decades, there has been a shift in the geographic distribution and seasonal patterns of dengue transmission, largely attributed to global climate change (Syarifuddin & Samosir, 2022).

Climate change has impacted many aspects of the environment, including temperature, rainfall, humidity, and extreme weather patterns, all of which play a role in the life cycle of the dengue vector mosquito. Warmer temperatures accelerate the mosquito life cycle and shorten the incubation period of the virus

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in the mosquito's body, increasing the potential for transmission to humans (Wu *et al.,*2022). Increased humidity and rainfall also create more breeding grounds for mosquitoes, especially in densely populated urban environments. This suggests that climate change has both direct and indirect impacts on dengue transmission dynamics. Furthermore, changing migration patterns, rapid urbanization, and population growth are exacerbating the situation and expanding dengue endemic areas (Umakanth & Suganthan, 2020).

Several local studies have found that a temperature increase of just 1–2°C can significantly increase the number of dengue cases in certain regions. The impacts of climate change are not evenly distributed across Indonesia; areas with high humidity and dense populations are more vulnerable to spikes in cases. Furthermore, uneven adaptation to climate change across regions exacerbates community vulnerability to vector-borne diseases. Unpredictable seasonal changes also complicate efforts to predict and prevent dengue transmission cycles (Abdullah *et al.*, 2022).

In 2021, there were 58.96 million reported cases of dengue fever in 126 countries worldwide (Zhang *et al.*, 2025). In 2024, there were 14.127.435 cases of dengue fever worldwide, the highest number recorded in the system since 2010 (Haider *et al.*, 2025). In the Asian Region, there were 884.402 cases of dengue fever in 2024 (Haider *et al.*, 2025). By the end of 2022, the number of dengue cases in Indonesia had reached 143.000 (Kemenkes RI, 2022). Based on data from the Semarang Health Department, the number of dengue fever cases in Semarang City fluctuates annually. From 2022 to 2024, there were 1.122 cases recorded.

The increase of dengue cases in Indonesia is influenced by urbanization, climate change, higher population mobility, and community behavior (Kemenkes RI, 2022). Dengue fever is a public health challenge in tropical and subtropical regions due to the rapid spread of mosquitoes. The life cycle of Aedes mosquitoes is influenced by climate change. Aedes can breed rapidly and actively bite at higher temperatures (WHO, 2022). From 2010 to 2023, annual temperatures in Indonesia generally increased, while the rainfall fluctuated each year. The increase in dengue fever cases in Indonesia was in line with the increase in annual temperatures (Akbar *et al.*, 2025).

Climate is one of the main factors that can affect mosquito breeding and dengue virus transmission. Climate change can affect the dynamics of infectious disease transmission, which is closely related to environmental conditions and vector behavior. Increase in annual temperatures, high rainfall, and humidity create ideal conditions for the growth of vector-related diseases and accelerate the cycle of infection. High temperatures shorten the extrinsic incubation period of the virus in mosquitoes, which can lead to frequent transmission cycles (Ogieuhi *et al.*, 2025).

Method

This study uses a descriptive observational design with an ecological study approach. This study aims to describe the relationship between climate variables and the number of dengue hemorrhagic fever (DHF) cases in the Semarang City area. The main focus of this study is to describe the variables of air temperature, humidity, rainfall, wind speed, and the number of DHF cases that occurred during a certain period. The type of data used in this study is secondary data obtained from two main sources. Data on DHF cases were obtained from the Semarang City Health Office, while climate data, including air temperature, humidity, rainfall, and wind speed, were obtained from the Central Java Climatology Station. Both data sources are official institutions that have the authority and validity in recording their respective data.

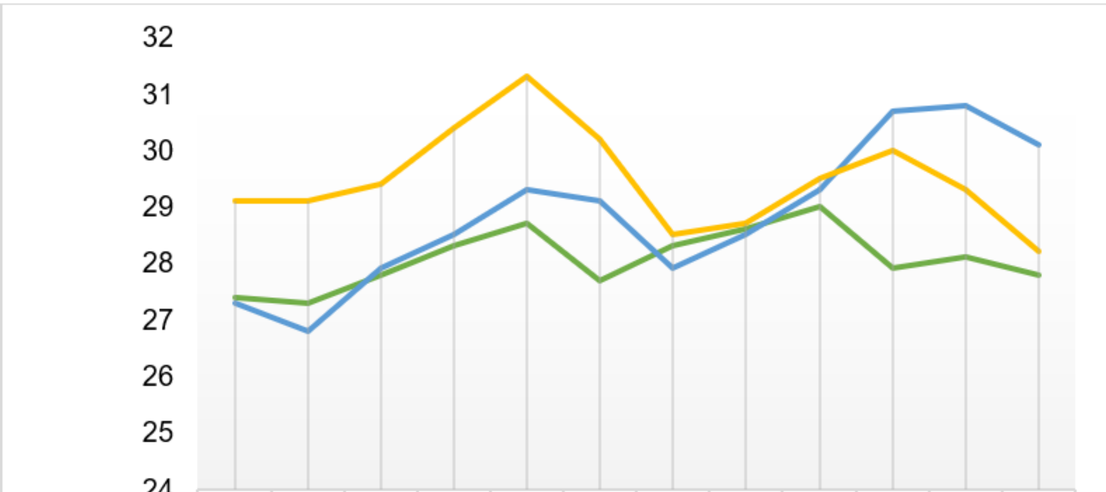
This study did not involve intervention on the research subjects and did not involve direct sampling of individuals. Therefore, an ecological study approach was used to analyze the relationship between environmental variables (climate) and aggregate data on dengue fever cases at the population level, not the individual. The instrument used in this study was a data summary table, which serves to group and organize climate data and dengue fever case data by month or year. This table was also used as an aid in the descriptive analysis process. The data collection technique used was a documentation study, namely by reviewing existing records, reports, or archives from the two relevant agencies. The researchers did not collect primary data through interviews or questionnaires.

Data analysis was conducted descriptively, presenting data in tables and graphs to facilitate visualization of trends and patterns in the relationship between climate variables and the number of dengue cases. The data obtained were analyzed to identify seasonal patterns, climate fluctuations, and the dynamics of dengue cases over the same time period. The timing of this study was adjusted to data availability, covering climate data and dengue cases, namely January-December 2022, 2023, and 2024, to illustrate seasonal trends and climate variability. This study did not conduct hypothesis testing or inferential analysis, given that its primary objective was to describe the phenomenon and provide an initial overview of the relationship between climate change and the increase in dengue cases.

To ensure data validity, researchers used only documented and published data from official government sources. Cross-validation was performed by matching data from the same year and location to avoid input or interpretation errors. In general, this descriptive, observational approach with ecological studies was chosen because it is appropriate for evaluating the impact of the macroenvironment (such as climate change) on aggregate public health issues, such as dengue.

Result and Discussion

During the 2022-2024 period, the average temperature each month fluctuated (Figure 1). In 2022, the highest average temperature occurred in September, which was 29°C. In 2023, the highest average temperature occurred in November, 30,8°C. The highest average temperature in 2024 occurred in May, which was 31,3°C. The average temperature in 2024 tends to be higher than the average temperature in 2022 and 2023. Average humidity in 2022-2024 was relatively stable (Figure 2). In 2022, the highest average humidity occurred in February (85,2%). In 2023, the highest average humidity occurred in February (86,9%). Meanwhile, in 2024, the highest average humidity occurred in December (82,8%). Precipitation in 2022-2024 fluctuated every month (Figure 3). In 2022, the highest precipitation occurred in December (17,9 mm). In 2023, the highest precipitation occurred in August (28,7 mm). In 2024, the



	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2022	27,4	27,3	27,8	28,3	28,7	27,7	28,3	28,6	29	27,9	28,1	27,8
2023	27,3	26,8	27,9	28,5	29,3	29,1	27,9	28,5	29,3	30,7	30,8	30,1
2024	29,1	29,1	29,4	30,4	31,3	30,2	28,5	28,7	29,5	30	29,3	28,2

Figure 1. Average Temperature in Semarang, 2022 to 2024

highest precipitation occurred in March (18,8 mm). From 2022 to 2024, wind velocity was relatively stable (Figure 4) at 1,7 m/s to 2,5 m/s. Dengue cases from 2022 to 2024 experienced significant fluctuations (Figure 5). The highest number of dengue cases in 2022 occurred in December with 55 cases. In 2023, the highest number of dengue cases occurred in November with 79 cases. The highest number of dengue fever cases in 2024 occurred in May with 52 cases. From 2022 to 2024, the highest number of dengue fever cases occurred in 2023, with 541 cases.

The average monthly temperature in 2022 to 2024 ranges from 26,8 to 31,3°C, which is optimal for the development of Aedes mosquitoes (18 to 31°C) (Delrieu *et al.*, 2023). In the adult stage, temperature affects the lifespan of vectors, allowing them to survive long enough to replicate and transmit the dengue virus (Rocklöv & Tozan, 2019; Mordecai *et al.*, 2017). Studies in Laos show that an increase in weekly temperature is associated with an increased risk of dengue cases (Sugeno *et al.*, 2023).

Temperature is a major environmental factor that significantly influences the life cycle of Aedes aegypti, the primary vector of dengue. Climate data shows that the average monthly temperature for the 2022–2024 period ranged from 26.8 to 31.3°C. This range is still within the optimal range of 18–31°C required for Aedes mosquitoes to reproduce (Delrieu et al., 2023). Therefore, climatic conditions during this period can be categorized as very favorable for the survival of dengue vector mosquito populations.

In the adult phase, temperature plays a crucial role in determining the lifespan of Aedes mosquitoes. Suitable temperatures allow mosquitoes to survive long enough to complete the dengue virus replication cycle within their bodies. A long lifespan increases the mosquito's ability to transmit the virus to humans through repeated bites. Research by Rocklöv & Tozan (2019) confirms that the longer a mosquito lives, the greater the potential for dengue transmission in a region. A study by Mordecai et al. (2017) also found that temperatures within the optimal range shorten the extrinsic incubation period of dengue virus.

The extrinsic incubation period is the time it takes for the virus to develop in the mosquito's body until it is ready to be transmitted. Higher temperatures within the optimal range allow the virus to replicate more quickly, allowing mosquitoes to transmit it earlier. This condition increases the efficiency of virus transmission from mosquitoes to humans. Research in Laos strengthens this relationship, finding that weekly temperature increases correlate with increased dengue cases (Sugeno et al., 2023). This correlation suggests that temperature not only influences mosquito ecology but also directly impacts dengue epidemiology.

Rising temperatures have the potential to trigger a spike in dengue cases in human populations in endemic areas. As ectothermic organisms, the Aedes mosquito relies heavily on environmental temperature to regulate its metabolism. Warm temperatures accelerate mosquito metabolism, including growth rate and reproductive cycles. As a result, mosquito populations can increase rapidly under optimal temperature conditions. Furthermore, temperature influences the frequency of Aedes mosquito bites. Mosquitoes that thrive in warmer temperatures tend to be more active in seeking out blood hosts (Hii et al., 2016).

Increased biting activity means greater opportunities for virus transmission from one individual to another (Cahyati et al., 2024; Siyam *et al.,* 2024). This demonstrates a direct relationship between temperature, mosquito behavior, and the risk of infection in humans. Temperature also influences the developmental stages of mosquitoes, from egg to adult. Within the optimal temperature range, the mosquito life cycle is shorter than at lower temperatures. This allows new generations of mosquitoes to emerge more quickly, resulting in a rapid increase in the adult population (Cahyati et al., 2024). The increase in the adult population will be directly proportional to the potential for dengue transmission (Cahyati et al., 2022). Not only does this increase the population, but temperatures also expand the mosquito's range into previously less-than-ideal areas. Areas with relatively low temperatures may not have previously supported Aedes populations, but with rising temperatures, they become more

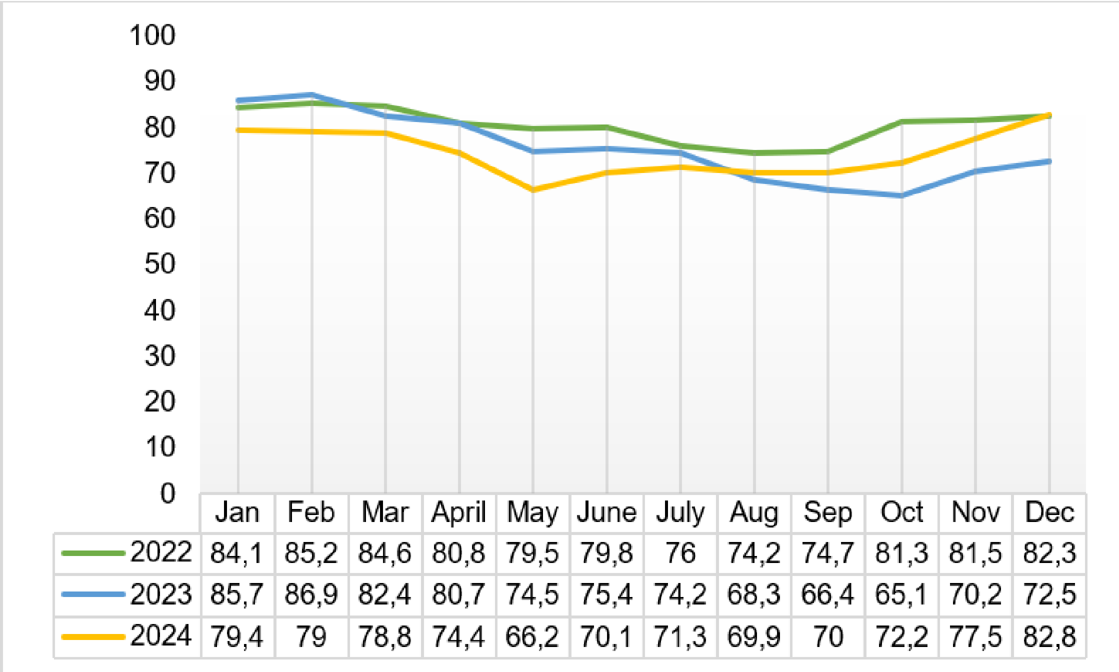


Figure 2. Average Humidity in Semarang, 2022 to 2024

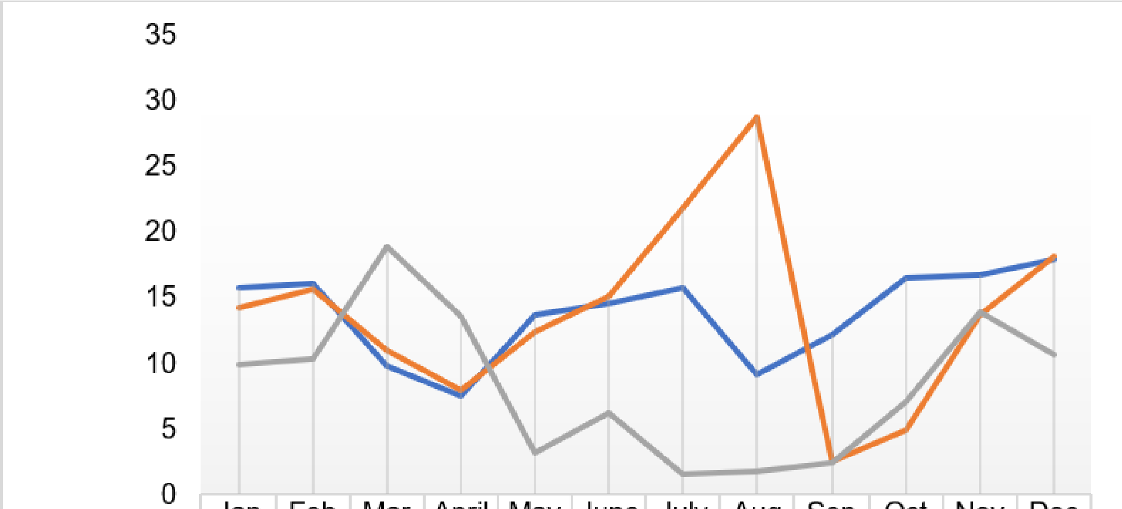
vulnerable. Changing temperature patterns due to global warming expand the dengue risk area, including non-endemic areas (Alhamda et al., 2025).

The average humidity observed in 2022-2024 was between 65.1% and 85.7%, creating an optimal environment for mosquito survival. A minimum humidity of 60% is required for Aedes aegypti mosquitoes to survive, because at low humidity the water in the mosquito's body will evaporate, causing its body fluids to dry out (Monintja *et al.*, 2021). Humidity and temperature can provide an optimal environment for mosquitoes to lay eggs until they hatch (Mamenun *et al.*, 2024). Humidity is significantly related to the number of mosquito eggs (Hii *et al.*, 2016). Studies in Bangladesh show a significant relationship between humidity and dengue fever cases (Islam *et al.*, 2018). Meta-analysis studies also show that humidity is one of the climatic factors associated with dengue outbreaks (Abdullah *et al.*, 2022).

Air humidity is a climatic factor that plays a significant role in the life cycle of the Aedes aegypti mosquito. Data shows that the average humidity during the 2022–2024 period ranged from 65.1% to 85.7%. This humidity range can be considered ideal for Aedes mosquito survival. Monintja et al. (2021) reported that mosquitoes require a minimum humidity of around 60% to survive. At humidity levels below this threshold, mosquito body fluids evaporate easily, making them susceptible to dehydration and death. Therefore, a humidity level of 65.1–85.7% during 2022–2024 clearly supports high mosquito survival rates.

High air humidity helps mosquitoes maintain body fluids, thus enabling them to live longer. The longer a mosquito lives, the greater its chance of transmitting the dengue virus to humans. This aligns with findings that the longevity of adult mosquitoes increases the risk of dengue epidemics. Humidity not only affects survival but also plays a crucial role in the success of the mosquito reproductive cycle (Hii *et al.*, 2016).

High humidity provides a stable environment for oviposition, or egg-laying. Mosquito eggs laid in conditions of sufficient humidity have a greater chance of hatching. Mamenun et al. (2024) confirmed that the combination of appropriate humidity and temperature creates an optimal environment for mosquito eggs to develop until they hatch. Hii et al. (2016) also found a significant relationship between air humidity and the number of eggs laid by mosquitoes. The higher the humidity, the more eggs female mosquitoes can produce.



	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2022	15,7	16	9,7	7,4	13,6	14,5	15,7	9,1	12,1	16,5	16,7	17,9
2023	14,2	15,6	10,9	7,9	12,3	15	21,8	28,7	2,5	4,9	13,6	18,1
2024	9,8	10,3	18,8	13,5	3,1	6,1	1,5	1,7	2,4	7	13,9	10,6

Figure 3. Average Rainfall in Semarang, 2022 to 2024

This condition ultimately contributes to an increase in the adult mosquito population. As the adult mosquito population increases, the risk of dengue transmission also increases (Mordecai *et al*., 2017).

An epidemiological study in Bangladesh found a significant association between air humidity and dengue fever cases (Islam et al., 2018). These results indicate that humidity not only affects mosquitoes but also has a significant impact on dengue epidemiology. The increase in dengue cases at high humidity levels can be explained by the increase in the population of more resilient vectors. A meta-analysis conducted by Abdullah et al. (2022) also confirmed that humidity is one of the climatic factors consistently associated with dengue outbreaks. This strengthens the evidence that humidity should be closely monitored in early warning systems for vector-borne diseases. At high humidity, mosquito flight activity also increases because environmental conditions are more favorable for their mobility. More intense flight activity increases the chances of mosquito contact with humans (Umakanth & Suganthan, 2020).

With increased contact, the risk of dengue virus transmission also increases. Humidity also plays a role in the survival of the virus within the mosquito's body (Cahyati & Fitriani, 2020). Humid conditions help maintain the mosquito's internal stability, thus improving the virus's replication process. Therefore, mosquitoes living in high humidity are more efficient at transmitting the virus to humans (Cahyati *et al.,* 2019). Monthly humidity fluctuations during the 2022–2024 period remained above the minimum threshold required for mosquitoes (Fakhriadi *et al.,* 2023). This explains why the risk of dengue remains high throughout the year, with no periods being completely unfavorable. From a control perspective, high humidity complicates efforts to suppress mosquito populations due to their higher survival rate. Therefore, public health interventions must be tailored to the humidity patterns in a region. For example, mosquito nest eradication (PSN) activities need to be intensified during periods of high humidity to suppress vector reproduction. Overall findings indicate that humidity levels of 65.1–85.7% during 2022–2024 provide strong ecological support for the Aedes mosquito life cycle. Thus, humidity can be categorized as a key climatic factor that directly and indirectly increases the risk of dengue transmission in the study area (Cahyati & Siyam, 2019).

Rainfall shows significant fluctuations

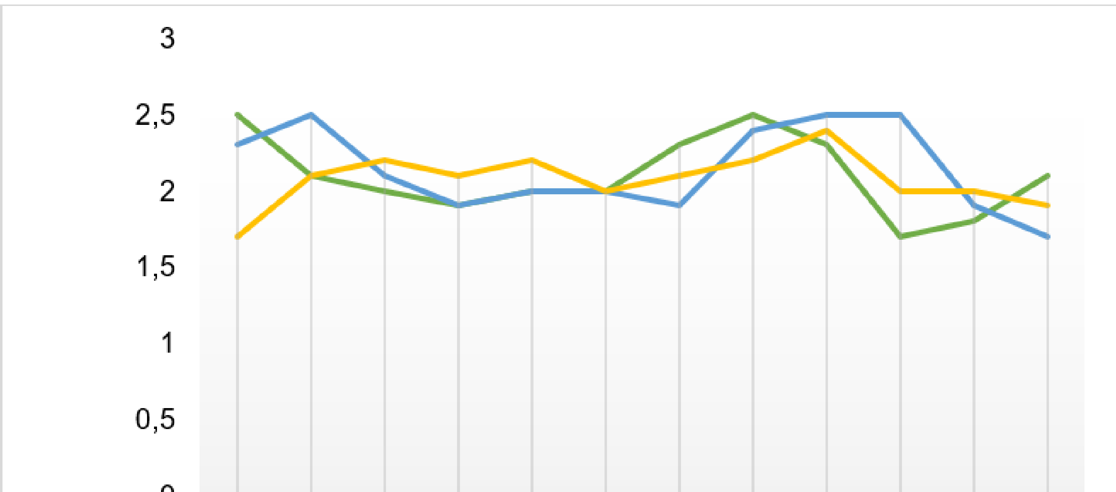
each month. The duration and quantity of rainfall are related to the breeding of Aedes mosquitoes (Andhikaputra *et al.*, 2023). High rainfall affects the availability of ideal breeding sites for mosquitoes (Ogieuhi *et al.*, 2025). High rainfall causes puddles to form, which can become breeding sites for mosquitoes to lay their eggs. Previous studies have shown that the highest number of dengue cases coincides with high rainfall (Borges *et al.,* 2024).

Rainfall is a climatic factor that significantly influences the population dynamics of the Aedes aegypti mosquito. Data shows that rainfall fluctuates significantly each month during the observation period. This fluctuation is directly related to the availability of mosquito breeding habitats. Andhikaputra et al. (2023) explain that the duration and quantity of rainfall are closely related to the Aedes mosquito breeding process.

Heavy rainfall creates puddles that can serve as potential breeding grounds for mosquitoes. These puddles can form in natural environments, such as holes in the ground, or in artificial containers like used cans, buckets, or tires. Ogieuhi et al. (2025) confirm that high rainfall increases the availability of ideal breeding sites for Aedes mosquitoes. The more puddles available, the greater the opportunity for an increase in the mosquito larval and pupal populations. This condition ultimately contributes to an increase in the number of adult mosquitoes in an area. More adult mosquitoes mean an increased risk of dengue virus transmission to the human population (Mordecai *et al.*, 2017).

Increased rainfall can also prolong the cycle of stagnant water, maintaining mosquito breeding sites for extended periods. This not only increases mosquito populations but also allows them to persist throughout the rainy season. Urban environments are often more vulnerable to this problem due to the abundance of man-made reservoirs that collect rainwater. This situation demonstrates that the interaction between climate and environmental factors significantly determines the risk of dengue transmission (Umakanth & Suganthan, 2020).

Previous research has found that peak dengue cases often coincide with periods of high rainfall (Borges et al., 2024). This suggests that rainfall can be an important epidemiological indicator in predicting dengue outbreaks. When rainfall lasts longer and more frequently, mosquito breeding intensity increases significantly. Therefore, the risk of dengue infection in the human population also increases during the rainy season. In addition to creating new habitats, rainfall also affects air humidity. The increased humidity caused by



	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2022	2,5	2,1	2	1,9	2	2	2,3	2,5	2,3	1,7	1,8	2,1
2023	2,3	2,5	2,1	1,9	2	2	1,9	2,4	2,5	2,5	1,9	1,7
2024	1,7	2,1	2,2	2,1	2,2	2	2,1	2,2	2,4	2	2	1,9

Figure 4. Wind Speed in Semarang, 2022 to 2024

rainfall also increases the mosquito's chances of survival. Thus, heavy rainfall has a dual effect: providing breeding sites while creating an ideal environment for adult mosquitoes. This cycle is highly dangerous because it can trigger a rapid explosion in mosquito populations. It is not surprising that dengue epidemics often occur during periods of high rainfall. This condition has been consistently reported in various tropical countries with similar climate patterns (Ogieuhi *et al*., 2025).

The results show that wind speed in 2022-2024 will be stable between 1.7 and 2.5 m/s. A study in Yogyakarta shows a negative correlation between wind speed and dengue cases, indicating that low to moderate wind speeds are more conducive to mosquitoes spreading, while high wind speeds disrupt mosquito flight activity (Yue *et al.,* 2019). Another study also states that wind speed correlates with the incidence of dengue fever (Hossain *et al*., 2023). The research results show that wind speeds during the 2022–2024 period were relatively stable, ranging from 1.7 to 2.5 m/s. This range can be categorized as low to moderate wind speeds, which are often found in tropical regions, including Indonesia (Zannah & Sulistyawati, 2020). This wind speed stability is important to study in relation to the spread of vector-based diseases, particularly dengue fever. Wind speed stability within this range indicates that there are no extreme fluctuations that could affect the flight patterns of insects, including the Aedes aegypti mosquito. This type of mosquito is the main vector of dengue fever. Therefore, understanding the interaction between wind speed and mosquito activity is crucial (Yue *et al.,* 2019).

When wind speeds are higher, mosquito flight activity is disrupted. Mosquitoes struggle to maintain their body direction and stability against gusts of wind. As a result, the mosquito's potential to bite humans decreases, thus reducing the spread of the disease. This finding is consistent with other studies, such as those reported by Hossain et al. (2023). This study confirmed a relationship between wind speed and dengue fever incidence. Therefore, microclimate factors, particularly wind, cannot be ignored in understanding the epidemiology of this disease.

From a mosquito ecological perspective, low to moderate wind speeds are optimal for their daily activities. Female mosquitoes are typically active in the morning and evening, when wind speeds tend to decrease. Therefore, stable conditions of 1.7–2.5 m/s can support this behavior. However, if wind speeds are too low, for example, approaching 0 m/s, the air becomes calmer, and environmental circulation decreases. This can actually increase mosquitoes' comfort while increasing the risk of human interaction (Ogieuhi *et al*., 2025).

Conversely, excessively high wind speeds can suppress mosquito populations. This is not only due to the disrupted flight but also because the aerial mating process becomes difficult. This can impact the number of adult mosquitoes. In the context of the spread of dengue fever, understanding wind speed is crucial for vector control programs. If data indicates a specific period with low wind speeds, the risk of dengue transmission can be predicted to increase (Mordecai *et al*., 2017).

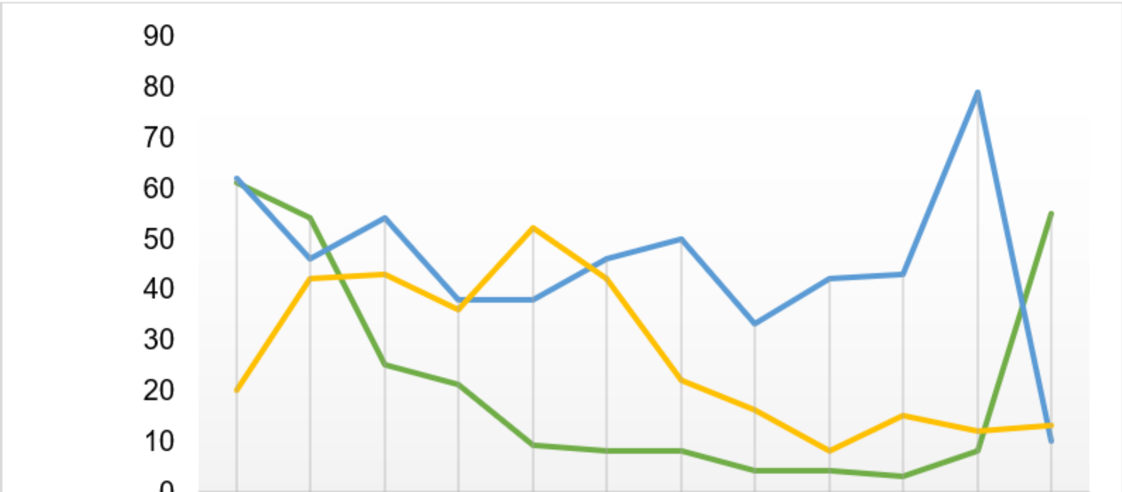
These predictions can help local governments establish prevention strategies. For example, intensified fogging programs, mosquito nest eradication, and public education can be scheduled more precisely according to environmental conditions. The negative relationship between wind speed and dengue cases can also be explained through mosquito behavior theory. Mosquitoes rely on chemical signals and human body heat to locate hosts. Strong winds will spread these signals more quickly, making it difficult for mosquitoes to track the source. Conversely, in weak wind conditions, chemical signals emitted by humans, such as carbon dioxide, can accumulate longer around the body. This makes it easier for mosquitoes to find hosts and increases the likelihood of a bite (Yue *et al.,* 2019).

Another contributing factor is the availability of mosquito larval habitat. While wind speed doesn't directly affect standing water, climate stability, which supports a certain humidity, can extend the lifespan of larval habitats. In the long term, the stability of wind speeds in 2022–2024 indicates that environmental conditions have remained relatively unchanged in terms of their ability to support mosquito life. This means that other environmental factors, such as temperature and rainfall, will be more dominant in influencing case dynamics. However, this doesn't mean wind speed can be ignored. In fact, this factor is important as a supporting indicator for epidemic prediction. When combined with other climate factors, wind speed data can strengthen the accuracy of prediction models (Ogieuhi *et al.*, 2025).

These results offer practical benefits in disease control. In addition to technical strategies, educating the public about the role of wind in mosquito transmission can increase participation in prevention. However, further research is needed, particularly experimental studies that directly observe mosquito behavior under varying wind speeds in the field. This could strengthen the validity of correlational findings. Overall, it can be concluded that the stability of wind speeds in the 2022–2024 range of 1.7–2.5 m/s has significant implications for dengue epidemiology. With evidence of negative correlation, vector control needs to be more intensive during periods of weak winds, so that dengue cases can be suppressed effectively (Rocklöv & Tozan, 2019).

The number of dengue fever (DHF) cases in Semarang City from 2022 to 2024 showed a fluctuating pattern. This fluctuation reflects the strong influence of environmental factors, climate, and community behavior on the dynamics of the disease. Data shows that the peak of dengue fever cases occurred in 2023, higher than in 2022 and 2024. This indicates specific conditions in that year that favored an increase in the Aedes aegypti mosquito population and an increased risk of transmission in the community.

Environmental factors are a key determinant of this fluctuation. Semarang City, as a coastal area with relatively high rainfall, is highly susceptible to the formation of stagnant water. These stagnant waters then become potential habitats for mosquito larvae. The significant increase in cases in 2023 could be attributed to climate anomalies, such as high rainfall or erratic seasonal patterns. These conditions extend the availability of mosquito breeding sites, leading to an increase in the vector population. Furthermore, high population mobility in Semarang also contributes to the spread of cases. With high population density, interactions between humans and mosquito



	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
2022	61	54	25	21	9	8	8	4	4	3	8	55
2023	62	46	54	38	38	46	50	33	42	43	79	10
2024	20	42	43	36	52	42	22	16	8	15	12	13

Figure 5. Dengue Cases in Semarang, 2022 to 2024

vectors become more intense, thus increasing the risk of transmission (Ogieuhi *et al*., 2025).

Every month, dengue fever cases in Semarang generally spike from December to April or May. This period coincides with the rainy season in Central Java, with high rainfall and increased humidity. This high rainfall during this period leads to numerous puddles, both in households and public spaces. These puddles are ideal breeding grounds for Aedes aegypti mosquito larvae. In addition to rainfall, temperatures from December to May are also relatively warm. Warm temperatures and high humidity are an optimal combination for the mosquito's life cycle, from egg to adult (Yue *et al.,* 2019).

The annual fluctuations between 2022 and 2024 demonstrate that dengue fever is not merely a seasonal problem but is also influenced by long-term environmental dynamics. Therefore, management strategies must be sustainable, not merely reactive when cases increase. The peak of cases in 2023 can serve as an important evaluation. The government and the public need to understand the factors causing this spike, whether it is due to extreme climate, weak vector control, or a combination of both. In addition to environmental factors, the epidemiological surveillance system also plays a role. The surge in cases could also be related to increased case detection and reporting, especially if health facilities are more active in recording cases (Haider *et al*., 2025).

Conclusion

The results of the descriptive analysis show dengue fever cases show a fluctuating trend, with the highest number in 2023 at 541 cases or the number of DHF are 260 (2022), 541 (2023), and 321 (2024), and the climate factors play an important role in the dynamics of dengue cases in the period from 2022 to 2024. The average monthly temperature (26.8-31.3℃) and humidity (61.5-85.7%) were within the optimal range for the survival of Aedes mosquitoes and dengue virus replication. Temperature is a major environmental factor that significantly influences the life cycle of Aedes aegypti, the primary vector of dengue. High rainfall caused waterlogging, which became a breeding ground for mosquitoes, while low to moderate wind speeds were more conducive to the spread of mosquitoes.

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