Public Health Research Development
eISSN: 3063-3265
Doi: https://doi.org/10.36568/phrd.v2i2.36
Citation: J. E. Oktavia, Suprijandani, D. Nurmayanti, Marlik, and Setiawan, "Environmental and Larval Indices as Predictors of Dengue Hemorrhagic Fever: A Five-Year Spatial Study in Surabaya, Indonesia", *PHRD*, vol. 2, no. 2, pp. 61–74, Oct. 2025.

Article

Environmental and Larval Indices as Predictors of Dengue Hemorrhagic Fever: A Five-Year Spatial Study in Surabaya, Indonesia

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Receive: 2025-07-30
Revised: 2025-10-24
Accepted: 2025-10-31

Key words:
1. Dengue Hemorrhagic Fever
2. Aedes aegypty
3. Geographic Information System

Abstract
Dengue Hemorrhagic Fever cases are one of the public health problems that are endemic in the Sememi Health Center working area. This study analyzes the relationship between environmental factors that influence dengue fever cases, including the larval index, rainfall, temperature, and humidity in the working area of the Sememi Community Health Center, which recorded 183 cases from 2020 to 2024.This study utilized a cross-sectional analytical design, with analysis conducted on 60 monthly secondary data collected over five years. The correlation test results show that only the number of free larvae has a significant relationship with cases of dengue fever (Sig.= 0.000), while other climate factors do not. These findings confirm the crucial role of the number of free larvae as a determining indicator of dengue fever cases. The main limitation of this study is the aggregate and secondary nature of the data, which does not allow for confirmation of cause and effect, but only correlation. Based on these findings, it is recommended that the Mosquito Nest Eradication program be strengthened as a top priority in efforts to control dengue fever.

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Introduction

Dengue fever remains a serious public health problem in tropical and subtropical regions, with tens of millions of infections each year burdening the health systems and economies of affected communities [1]. Dengue is transmitted by the Aedes aegypti and Aedes albopictus mosquitoes, so the population dynamics of these vectors are the main determinants of changes in disease incidence at the local and settlement levels [2]. In Indonesia, the pattern of dengue hemorrhagic fever shows seasonal fluctuations and episodic increases that are often associated with ecological and human behavioral changes. Therefore, effective preventive interventions must be based on an understanding of the environmental and entomological factors that influence the risk of transmission [3].

Climate variables such as rainfall, temperature, and humidity have long been identified as influencing the life cycle of Aedes and the potential for dengue transmission, because rainfall determines the availability of larval habitats, temperature affects the rate of larval development and the ability of the virus in vectors, and humidity affects the survival of adult mosquitoes and biting patterns [4]. However, the statistical relationship between these climate variables and case incidence is often contextual: some studies find strong correlations between temperature/rainfall and dengue incidence, while others report weak or insignificant results, depending on the temporal scale, spatial scale, and intermediate variables analyzed [4]. Therefore, analysis combining climate data with entomological indicators and spatial mapping is important for interpreting local variations in dengue risk [5].

Local-scale entomological indicators, such as the Larval Index or other entomological indices (House Index, Container Index, Breteau Index), describe the density and distribution of potential Aedes breeding sites in residential environments and are often directly associated with the risk of transmission [6]. Several regional studies report that areas with low Larval Index (or high larva index) tend to experience higher incidence of dengue fever, making mosquito fogging and nest eradication programs that increase the Larval Index a key preventive intervention [7]. However, the effectiveness of Aedes mosquito population predictions in forecasting clinical cases of dengue fever is also influenced by the quality of entomological data collection, surveillance frequency, community behavior, and microenvironmental factors that are difficult to record through macroclimate data [8].

The use of Geographic Information Systems to map case distribution and risk indicators has improved surveillance capabilities and area-based intervention planning [9]. Spatial mapping techniques enable the identification of clusters of dengue fever cases, vulnerability zoning, and spatial correlations between environmental variables and disease patterns that are not apparent in aggregate analysis alone [10]. In many studies, the combination of statistical analysis (e.g., Spearman's correlation, regression, or spatial models) and GIS output provides stronger evidence for targeted control measures than non-spatial analysis alone [5].

However, current literature shows substantial variation in results: several multisite studies and systematic reviews report that climate variables can explain most of the seasonal variation in dengue at the regional level, while local ecological studies often find that local entomological indicators (such as larval density) explain case variation more strongly than macro-level climate variables over a given time period [4]. This difference indicates that the relative contribution of climatic versus entomological factors is scale-dependent and influenced by urban environmental heterogeneity, sanitation conditions, population density, and social dynamics such as compliance with mosquito control measures [3].

In the Indonesian context, several spatial and local ecological studies have shown that urban areas with high population density and poor entomological indices are often the location of dengue fever clusters. However, not all studies have found a consistent relationship between rainfall/temperature and the incidence of dengue fever, indicating the need for studies that integrate periodic entomological data, local climate parameters, and spatial mapping to explain local patterns [3]. Field studies in several districts/cities also emphasize that the decline in the national Larvae-Free Rate (<95% target) is related to a spike in cases in certain years, so mosquito breeding site eradication programs must be strengthened based on clear spatial and temporal evidence [7].

Developing analytical techniques, including the use of logistic models to predict larval habitats based on container characteristics and water quality, as well as the integration of GIS with machine learning, have shown potential for improving the accuracy of larval distribution predictions and high-risk areas at the household and village levels [8]. This approach allows for more efficient intervention by prioritizing locations that are ecologically and behaviorally likely to produce Aedes breeding sites [8].

Although these methodological advances are promising, there are important gaps in the empirical evidence: many local studies are still retrospective and use aggregate data that limits causal inference, and the frequency of Larval Index measurements is not high enough to capture the rapid dynamics of larval populations on a month-to-month scale [3]. In addition, the heterogeneity of entomological survey methodologies and differences in indicator definitions (e.g., variations in the calculation of the Larval Index or sampling periods) hinder cross-study comparisons and robust evidence synthesis [6].

Another gap is the lack of simultaneous integration between periodic entomological data, monthly-resolution local climate data, and consistent spatial analysis at the subdistrict level over a period of more than several years; this limitation reduces the ability to assess whether the observed correlations are consistent throughout the epidemiological cycle or are merely temporary phenomena resulting from episodic climate fluctuations [4]. Furthermore, few studies have comprehensively examined the validity of the Larva Free Index as a key predictive indicator for clinical cases of dengue fever at the subdistrict level over a multi-year period in Indonesia, even though national policy has designated the Larva Free Index as one of the key target indicators [7].

Based on this review of the state of scientific knowledge, empirical studies combining appropriate non-parametric statistical analysis (e.g., Spearman for non-normal data), spatial visualization with ArcGIS, and multi-year temporal evaluation of the relationship between Larval Index, rainfall, temperature, humidity, and the incidence of dengue fever at the sub-district level will fill the existing evidence gap. This approach will not only strengthen the evidence base for area-based interventions, but also help validate whether the focus on increasing the Larvae-Free Index (through Mosquito Breeding Site Eradication) actually has a consistent impact on reducing dengue fever cases in the Indonesian urban context.

Materials and Method

Research Design and Location

This study used an observational analytical design with a cross-sectional approach. This approach was chosen to analyze the relationship between environmental factors and the incidence of dengue fever in the working area of the Sememi Community Health Center, Surabaya City, East Java Province, which covers four administrative villages. The study covers a five-year period, from January 2020 to December 2024, with a focus on analyzing climate variations and entomological conditions related to fluctuations in dengue fever cases in the area. This design allows researchers to identify the correlational relationship between environmental variables such as rainfall, air temperature, humidity, and larval index with the incidence of dengue fever without intervening in the variables being studied.

Population and Research Subjects

The population in this study was all cases of dengue hemorrhagic fever recorded in the Sememi Community Health Center working area during the period 2020–2024. The research analysis unit was monthly aggregate data from each sub-district in the community health center working area. Each sub-district contributed monthly data for five years (60 months), resulting in a total of 240 observation units (4 sub-districts × 60 months). Dengue Hemorrhagic Fever case data were obtained from official reports from the Sememi Community Health Center and verified using secondary data from the Surabaya City Health Office. Because this study used secondary data, it did not involve the direct participation of individual respondents.

Data Sources and Types

This study used secondary data obtained from several government agencies. Data on the number of dengue fever cases, larval index, rainfall, temperature, and humidity were collected from the Sememi Community Health Center, Surabaya City Health Office, Central Statistics Agency, and Surabaya City Meteorology, Climatology, and Geophysics Agency. The dependent variable of the study was the monthly number of dengue fever cases, while the independent variables included the number of mosquitoes, rainfall (mm), air temperature (°C), and air humidity (%). These variables were selected because they biologically and ecologically influence the life cycle and density of Aedes aegypti mosquitoes, which are the main vectors for the transmission of dengue hemorrhagic fever.

Data Collection Procedures

Data was collected through official requests to relevant agencies covering a five-year period (2020–2024). Rainfall, temperature, and humidity data were adjusted according to monthly climatology reports from the Meteorology, Climatology, and Geophysics Agency to align with the period of dengue fever cases. Larva-free data were obtained from routine entomological surveys conducted by environmental health officers through inspections of water storage containers in residents' homes and public facilities. The data obtained were compiled into a standardized monthly data series for temporal and spatial analysis.

Analysis Instruments and Devices

This study analysis uses two main tools, namely ArcGIS software and SPSS (Statistical Package for the Social Sciences). ArcGIS is used to create spatial maps, analyze the geographical distribution of dengue fever cases, and visualize the relationship between the number of mosquito larvae and the distribution pattern of cases. SPSS is used to perform descriptive statistical analysis and correlation tests between variables. Spatial processing was carried out using geocoding techniques on the administrative boundaries of each sub-district, followed by an overlay of dengue fever case data, mosquito larvae counts, and environmental parameters to produce annual thematic maps. These maps provide a visual representation of the spatial and temporal dynamics of dengue fever case distribution, enabling more accurate identification of high-risk areas.

Data Analysis

The collected data was then processed through verification, tabulation, and statistical analysis stages. The initial stage involved descriptive analysis to describe the general characteristics of the data, such as monthly trends in dengue fever cases, fluctuations in the number of mosquito larvae, and variations in rainfall, temperature, and humidity during the five years of observation. The results of the descriptive analysis were visualized in the form of tables, line diagrams, and thematic maps so that seasonal patterns and differences between years could be clearly seen. The next stage involved inferential analysis using Spearman's rank correlation test (Spearman's rho) to assess the relationship between the number of dengue fever cases and environmental factors. The Spearman test was chosen because the data was non-parametric and did not meet the assumptions of normal distribution. The test was conducted with a significance level (α) of 0.05. A p-value < 0.05 indicated a significant relationship between the variables tested, while a p-value ≥ 0.05 indicated no significant relationship.

Spatial Analysis Using GIS

Spatial analysis using ArcGIS produced a map of the distribution of dengue fever cases based on the category of mosquito larvae-free numbers for each year of observation. Each case point is mapped to the administrative area of the sub-district and given a symbol indicating the intensity of the incident. The map shows that Sememi Sub-district consistently had the highest number of cases during the five years of observation and had a low Larvae-Free Index value, thus categorizing it as an area with a high risk of Dengue Hemorrhagic Fever transmission. Spatial visualization also shows changes in the Larva-Free Index color in several subdistricts, such as Kandangan Subdistrict, which shifted from the moderate to high risk category in 2023–2024. These mapping results reinforce the statistical test findings that entomological factors are most significantly associated with an increase in dengue fever cases, while also providing a basis for more targeted area-based interventions.

Research Ethics Considerations

This study used aggregate secondary data obtained from government agencies without involving individual identities, thus posing no ethical risks to human subjects. Nevertheless, the researchers obtained written permission from the Sememi Community Health Center and the Surabaya City Health Office to use the research data. All data was kept confidential and used only for academic purposes and the development of public health science.

Results

Distribution of Dengue Fever Cases in the Sememi Community Health Center Working Area from 2020 to 2024

Based on the data of Dengue Hemorrhagic Fever cases in the working area of Sememi Public Health Center from 2020 to 2024, there was a fluctuation in the number of cases. The case distribution showed a seasonal pattern, with the peak generally occurring at the beginning of the year. The year 2022 recorded the highest total number of cases, with a significant surge in March reaching 20 cases.

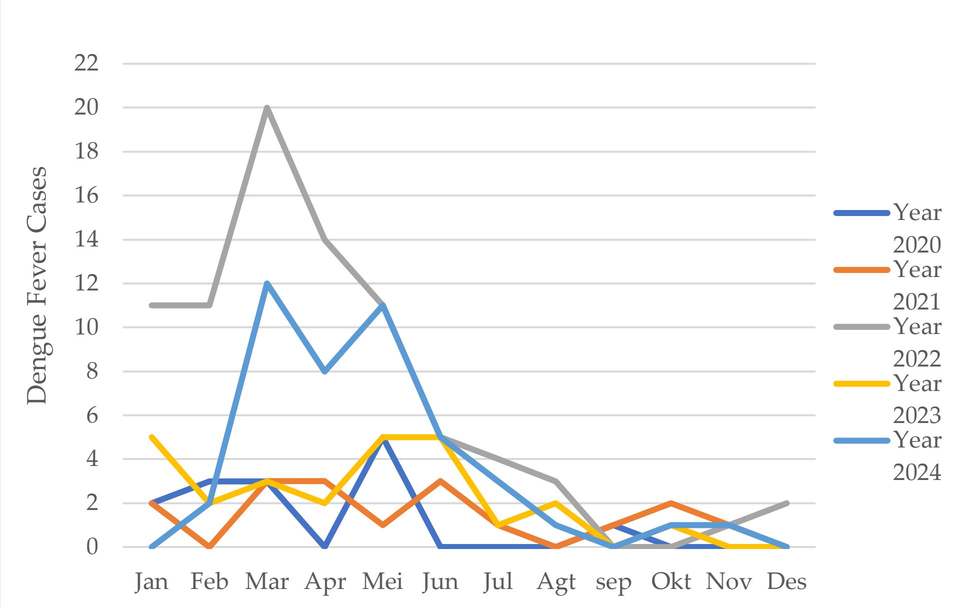

Figure 1 Graph of Dengue Fever Case Distribution in the Sememi Community Health Center Working Area 2020-2024

Distribution of Larvae-Free Figures in the Seememi Community Health Center Working Area for 2020-2024

Based on the Larvae Free Rate data in the working area of Sememi Public Health Center from 2020 to 2024, fluctuations were observed. The highest Larvae Free Rate rates were recorded in 2020 and 2021 at 93%, while the lowest Larvae Free Rate occurred in 2022 at 81%.

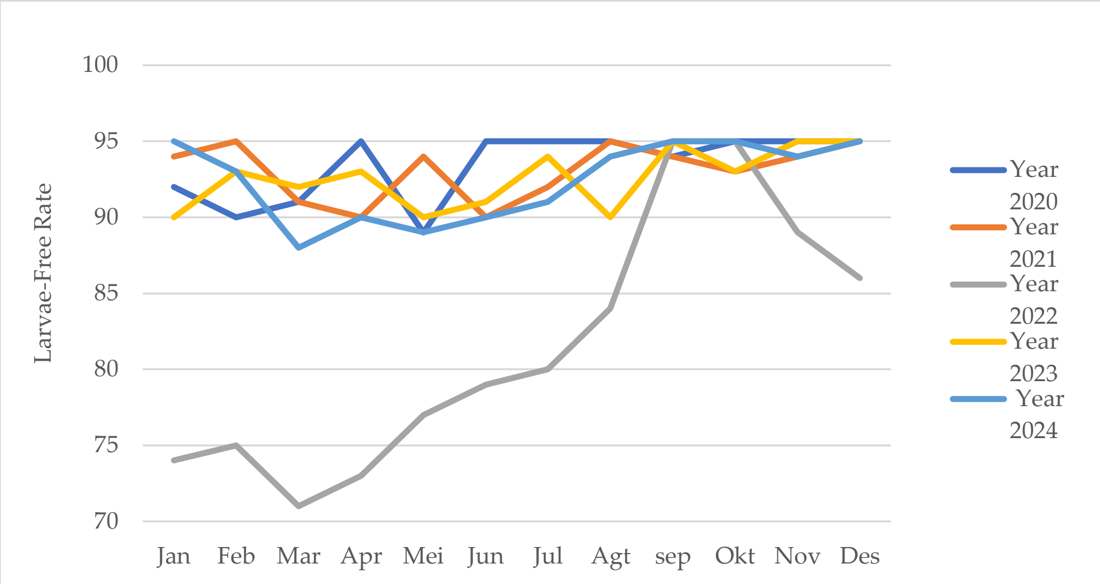

Figure 2. Graph of the Distribution of Larvae-Free Rate in the Sememi Community Health Center Working Area 2020-2024

Rainfall Distribution in the Sememi Community Health Center Working Area for 2020-2024

Figure 3 presented data on the distribution of monthly rainfall in the working area of Sememi Community Health Center during the years 2020–2024. The wettest months with the highest rainfall tended to occur at the beginning and end of the year, particularly in January, February, March, November, and December. The driest months with low or even zero rainfall often occurred in the middle of the year, such as in July, August, September, and October. The highest average rainfall was recorded in 2020, reaching 196.45 mm.

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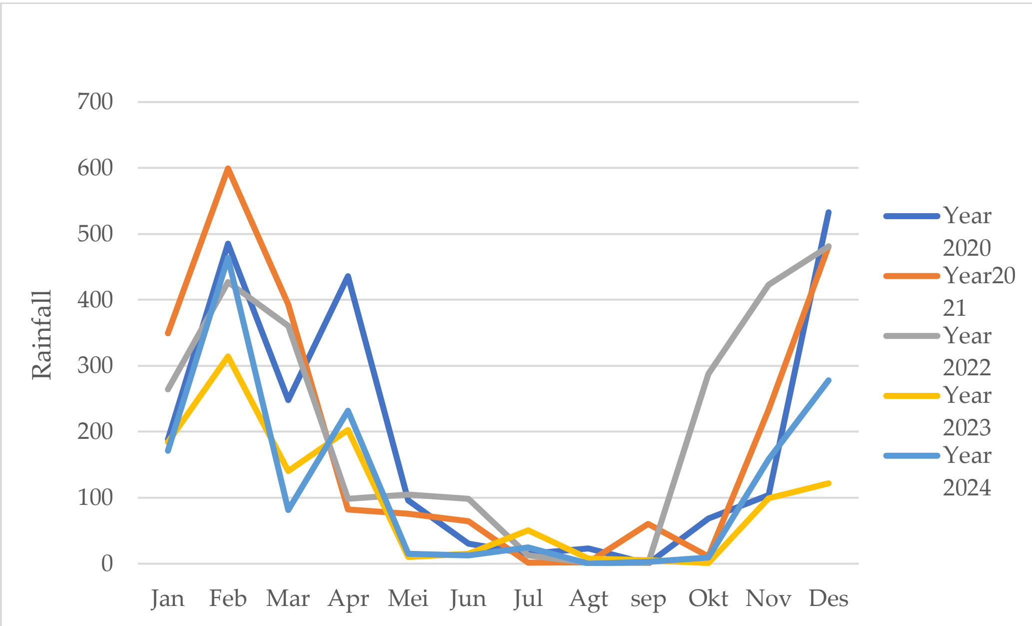

Figure 3 Rainfall Distribution Graph in the Sememi Community Health Center Working Area 2020-2024

Temperature and Humidity Distribution in the Sememi Community Health Center Working Area from 2020 to 2024

Based on Figures 4 and 5, there were fluctuations in monthly temperature and humidity in the Sememi Community Health Center working area during the 2020–2024 period. Despite differences in values between years, the general pattern of higher temperatures in the middle of the year and humidity that varied according to the season remained apparent. The average monthly temperature tended to range between 27°C and 30°C, while humidity varied between 65% and 84%.

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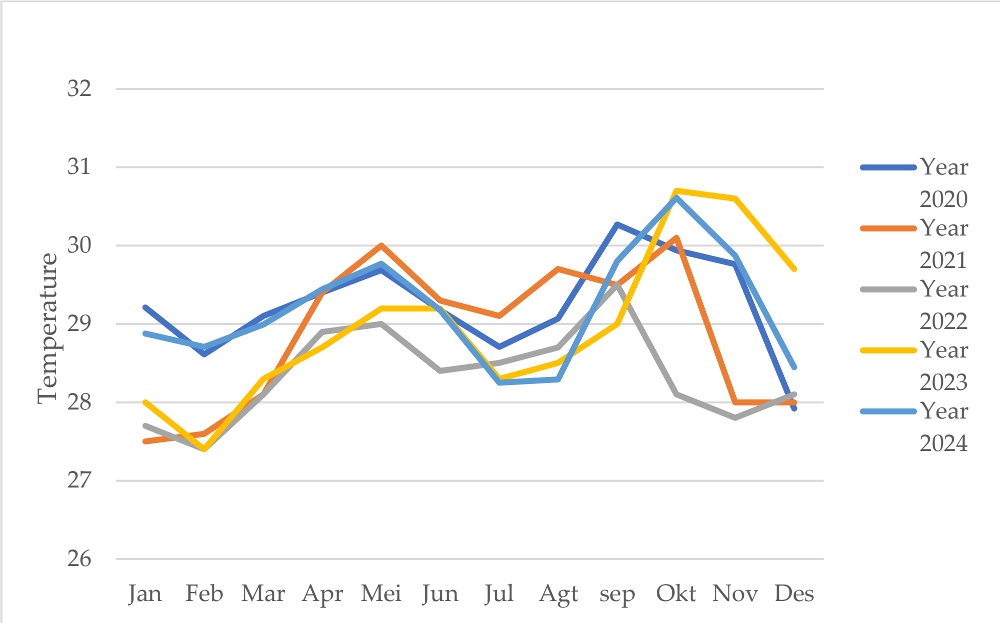

Figure 4 Temperature Distribution Graph in the Sememi Community Health Center Working Area from 2020 to 2024

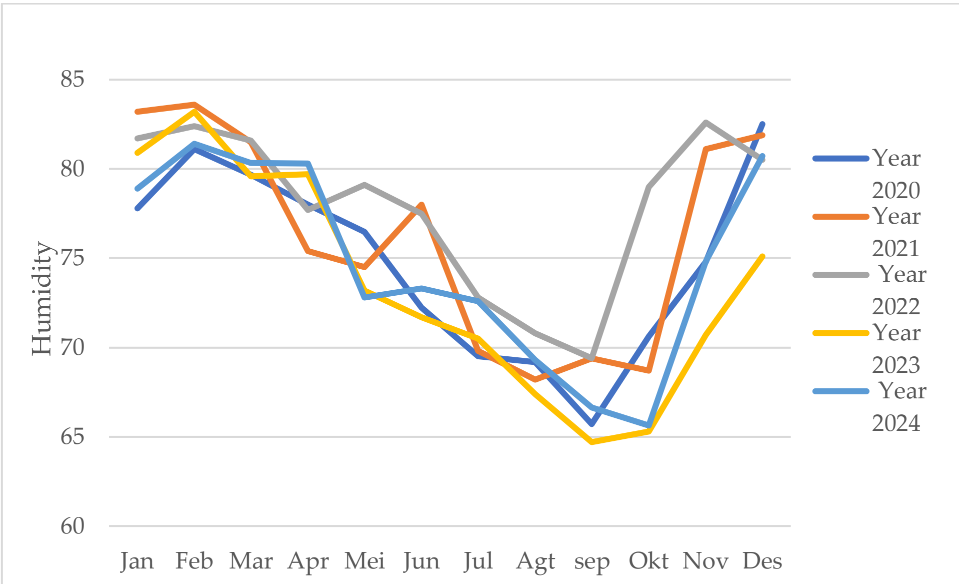

Figure 5 Graph of Humidity Distribution in the Sememi Community Health Center Working Area from 2020 to 2024

Overview of Dengue Fever Distribution Based on Larvae-Free Rates in the Sememi Community Health Center Work Area from 2020 to 2024

The map of the Sememi Community Health Center's working area illustrated the distribution of dengue fever cases based on the Larva-Free Rate during the 2020–2024 period. Based on the map of dengue fever case distribution and the Larva-Free Rate, the highest number of cases occurred in 2022. The lowest number of dengue fever cases was recorded in 2021, with Sememi Village having the highest number of cases year after year.

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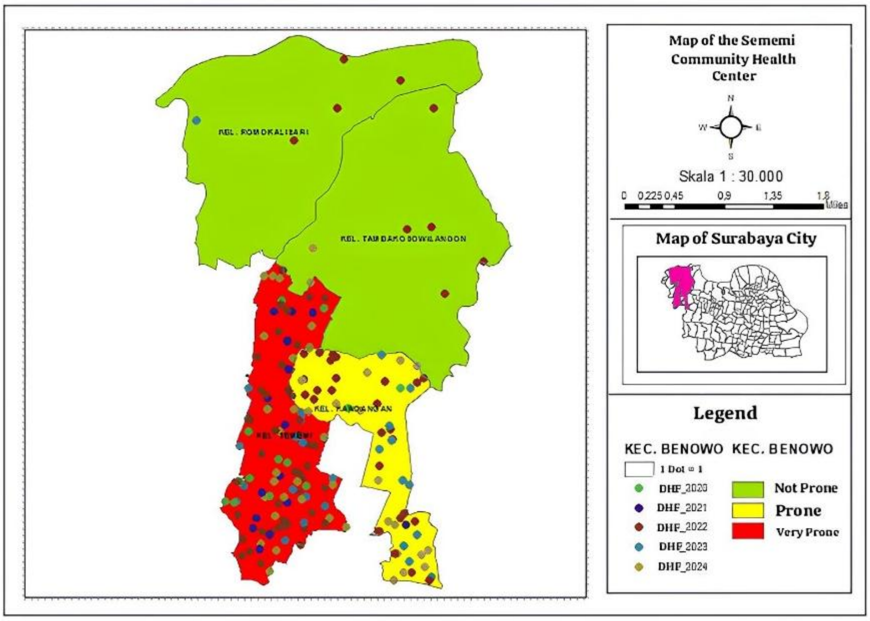

Figure 6 Map of dengue fever distribution based on Larva-Free Rate in the Sememi Community Health Center working area 2020-2024

Analysis of the Relationship between Dengue Fever Cases Based on Larvae-Free Rates, Rainfall, Temperature, and Humidity in the Sememi Community Health Center Working Area from 2020 to 2024

Table 1 Correlation analysis of dengue fever cases based on Larva-Free Rate, rainfall, temperature, and humidity

Variable	N	Correlation (r)	Significant (p)	Description
Larva-free rate with dengue fever cases	60	-.952**	.000	There is a correlation between the Larva-free rate and dengue fever cases.
Rainfall with dengue fever cases	60	-.101	.442	There is no correlation between rainfall and dengue fever cases.
Temperature with dengue fever cases	60	.066	.617	There is no correlation between temperature and dengue fever cases.
Humidity in dengue fever cases	60	.237	.068	There is no correlation between humidity and dengue fever cases.

The Larva-free rate data results show a relationship between dengue fever cases with a value (Sig. = 0.000) smaller than 0.05 (α). The variables of Temperature (Sig. = 0.617), Humidity (Sig. = 0.068), and Rainfall (Sig. = 0.617) do not show a significant relationship with dengue fever cases, due to their significance values.

Discussion

Data on dengue fever cases at the Sememi Community Health Center shows a clear seasonal trend in the spread of dengue fever at the Sememi Community Health Center. An extreme spike in cases occurred in 2022 with 82 cases, more than three times the number of cases in the previous year. The beginning of the year (January, February, March) consistently saw an increase in cases, especially in 2022 and 2024. After reaching its peak, dengue fever cases dropped sharply in the middle of the year (July-September), with some months even recording no cases. Toward the end of the year (October-December), there is a tendency for cases to increase again, although the volume is not comparable to the peak at the beginning of the year.

Indonesia is facing a significant increase in dengue fever cases, with a total of 131,265 cases recorded in 2022. This report shows a 56% increase from 73,518 cases in the previous [11]. Fatmasari et al. (2023) in their study in Semarang City showed an upward trend over the last three years since 2020. Dengue fever cases in Situbondo have fluctuated over the past three years since 2019 [12]. Data from the Health Department revealed a drastic increase of up to threefold, reaching 857 cases in 2022 [13].

Researchers believe that dengue fever follows a consistent seasonal pattern, with cases peaking at the beginning of the year and declining towards the middle of the year, indicating a recurring annual cycle. Therefore, aggressive prevention strategies through mosquito breeding site eradication, fogging, and public education campaigns are effective in reducing the number of dengue fever cases.

In the highest average years, such as 2020 and 2021, the Larva Free Rate also did not meet the standard. A drastic decline in the Larva Free Rate, with an average of 81% in 2022, was observed, with almost all months falling far below the standard. The improvement in 2024 indicates progress, but it is not yet consistent in meeting the standards. This suggests that in certain months, efforts to eliminate mosquito breeding sites have decreased, compounded by environmental conditions that favor mosquito breeding.

Research by Khikma & Sofwan (2021) in Brebes Regency found that all subdistricts recorded a decrease in the Larva-Free Rate in 2022, and no subdistrict met the established standard [14]. The study by Mishbaahul Muniir et al. (2023) in Yogyakarta City revealed a significant association between variations in Larva-Free Rate transmission risk across neighborhoods and fluctuations in DBD incidence in the three neighborhoods [15]. The entomological index indicating larvae is an indicator of vector population. The higher the presence of larvae, the greater the risk of dengue fever transmission [16].

The fluctuating Larva-Free Rate in the Sememi Community Health Center working area from 2020 to 2024 reflects a pattern found in various other studies. The sharp decline in 2022 and the inconsistency in achievements in 2024 suggest that the control measures implemented are insufficient to address seasonal challenges and environmental variations. It is important to regularly conduct awareness campaigns about the risks of dengue fever, while also conducting regular monitoring of mosquito larvae.

Figure 3 shows significant fluctuations throughout the year. Rainfall peaks in certain months at the beginning of the year (January, February, March) and increases again at the end of the year (November, December). The middle of the year is dominated by dry months, with very low or even no rainfall at all in July, August, September, and October. Overall, 2020 was recorded as the year with the highest average rainfall, reaching 196.45 mm.

This study is in line with the research conducted by Arieskha et al. (2019) in Tegal, which showed that rainfall has a seasonal trend throughout the year. It was noted that January and February at the beginning of the year tend to have high rainfall. This period then experiences a gradual decline until its peak in September with lower rainfall. Rainfall increases toward the end of the year (October–December) [17]. Research in Bandar Lampung City during the period from 2015 to 2019 showed that the average rainfall pattern exhibited a significant trend. The months with the highest rainfall are consistently recorded in December, January, and February. Conversely, the drier period with much less rainfall occurs in June and July [18]. Rainfall intensity that is not heavy or moderate, but often interspersed with hot weather, effectively increases the number of breeding and hatching sites, thereby accelerating their reproduction [19].

This study indicates that the peak rainfall pattern occurs at the beginning of the year and decreases at the end of the year. Puddles and breeding sites remain available from the heavy rains. Researchers suggest that preventive interventions should be intensified during the transition period from the rainy season to the dry season, given that remaining water pools provide an ideal habitat for mosquitoes, and highlight the need for more specific prevention strategies tailored to seasonal patterns.

From Figures 4 and 5, it can be observed that the temperature and humidity at the Sememi Community Health Center show clear seasonal patterns. Months with high relative humidity (above 75-80%), such as January, February, November, and December, are often associated with slightly more stable or slightly lower temperatures, reflecting the rainy season. Conversely, during the middle of the year, particularly from July to September, humidity tends to decrease significantly, indicating a drier period, although temperatures remain within a relatively warm range. Interannual variations are also evident, with some years showing lower overall humidity compared to others.

In the study by Rakhmatsani & Susanna (2024), data shows that Bogor Regency consistently experiences the highest monthly humidity mostly during the period from January to February. The highest monthly temperatures in the region are generally recorded in April and May. This pattern indicates differences in climate characteristics at the beginning of the year compared to the middle of the [20]. Optimal humidity conditions make mosquitoes more active, thereby indirectly increasing the frequency of biting activity [4]. The optimal temperature for mosquito reproduction is 25°C–27°C. Mosquito growth slows down at 35°C and stops completely below 10°C or above 40°C [21].

Seasonal patterns of temperature and humidity in the Sememi Community Health Center area show that periods of high humidity, such as January, February, November, and December, have the potential to accelerate the life cycle of Aedes aegypti mosquitoes. The optimal temperature for mosquitoes ranges from 25°C to 27°C, which is still within the range that allows mosquitoes to breed and remain active throughout the year, even when humidity decreases and temperatures remain relatively warm. Regular monitoring of climatic conditions is an important strategy in planning for dengue fever prevention.

This map of the Sememi Community Health Center's working area illustrates the distribution of dengue fever cases during the 2020-2024 period and links them to the Larva-Free Index category in each sub-district within the Sememi Community Health Center's working area. The dots with symbols indicate the number of dengue fever cases. Based on the map of dengue fever case distribution and Larva-Free Rate, the highest number of dengue fever cases occurred in 2022, indicated by green dots. The lowest number of dengue fever cases was in 2021, with brown dots. Kandangan sub-district experienced a change in the Larva-Free Index color from yellow in 2022 to red in 2023-2024, indicating that Kandangan sub-district has become highly vulnerable in terms of the Larva-Free Index. Among all neighborhoods, Sememi should be given special attention every year, as it consistently has the highest number of DBD cases accompanied by a low or highly vulnerable Larva-Free Index. The results of this study indicate a correlation between dengue fever cases and the Larvae-Free Index in the Sememi Health Center's service area. A low Larvae-Free Index is always accompanied by a high number of cases in the Sememi Health Center's service area.

This study is in line with the research conducted by Reza et al. (2024), which indicates a strong relationship between the Larvae-Free Rate and the emergence of dengue fever cases [22]. The results of the study by Amelinda et al. (2022) in Jakarta state that if an area has a high Larvae-Free Rate, then that area has a low incidence of dengue fever cases [23]. The study conducted by Demes et al. (2024) in Kediri noted that a low Larval Index <95% in Kediri Regency indicates a high risk of DBD in that area. Neighborhoods with high DBD case rates have a high vulnerability to disease spread. Continuous monitoring and effective control measures must be implemented in neighborhoods at high risk of DBD case spread to prevent the disease from spreading to other neighborhoods [24].

Through the analysis of the data presented, the researchers highlight a strong correlation between the Larvae-Free Rate and dengue fever cases in the Sememi Community Health Center working area from 2020 to 2024. The visual data presented on the map clearly illustrates that a consistently low Larvae-Free Rate correlates with a high number of dengue fever cases. The Sememi sub-district, with the highest Larvae-Free Index, is the sub-district with the highest annual dengue fever incidence and should be the primary focus of attention. The shift in the Larvae-Free Index status of the Kandangan sub-district from high-risk to very high-risk in 2023-2024 indicates the need for swift intervention to prevent further spread of cases.

The results of the correlation analysis in the SPSS test show that of the four independent variables analyzed (Larval Index, Temperature, Humidity, and Rainfall), only the Larval Index variable has a statistically significant relationship with the number of dengue cases. The significance value of the Larval Index is 0.000 ($p < 0.05$), indicating that the Larval Index contributes most strongly to this model. This evidence reinforces that increasing the coverage of mosquito breeding site eradication, as represented by the Larval Index, can be a key factor in controlling dengue fever cases. The variables of temperature, humidity, and rainfall, although theoretically related to mosquito vector ecology, did not show a significant relationship in this model. The significance values for temperature (0.617), humidity (0.068), and rainfall (0.442) are above the 0.05 threshold, indicating that, within the context of the study area and period, these three environmental factors do not have a sufficiently strong association with the number of DBD cases.

This study is in line with the research by Reza et al. (2024), which found a strong correlation between the Larval Index and the distribution of dengue cases in the region, which was statistically significant (p=0.005) [25]. The correlation between the Larval Index and dengue fever cases is weak with a positive direction (r=0.108). Mosquito larvae density increases when the Larval Index is low, but there is no significant increase in dengue fever cases that can be predicted [26]. Rainfall (p=0.399) does not show a significant relationship with dengue fever cases. Another study in line with this is Asmuni et al., (2020), where rainfall did not show a significant correlation because the *p-value* was 0.119, but air temperature showed a correlated result with a *p-value* of 0.043 [27]. Based on the study by Virdayanti et al. (2025), with a p-value of 0.231, it can be concluded that humidity is not significantly correlated with DBD cases. Similarly, for temperature, with a p-value of 0.438, there is no significant correlative relationship between temperature and DBD [28].

The results of the correlation analysis highlight that the Larval Index is the only significant factor associated with dengue cases, with p=0.000, confirming the importance of mosquito breeding site eradication. Temperature, humidity, and rainfall are theoretically related, but this study shows no association (p>0.05). This study aligns with findings from other researchers who also found that climatic factors are not significant in relation to dengue fever. These findings highlight the importance of community-based behavioral interventions and strengthening mosquito breeding site eradication programs as the primary efforts in controlling dengue fever.

Conclusions

The results of the study show that areas with low Larval Index scores are associated with an increase in dengue fever cases in this ecological analysis, especially in the high-risk Sememi subdistrict. The Larval Index proved to be the most significant factor compared to rainfall, temperature, and humidity. However, because the design of this study was ecological and retrospective, the relationship found cannot be concluded as causality, but only shows a correlation at the population level. These findings highlight the importance of community-based behavioral interventions and the strengthening of mosquito breeding site eradication programs as key efforts in controlling dengue fever cases.

Conflicts of Interest

The researchers declare that there are no conflicts of interest related to this study.

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