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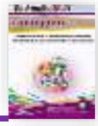

Environmental and Behavioral Factors of "3M Plus" Practices (Cover, Drain and Recycle) Associated with Dengue Fever Incidence in Cilongok District, Banyumas Regency

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Abstract

Dengue hemorrhagic fever has been a public health concern in Cilongok District evident by a sharp increase in its cases in the last two years. This study aims to analyze the relationship between physical, biological, and social environmental factors, as well as the behavior of 3M Plus, with the incidence of dengue hemorrhagic fever in Cilongok District, Banyumas Regency. The research followed a quantitative approach of observational analytics with a case-control design. A total of 60 respondents were involved, consisting of 30 cases and 30 controls that were selected using neighborhood-matched controls based on a residential distance of less than 100 meters. Data analysis was carried out using chi square test and logistic regression. The results of the study show a cumulative increase in dengue cases from 26 cases in 2023 to 126 cases in 2024. Spatial analysis showed an uneven distribution of cases with high concentrations in densely populated areas, especially Langgongsari Village, Pageraji Village, and Panusupan Village. Indoor temperature was significantly associated with the incidence of dengue (p = 0.038; OR = 3.500), as well as air humidity (p = 0.039; OR = 3.455). Biological factors measured through the House Index (p = 0.398; OR = 1.902) and Container Index (p = 0.398; OR = 1.902) do not indicate a meaningful relationship. In social environmental factors, the habit of hanging clothes was significantly related to the incidence of dengue (p = 0.004; OR = 5.675), as well as the absence of gauze wire in house ventilation (p = 0.008; OR = 5,231). The other 3M Plus behavioral variables did not show a significant relationship. This study shows that the incidence of dengue fever in Cilongok District is influenced by microclimatic conditions in the house and specific behaviors that increase the chances of human-vector contact. Efforts to control dengue need to integrate ventilation and humidity management of the house with targeted behavior change interventions, especially reducing clothing storage in the room and increasing household physical protection

Keywords: Dengue Hemorrhagic Fever, Environmental Factors, 3M Plus Behavior

INTRODUCTION

Vector-borne diseases (VBDs) are infections transmitted to humans and animals by blood-feeding arthropods, such as mosquitoes, ticks, fleas, and sandflies. The vectors carry pathogens (viruses, bacteria, parasites) from one to another. When a vector bites, it can infect the host, ingesting the pathogens that can multiply and be transmitted to a new host. Vector-borne diseases account for more than 17% of all infectious diseases globally and cause over 700,000 deaths each year due to infections transmitted by parasites, bacteria, or viruses (WHO, 2026). Since 2014, several vector-borne diseases, including dengue, malaria, chikungunya, yellow fever, and Zika, have re-emerged as major global public health threats with widespread outbreaks across multiple regions (WHO, 2024), and dengue hemorrhagic fever (DHF) is one of the most rapidly expanding vector-borne diseases worldwide.

Dengue is caused by the dengue virus (DENV), transmitted primarily by female Aedes aegypti and Aedes albopictus mosquitoes (Iryanti et al., 2024). The virus belongs to the genus Flavivirus in the Arbovirus group, and it is divided into four serotypes, namely, DENV-1, DENV-2, DENV-3, and DENV-4 (Wheaton et al., 2025). Infection with any of these serotypes can produce different kinds of symptoms, such as dengue fever, dengue hemorrhagic fever, and dengue shock syndrome, which can lead to serious complications if not treated seriously (Freppel et al., 2025).

Dengue cases have increased worldwide over the past decade, reaching a historic peak in 2023 with approximately 6,5 million cases and more than 7,300 deaths across 80 countries (World Health Organization, 2024). Southeast Asia remains a major hotspot, with several countries, including Indonesia, consistently ranking among those with the highest dengue cases globally. In Indonesia, dengue occurs in epidemic cycles, with a major resurgence in recent years. National surveillance data indicate a sharp rise in cases from 41.4 per 100.000 population in 2023 to 94 per 100.000 population in 2024, accompanied by 257.271 reported cases and 1.461 deaths (WHO, 2025),(Kementrian Kesehatan Republik Indonesia, 2024). Although the national case fatality rate has declined, mortality remains uneven across regions. Central Java reported one of the highest case fatality rates in 2023 at 2.15%, alongside a substantial increase in cases from 6.656 in 2023 to 17.028 in 2024, with Banyumas Regency recording the highest district-level case (Kementrian Kesehatan Republik Indonesia, 2024), (Dinas Kesehatan Provinsi Jawa tengah, 2024).

There has been an increase in dengue cases occurring in Banyumas Regency over recent years. Surveillance data from the Banyumas District Health Office indicate that dengue cases rose from 269 cases in 2023 to 2,213 cases in 2024, which evidences the escalation of dengue cases (Dinas Kesehatan Kabupaten Banyumas, 2025). Within Banyumas Regency, Cilongok Subdistrict has become the most affected areas. The cases of dengue increased from only 3 cases in 2021 to 126 cases in 2024, corresponding to an increase of more than 480%, with a reported case fatality rate of 1.4% (Dinas Kesehatan Kabupaten Banyumas, 2025). This sharp increase suggests the influence of specific and local environmental as well as behavioral factors that may contribute to the transmission of dengue in this specific region. The high rate of dengue occurrence is triggered by environmental and climate conditions. Some of the natural phenomena that can increase the transmission of dengue are such as rainfall, temperature, and humidity associated with climate phenomena such as El Niño and La Niña How can these natural phenomena influence dengue transmission? Increased rainfall and higher relative humidity prolong mosquito survival and accelerate population growth, thereby enhancing transmission potential (Farooq et al., 2025). Optimal temperatures ranging from 25–30°C further support mosquito longevity and viral replication, enabling faster progression to the infectious stage (Ismah et al., 2021).

Climate change is not the only factor contributing to dengue transmission. Physical and social environmental factors also play a crucial role in this transmission. Poor sanitation, high population density, inadequate water storage practices, and limited control of mosquito breeding sites are perfect causes that increase the spread of Aedes mosquitoes (Mentari & Hartono, 2023). Studies from systematic reviews and meta-analyses indicate that densely populated urban and peri-urban areas face substantially higher dengue risk due to intensified human–vector contact (Akbar et al., 2023). Community behavior, mobility patterns, and insufficient public awareness regarding mosquito control have also been identified as key drivers of dengue spread, particularly in semi-urban settings (Mubarak et al., 2020).

Spatial approaches provide important insights into the geographic distribution of dengue risk. Studies have proven that dengue cases often occur in places with specific geographic characteristics, for example, most cases of dengue can be seen in high indoor temperatures, elevated humidity, and proximity to water source areas (Bakung et al., 2024; Widyanto et al., 2024). Furthermore, changes in climate and land use interact with local behaviors to shape dengue transmission patterns over time (Marina et al., 2023). The growing body of spatial epidemiological research underscores the importance of integrating environmental, biological, and behavioral data to guide targeted interventions (Sari & Putri, 2024).

There is a lack of integrated, subdistrict-level studies that simultaneously examine physical, biological, and social environmental factors in high-risk areas such as Cilongok. Understanding how these factors interact within a localized context is essential for designing effective, evidence-based dengue control strategies. Therefore, this study aimed to analyze the association between environmental factors and 3M Plus behaviors with the incidence of dengue hemorrhagic fever in Cilongok Subdistrict, Banyumas Regency, using a case–control design complemented by descriptive temporal and spatial analysis.

METHODS

This study was conducted in Cilongok Subdistrict, Banyumas Regency, an area endemic for Dengue Hemorrhagic Fever (DHF). A quantitative analytical observational study with a retrospective case–control design was applied to examine the association between environmental risk factors and DHF incidence. Data collection for environmental measurements and interviews was conducted from August to September 2025, while dengue case data were obtained retrospectively from medical records for the period January to December 2024.

The case population consisted of 126 patients diagnosed with DHF and recorded at Cilongok Public Health Center I and II in 2024. Sample size was determined using Lemeshow's formula for case–control studies, yielding a minimum of 26 cases, which was rounded up to 30 cases. With a 1:1 case-to-control ratio, the total sample comprised 60 respondents, including 30 cases and 30 controls.

Purposive sampling technique was employed in this study by focusing on individuals clinically diagnosed with DHF, residents of the study area for at least 12 months, and willing to participate. Controls were individuals without a history of dengue in the past year who resided in the same neighborhood within a distance of less than 100 meters from the case households. This neighborhood-based selection aimed to minimize environmental differences between groups. Potential confounding variables were addressed in the multivariate analysis.

The dependent variable was DHF incidence. Independent variables included physical factors (indoor temperature and humidity measured using a thermometer–hygrometer), biological factors (House Index and Container Index assessed through larval surveys), and social factors related to dengue prevention behaviors. Data on social factors were collected through structured interviews and observations using a questionnaire that had undergone validity and reliability testing.

Data analysis included univariate analysis to describe variable distributions, bivariate analysis using Chi-square tests to estimate Odds Ratios with 95 % confidence intervals, and multivariate analysis using multiple logistic regression to identify independent risk factors. Temporal trends of dengue cases from 2020 to 2024 were presented descriptively using graphical visualization. Spatial analysis was conducted descriptively to map the distribution of dengue cases in Cilongok Subdistrict.

This study was reviewed and approved by the Health Research Ethics Committee of the Faculty of Public Health, Diponegoro University (No:304/EA/KEPK-FKM/2025). All procedures were conducted in accordance with WHO ethical standards and the 2016 CIOMS guidelines.

RESULTS

This study aimed to analyze the association between environmental factors and 3M Plus behaviors with the incidence of dengue hemorrhagic fever in Cilongok Subdistrict, Banyumas Regency, using a case–control design complemented by descriptive temporal and spatial analysis. After carrying out the data analyses, we found the following findings.

Table 1 Characteristics of Respondents (n = 60)

Characteristics of Respondents	Incidence of Dengue Fever			
	Cases		Control	
	f	%	f	%
Gender				
Male	9	30.0	8	26.7
Female	21	70.0	22	73.3
Age				
Adult	25	83.3	28	93.3
Elderly	5	16.7	2	6.7
Body Mass Index (BMI)				
Underweight	0	0	2	6.7
Normal	15	50.0	13	43.3
Overweight	10	33.3	9	30.0
Obesity	5	16.7	6	20.0
Education Level				
No formal education	2	6.7	0	0
Elementary school	9	30.0	9	30.0
Junior high school	5	16.7	10	33.3
Senior high school	10	33.3	10	33.3
Diploma (D1/D2/D3)	2	6.7	0	0
Bachelor’s degree (D4/S1)	2	6.7	1	3.3
Occupation				
Farmer	4	13.3	2	6.7
Trader	4	13.3	5	16.7
Civil servant	2	6.7	1	3.3
Laborer	2	6.7	6	20.0
Housewife	18	60.0	16	53.3
Activity Time				
Morning–Afternoon	4	13.3	2	6.7
Morning–Evening	5	13.3	5	16.7
Morning–Night	3	6.7	1	3.3
Afternoon–Evening	0	6.7	6	20.0
At home	18	60	16	53.3
Home Ownership				
Owner-occupied	27	90	23	76.7
Rented/leased	1	3.3	2	6.7
Parents’ house	2	6.7	5	16.7
Type of Housing				
Permanent brick house	19	63.3	12	40
Semi-permanent house	8	26.7	16	53.3
Wooden/bamboo house	3	10	2	6.7

The study included 60 respondents, consisting of 30 dengue cases and 30 neighborhood-matched controls. The majority of respondents were female, accounting for 70% of cases and 73.3% of controls. Most respondents were adults aged 18 to 59 years, representing 83.3 % of cases and 93.3% of controls. Normal body mass index was observed in 50% of cases and 43.3% of controls. Regarding educational level, the largest proportion among cases and controls was junior high school graduates, each accounting for 30%. The proportion of respondents with elementary education was 16.7% of cases and 33.3% of controls, while senior high school graduates accounted for 33.3% in both groups. The most common occupation was housewife, comprising 60% of cases and 53.3% of controls. Most respondents reported spending the majority of their daily activities at home, with proportions of 60% ofcases and 53.3% of controls. Home ownership status showed that 90% of cases and 76.7% of controls lived in privately owned houses. Permanent brick houses were more common among cases 63.3% compared to controls 40%.

Table 2. Physical Environmental Factors

Physical Environmental Factors	**Incidence of Dengue Fever**				***p-value***	**OR**
	Cases		**Control**			
	f	**%**	**f**	**%**		
Temperature						
25-30°C	21	70	12	40	0.038	3.500 (1.201-10.196)
<25°C and >30°C	9	30	18	60		
Humidity						
60% - 80%	20	66.70	11	51.70	0.039	3.455 (1.195 – 9.990)
<60% and >80%	10	33.30	19	63.30		

Bivariate analysis of physical environmental factors showed a significant association between indoor temperature and DHF incidence. The proportion of respondents living in houses with indoor temperatures ranging from 25°C to 30°C was higher among cases 70% than controls 40%. Indoor temperature was identified as a risk factor for DHF with a *p-value* of 0.038 and OR of 3.500 (95% CI: 1.201–10.196). Indoor humidity ranging from 60% to 80% was also more prevalent among cases 66.7% than controls 51.7% and was significantly associated with DHF incidence *p-value* 0.039 and OR 3.455 (95% CI: 1.195–9.990).

Table 3. Biological Environmental Factors

Biological Environmental Factors	Incidence of Dengue Fever				*p-value*	OR
	Cases		Control			
	f	%	f	%		
House Index (HI)						
House (≥ 5%)	11	36.7	7	23.3	0.398	1.902 (0.617 – 5.863)
House (< 5%)	19	63.3	23	76.7		
Container Index (CI)						
Container (≥ 5%)	15	13.89	7	8.14	0.398	1.902 (0.617 – 5.863)
Container (< 5%)	93	86.11	79	91.86		

Based on Table 3 of the bivariate analysis (relationship between biological environment and dengue fever incidence in Cilongok subdistrict). The proportion of HI > 5% was greater in cases (36.7%) than in controls (23.3%), and there was no significant relationship between HI and DHF incidence (p-value 0.398), which was a risk factor with an OR of 1.902 (95% CI 0.617–5.863). The proportion of CI >5% was higher in cases (36.7%) than in controls (23.3%), and there was no significant association between container index and DHF incidence (p-value 0.398) and OR of 1.902 (95% CI 0.617–5.863).

Table 4. Social Environmental Factors

Social Environmental Factors	Incidence of Dengue Fever				p-value	OR
	Cases		Control			
	f	%	f	%		
Closing						
Poor	27	90	24	80	0,470	2.250 (0.507-9.993)
Good	3	10	6	20		
Draining						
Poor	13	43.3	7	23.3	0.171	2.513 (0.826-7.642)
Good	17	56.7	23	76.7		
Recycling						
Poor	25	83.3	22	73.3	0.531	1.818 (0.518-6.382)
Good	5	16.7	8	26.7		
Plus						
Poor	23	76.7	26	86.7	0.505	0.505 (0.131-1.951)
Good	7	23.3	4	13.3		
Water Storage						
Poor	23	76.7	22	73.3	1.000	1.195 (0.371-3.852)
Good	7	23.3	8	26.7		
Hanging Clothes						
Poor	23	76.7	11	36.7	0.004	5.675 (1.841-17.494)
Good	7	23.3	19	63.3		
Abate Powder						
Poor	28	93.3	29	96.7	1.000	0.483 (0.041-5.628)
Good	2	6.7	1	3.3		
Use of Mosquito Repellents						
Poor	13	43.3	18	60	0.301	0.510 (0.183-1.424)
Good	17	56.7	12	40		
Use of Mosquito Nets						
Poor	26	86.7	29	96.7	0.350	0.224 (0.024-2.136)
Good	4	13.3	1	3.3		

Community Clean-up						
Poor	18	60	20	66.7	0.789	0.750 (0.262-2.151)
Good	12	40	10	33.3		
Availability of Window Screens						
Not available	17	56.7	6	20	0.008	5.231 (1.657-16.515)
Available	13	43.3	24	80		
Presence of Vegetation						
Not present	8	26.7	8	26.7	1.000	1.000 (0.318 – 3.140)
Present	22	73.3	22	73.3		

Based on Table 4 of the bivariate analysis (the relationship between the 3M Plus social environmental factors and the incidence of dengue fever in Cilongok subdistrict). The proportion of bad habits of covering water containers was higher in cases (90%) than in controls (80%), and there was no relationship between covering behavior and DHF incidence, with a p-value of 0.470 and an OR of 2.250 (0.507–9.993). The proportion of poor behavior in draining water storage containers was higher in 43.3% of cases compared to 23.3% in the control group, and there was no significant relationship between draining and the incidence of DHF with a p-value of 0.171 and was a risk factor with an OR of 2.513 (95% CI 0.826 – 7.642). The proportion of poor recycling behavior was higher in cases (83.3%) than in controls (73.3%), and there was no association between recycling behavior and the occurrence of DHF (p-value 0.531). Recycling behavior was a risk factor with an OR of 1.818 (95% CI 0.518–6.381).

Additional preventive measures are a complementary component of the dengue fever control strategy. Additional preventive measures play a direct role in breaking the chain of dengue transmission because these interventions target the mosquito life cycle and potential human contact. Inspection of water storage containers p-value 1.000 and OR 1.195 (95% CI 0.371 - 3.852). The habit of hanging clothes has a p-value of 0.004 and OR 5.675 (95% CI 1.841 - 17.494). Use of abate powder p-value 1.000 and OR 0.483 (95% CI 0.041 - 5.628). Use of mosquito repellent p-value 0.301 and OR 0.501 (95% CI 0.183 - 1.424), and use of mosquito nets p-value 0.350 and OR 0.224 (95% CI 0.024 - 2.138). Availability of wire mesh in ventilation p-value 0.008 and OR 5.231 (95% CI 1.657 - 16.515). Community service activities have a p-value of 0.789 and OR 0.750 (95% CI 0.262 - 2.151).

Table 5. Results of Multivariate Analysis of Logistic Regression on the Incidence of Dengue in Cilongok District

Variable	B	p-value	OR	95% CI	
				Lower	Upper
Habit of hanging clothes	1.935	0.007	6.925	1.692	28.337
Wire Gauze Availability	1.805	0.013	6.083	1.475	25.088
Temperature in the House	1.790	0.015	5.989	1.414	25.363
Humidity in the House	1.465	0.034	4.328	1.114	16.810
Constant	-3.572	1.008	0.028		

Multivariate analysis results show that the habit of hanging clothes, the presence of wire mesh, temperature, and humidity inside the house are significantly associated with the incidence of dengue fever because all variables have a p-value < 0.05 and 95% CI OR does not cross the number 1. This means that these four variables are independent risk factors for the incidence of dengue fever.

Temporal and Spatial Distribution

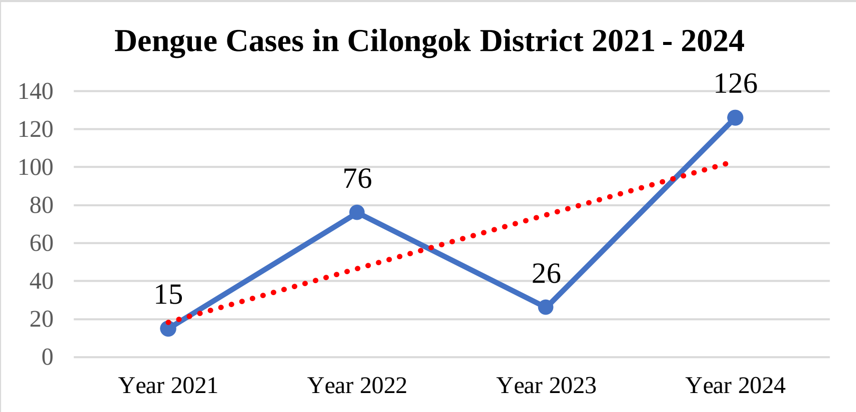

Figure 1. Annual Trend of Dengue cases 2020 - 2024

Based on Figure 1. Annual trend of dengue cases, 2020–2024 Cilongok Subdistrict was one of the areas with the highest incidence of Dengue Hemorrhagic Fever (DHF) in Banyumas Regency in 2024. Data from the Banyumas Regency Health Office show sharp fluctuations in cases over the past four years, with a significant increase from 15 cases in 2021 to 76 cases in 2022, followed by a decrease to 26 cases in 2023, and then a drastic surge in 2024, reaching 126 cases. This figure represents the highest number during the observation period, with an incidence rate (IR) of 116.7 per 100,000 population and one death (case fatality rate of 1.4%).

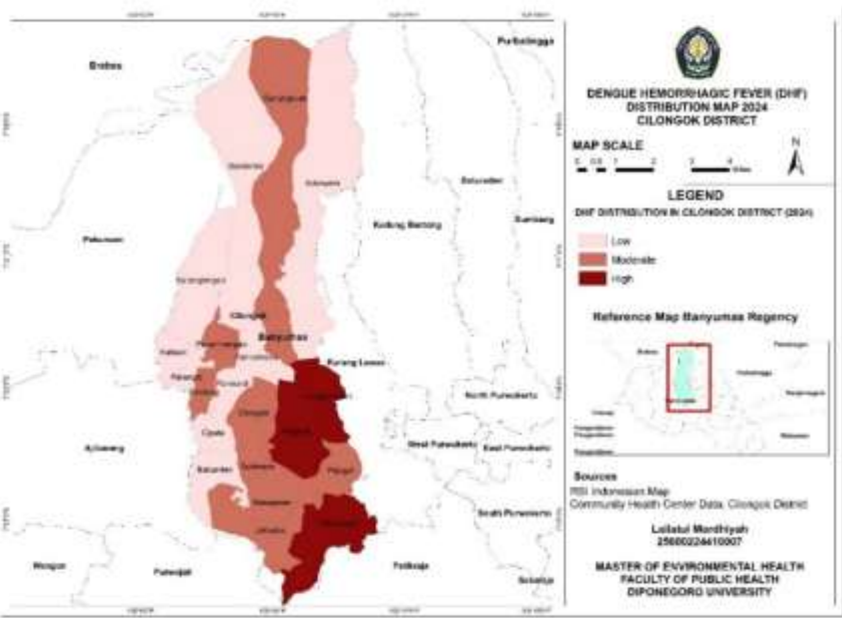

Figure 2. Spatial distribution of dengue cases in Cilongok Subdistrict

Based on Figure 2, dengue fever cases are spread throughout the villages of Cilongok District. The highest distribution of dengue fever cases is in Longgangsari Village, Pageraji Village, and Panusupan Village.

DISCUSSION

This study identified indoor environmental conditions and certain household behaviors as key factors of dengue fever cases in Cilongok District. Indoor temperature, indoor humidity, the habit of hanging clothes indoors, and the absence of fixed ventilation screens were independently associated with the risk of dengue fever. These findings support growing evidence that dengue transmission is strongly influenced by microenvironmental factors and household-level behaviors rather than vector indices alone. (Abreu et al., 2025).

The association between higher indoor temperature and humidity with the inreasing of dengue cases has been discussed by previous studies. Aedes aegypti mosquitoes exhibit optimal egg hatching rates, survival, feeding activity, and viral replication at temperatures between 25°C and 30°C and relative humidity above 60% (Doeurk et al., 2025; Abdullah et al., 2022). Research conducted in Manado, Indonesia, reported that indoor temperature directly impacts transmission, especially during high humidity (Monintja et al., 2021). Indoor environments with poor ventilation can maintain these conditions for long periods, increasing the intensity of human-vector contact. A study in Sintang District reported that individuals who did not install window screens were at higher risk of dengue fever (Kastari & Prasetyo, 2022), and another study showed that installing window screens was significantly associated with dengue fever cases (Tivani et al., 2025).

Conversely, biological environmental indicators measured using the House Index and Container Index were not significantly associated with dengue fever incidence in this study. These findings differ from traditional dengue fever surveillance models that emphasize larval density as the primary predictor of risk. Several recent studies have reported weak or inconsistent associations between larval indices and dengue incidence, particularly in endemic areas (Ichsan et al., 2023). Larval indices provide a snapshot of vector presence and may fail to capture adult mosquito abundance, human mobility, or exposures occurring outside the household environment. Additionally, transovarial transmission of the dengue virus in Aedes mosquitoes may reduce the direct relationship between observed larval density and infection risk (Sinha et al., 2024).

Behavioral factors emerged as the most prominent contributors to dengue risk in this study. The habit of hanging clothes indoors showed the strongest association with dengue incidence. Clothes hung indoors provide resting and hiding places for adult Aedes mosquitoes, facilitating their prolonged presence indoors and increasing the likelihood of bites (Seang-arwut et al., 2023). Similar findings have been reported in studies from Indonesia and other Southeast Asian countries, where storing clothes indoors is common due to limited space or high rainfall (Fadrina et al., 2021), (Shandy et al., 2023). Respondents' habit of hanging clothes in the bathroom was to reduce the number of clothes hanging in the bedroom after use.

The availability of window screens or ventilation showed a strong protective effect against dengue infection. Physical barriers such as screens reduce the entry of mosquitoes into the house and limit exposure to bites indoors. These findings are in line with previous studies showing that the presence of screens in better ventilation significantly reduces the risk of dengue fever (Kastari & Prasetyo, 2022). This study supports the finding that wire mesh screens function effectively as physical barriers. In line with Annisa Aruna's research, it shows that the action of installing wire mesh screens is significantly associated with the incidence of dengue fever (p-value 0.004) (Tivani et al., 2025). Compared to chemical-based interventions, structural modifications offer a sustainable and long-term approach to dengue prevention at the household level.

This study provides local evidence from Cilongok District, an area that experienced a sharp increase in dengue cases in 2024. By integrating physical, biological, and behavioral factors, these findings emphasize the need for highly localized dengue control strategies that prioritize indoor environmental management and daily household practices. Unlike studies that focus primarily on climate variables or larval indices, this research highlights modifiable behaviors that directly influence human-vector interactions within the home.

Several limitations should be acknowledged. Environmental measurements of temperature and humidity were taken at a single point in time and may not represent long-term exposure patterns. The relatively small sample size limits statistical power and may result in wide confidence intervals. In addition, the descriptive nature of spatial analysis limits inferences about spatial clustering or transmission pathways. Despite these limitations, this study provides relevant practical insights for dengue prevention in endemic communities.

CONCLUSIONS

This study demonstrates that dengue risk in Cilongok Subdistrict is strongly associated with indoor environmental conditions and specific household behaviors rather than with larval indices alone. Indoor temperature and humidity, the habit of hanging clothes indoors, and the absence of ventilation screens emerged as the most relevant factors linked to dengue incidence.

These findings underscore the importance of addressing household-level microenvironments in dengue prevention strategies.

Based on these results, dengue control interventions should prioritize improvements in indoor environmental management and behavior-focused prevention. The promotion of ventilation screens should be considered a primary preventive measure to reduce indoor mosquito exposure. Behavioral interventions should specifically target the practice of hanging clothes indoors, which represents a modifiable risk factor with substantial impact. Integrating these measures with existing 3M Plus programs may enhance the effectiveness of dengue prevention at the community level.

Future research should incorporate repeated environmental measurements and larger sample sizes to improve exposure assessment and statistical power. More advanced spatial analyses may also help clarify transmission patterns and guide targeted interventions in high-risk areas.

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