



The Relationship Between the Availability, Type, and Management of Water Reservoirs and the Incidence of Dengue Hemorrhagic Fever (DHF) in Pematangsiantar City in 2024

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Abstract

Dengue Hemorrhagic Fever (DHF) remains a significant public health challenge in Indonesia, including in Pematangsiantar City. In 2024, the city recorded 315 DHF cases with a case fatality rate (CFR) of 1.59%. This study aims to evaluate environmental factors, particularly those related to the management of water reservoirs, to develop more effective strategies for the prevention and control of DHF. This case-control study was conducted in Pematangsiantar City, involving 78 respondents in both the case and control groups. Data were analyzed using the chi-

square test. The findings revealed a significant association between several host factors and the incidence of DHF. The availability of water containers was significantly associated with DHF incidence ($p = 0.012$), where the presence of containers was linked to a lower risk of DHF ($OR = 0.088$; 95% CI: 0.011–0.708). The type of water reservoir also played a key role ($p = 0.003$), with open containers being associated with a higher risk of DHF ($OR = 0.332$; 95% CI: 0.167–0.662). Additionally, infrequent drainage of water reservoirs (less than once per week) was associated with nearly a threefold increase in risk ($p = 0.006$; $OR = 2.650$; 95% CI: 1.371–5.122). The habit of covering water containers also showed a significant association ($p = 0.027$), where individuals who did not cover containers had a higher risk of DHF ($OR = 2.277$; 95% CI: 1.148–4.517). In conclusion, water reservoir management—including availability, container type, drainage frequency, and covering practices—is a crucial determinant in DHF prevention. Therefore, community-based behavioral interventions and environmental sanitation improvements should be prioritized in DHF control programs, especially in endemic areas such as Pematangsiantar City.

Keywords: Dengue Hemorrhagic Fever, Frequency of Drainage, Water reservoir

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Introduction

As a continuation of the Millennium Development Goals (MDGs) program, which ended in 2015, the Sustainable Development Goals (SDGs) were introduced with 17 goals and 169 global targets. One of the key objectives is SDG 3, which focuses on ensuring healthy lives and promoting well-being for all age groups. This goal encompasses 13 specific targets, including ending the epidemics of infectious diseases such as HIV/AIDS, tuberculosis, malaria, hepatitis, and neglected tropical diseases—including Dengue Hemorrhagic Fever (DHF)—through an integrated and coordinated approach (WHO, 2020).

The World Health Organization (WHO) classifies dengue fever as a major global health concern, with more than 3.9 billion people in 128 countries at risk of infection. The threat continues to rise due to increasing case numbers and fatalities driven by climate change, as well as the significant social and economic burden it imposes. Dengue fever is an acute viral infection transmitted through the bites of *Aedes aegypti* and *Aedes albopictus* mosquitoes, which are prevalent in tropical and subtropical regions and often trigger outbreaks (Mustafa & Makhawi, 2023).

In 2020, WHO identified dengue as one of the top 10 global health threats. A sharp increase in cases occurred in 2023, with over five million cases and approximately 5,000 deaths reported across more than 80 countries. Southeast Asia was among the most affected regions, particularly Bangladesh (308,167 cases, 1,598 deaths) and Thailand (136,655 cases, 147 deaths). Case Fatality Rates (CFR) varied, ranging from 0.04% in Nepal to 0.72% in Indonesia (WHO, 2024).

In Indonesia, the first dengue cases were reported in Jakarta (1968) and Surabaya (1969), later spreading widely and becoming endemic—especially in densely populated urban areas. In response to frequent outbreaks, the Indonesian government has set a target to eliminate dengue-related deaths by 2030, aligning with WHO's "Zero Dengue Deaths by 2030" initiative. The national strategy, led by the Ministry of Health, is built upon three core pillars: vaccine development, enhanced vector control, and cross-sectoral collaboration, including environmental interventions (Directorate General of P2P, Ministry of Health RI, 2023).

Dengue control efforts in Indonesia are integrated into planning documents such as the 2020–2024 National Medium-Term Development Plan (RPJMN) and regulated by Ministry of Health Regulation No. 13 of 2022. National targets include achieving an incidence rate (IR) of ≤ 10 per 100,000 populations in at least 85% of districts/cities and reducing the CFR to 0.5%. In 2023, Indonesia recorded 11,270 dengue cases with 894 deaths—a decrease from the previous year. However, the IR target was only met by 111 out of 514 districts/cities (21.59%) (Ministry of Health RI, 2024).



The rising spread of dengue is influenced by various factors, including changes in mosquito distribution patterns due to El Niño and climate change, weakened health systems post-COVID-19, rapid urbanization, and socioeconomic instability in several countries. Inadequate surveillance systems also exacerbate the situation, as delays in case detection and response contribute to increased severity and broader transmission (WHO, 2024).

Research on DHF risk factors presents varied findings. Sandy (2024), in Jayapura Regency, found that only rainfall was significantly associated with DHF cases, while temperature and humidity showed no effect. In contrast, Kazari (2023) reported that environmental factors such as covering water containers, presence of mosquito larvae, and community behaviors—including water reservoir maintenance, knowledge, and attitudes toward the “3M” campaign—had a significant impact on DHF incidence.

In North Sumatra Province, all regencies/cities are considered dengue-endemic, with Medan, Deli Serdang, and Pematangsiantar among those with the highest case numbers. In Pematangsiantar, dengue fever ranks among the top five infectious diseases (BPS North Sumatra, 2023), spreading across 53 administrative areas (Mayor of Pematangsiantar, 2023). Since 2020, case numbers have steadily increased: from 65 cases (2020) to 104 (2021), and a sharp rise to 629 cases in 2022 (IR: 241.1 per 100,000; CFR: 2.07%). Though cases declined to 177 in 2023 (IR: 64.6; CFR: 1.7%), the figure remained higher than in 2021. As of 2024, 315 cases have been recorded (Pematangsiantar Health Office, 2024).

A preliminary survey conducted in the Bane and Bahkapul Health Center service areas revealed that 53.3% of 30 respondents reported having family members who had been infected with DHF within the past five years. Pematangsiantar City experiences rapid urbanization and environmental conditions conducive to mosquito breeding, such as stagnant water and inadequate sanitation. Common breeding grounds include water containers, flower pots, gutters, and discarded items. Weather changes—particularly in rainfall, temperature, and humidity—also influence the spread of DHF. Moreover, high population mobility facilitates transmission. Case surges typically occur during the rainy season due to the proliferation of mosquito breeding sites. Control measures have focused on environmental management and behavioral change through the “3M” and “3M Plus” campaigns, including the use of larvicides, mosquito repellents, and window screens (Ministry of Health RI, 2024).

Given this context, the present study aims to analyze the distribution of DHF cases based on environmental management factors, particularly those related to mosquito breeding site control and sanitation, as a preventive strategy to reduce the risk of DHF transmission.

Methods



This research is an observational analytical epidemiological study employing a case-control design. The study was conducted in Pematangsiantar City, one of the ten districts/cities in North Sumatra with the highest number of dengue fever cases. The research period spanned from December 2024 to June 2025. The population in this study consisted of all residents of Pematangsiantar City in 2024, totaling 277,054 people.

The sample comprised case and control groups. The case group included individuals from Pematangsiantar City who, in 2024, were recorded as having been hospitalized and diagnosed with Dengue Hemorrhagic Fever (DHF) or Dengue Fever (DF), based on data from the Disease Prevention and Control (P2P) Division of the Pematangsiantar City Health Office. That year, a total of 315 DHF/DF cases were reported, distributed across eight sub-districts. The control group consisted of residents who did not experience dengue fever during 2024. Control subjects were selected from neighbors living within a maximum distance of 400 meters from each case.

The sampling technique used in this study was purposive sampling. Based on sample size calculations, 71 respondents were obtained for each group (case and control). However, to account for the large population and the possibility of dropouts for various reasons, the researcher added a 10% buffer. As a result, the final sample included 78 respondents in the case group and 78 in the control group, maintaining a 1:1 ratio.

The dependent variable in this study was the incidence of Dengue Hemorrhagic Fever (DHF). The independent variables included host-related factors, such as the presence and type of water reservoirs, frequency of reservoir drainage, and the habit of covering water reservoirs. Primary data were collected through interviews using structured questionnaires and direct observation. To assess the relationship between DHF incidence and host factors, bivariate analysis was performed using the chi-square test.

Results

Dengue Hemorrhagic Fever Incidence

According to data from the Pematangsiantar City Health Office, there were 315 reported cases of Dengue Hemorrhagic Fever (DHF) in 2024. The trend of DHF incidence in Pematangsiantar City from 2020 to 2024 shows that the highest number of cases occurred in 2022, with 629 cases, while the lowest was in 2020, with 65 cases. The number of DHF cases varied each year. There was a sharp increase in cases in 2022, followed by a decrease in 2023, and a subsequent rise in 2024.

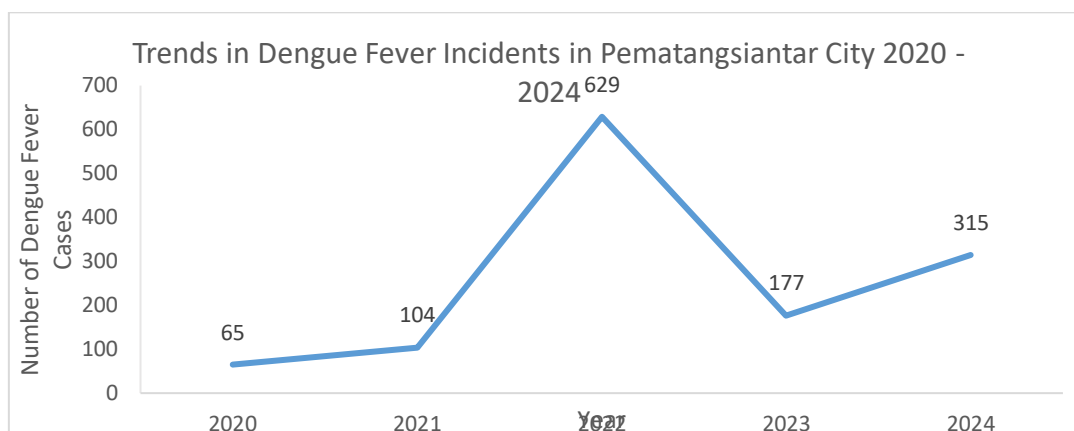


Figure 1. Trend of Dengue Fever Incidence in Pematangsiantar City, 2020–2024

Source: Data from the Pematangsiantar City Health Office

The number of dengue cases varies across sub-districts from year to year. Several sub-districts experienced a spike in cases in 2022, with Siantar Martoba recording the highest number (114 cases). In contrast, dengue cases dropped significantly in almost all sub-districts in 2023. However, in 2024, an increase was observed again in several areas. Over the 2020–2024 period, the incidence of dengue fever remained consistently high in the Siantar Martoba Sub-district compared to the other seven sub-districts, although the number of cases fluctuated each year.

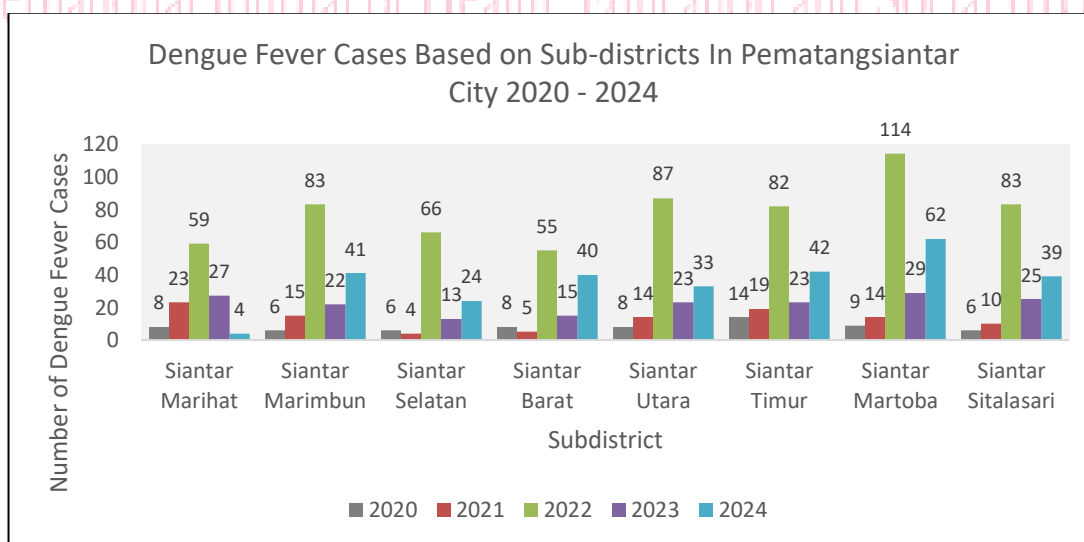


Figure 2. Dengue Fever Cases by Sub-District in Pematangsiantar City

Source: Data from the Pematangsiantar City Health Office



Dengue cases tend to increase starting in May each year, with a downward trend typically observed in December. In 2022, there was a significant surge in cases, particularly from May to August, peaking in August with 87 reported cases. Although a decline was observed in 2023 and 2024, fluctuations still occurred—especially between September and November 2024, when cases began to rise again. The number of dengue cases in 2020 and 2021 was relatively lower compared to the subsequent years.

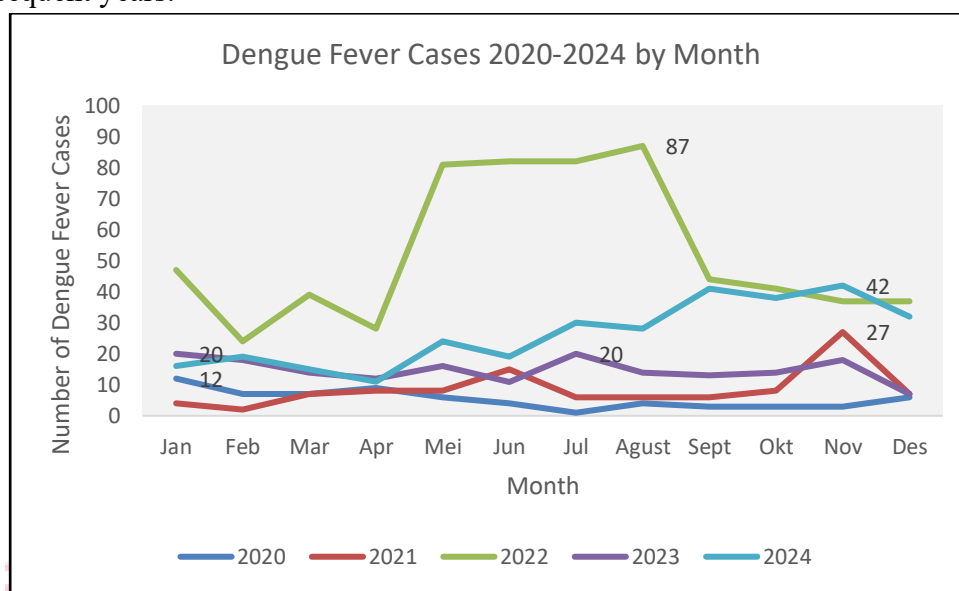


Figure 3. Dengue Fever Cases by Month in Pematangsiantar City (2020–2024)

Source: Data from the Pematangsiantar City Health Office

Respondent Characteristics

The characteristics of respondents in this study include five sociodemographic aspects: age, gender, ethnicity, education level, and employment status.

Age

Based on the data in Table 1, the majority of respondents in the case group were children (0–18 years), accounting for 78.2%. Meanwhile, all respondents in the control group (100%) were adults (>18 years), in accordance with the study's inclusion criteria. The case group consisted of individuals who had been diagnosed with DHF according to data from the Pematangsiantar City Health Office in 2024.

The results of the bivariate analysis showed a statistically significant relationship between age and the incidence of DHF ($p < 0.001$). The Odds Ratio (OR) of 5.588 (95% CI: 3.633–8.597) indicated that adults were 5.6 times more likely to contract DHF than children.



Gender

In terms of gender, the proportion of DHF cases was higher among males (51.3%), while the control group was predominantly female (82.1%). The chi-square test results revealed a significant association between gender and DHF incidence ($p < 0.001$), with an OR of 4.812 (95% CI: 2.321–9.976). This suggests that females were approximately 4.8 times more likely to be affected by DHF than males.

Ethnic Group

The distribution based on ethnicity showed that most DHF cases occurred among the Batak ethnic group, with 52 individuals (66.7%), followed by the Javanese ethnic group with 24 individuals (30.8%). In contrast, the control group was predominantly Javanese, with 39 respondents (50%), followed by the Batak ethnic group with 35 respondents (44.9%).

Level of Education

In terms of educational background, the majority of respondents in the case group had never received formal education (29.5%), while the control group was dominated by high school/vocational school graduates (69.2%). This reflects the dominance of children and toddlers in the case group. After categorizing respondents based on educational level, it was found that most in the case group had a low level of education (62.8%), while the control group was dominated by those with a higher education level (85.9%). Respondents with a low level of education had a 10.29 times higher risk of contracting dengue fever than those with a higher level of education (OR = 10.292; 95% CI: 4.691–22.580).

Employment Status

Regarding employment status, the case group was predominantly composed of students (47.4%) and toddlers (28.2%), while the control group was mostly housewives (56.4%), followed by the self-employed (17.9%). When employment status was categorized into two groups—employed and unemployed—it was found that the majority in both groups were unemployed: 84.6% in the case group and 60.3% in the control group. This can be attributed to the fact that many of the case group respondents were children and adolescents, while most control respondents were housewives. Statistical analysis showed a significant association between employment status and the incidence of DHF ($p = 0.001$), where unemployed respondents had a 3.63 times greater risk of developing DHF compared to those who were employed (OR = 3.628; 95% CI: 1.689–7.789).



Table 1. Distribution of Respondents by Sociodemographic Characteristics

Respondent Characteristics	Case		Control		Amount	
	n	%	n	%	n	%
Age						
Children (0-18 Years)	61	78.2	0	0.0	61	39.1
Adults (> 18 years)	17	21.8	78	100.0	95	60.9
Gender						
Man	40	51.3	14	17.9	54	34.6
Woman	38	48.7	64	82.1	102	65.4
Race						
Java	24	30.8	39	50.0	63	40.4
Batak	52	66.7	35	44.9	87	55.8
Malay	0	0.0	1	1.3	1	0.6
Other	2	2.6	3	3.8	5	3.2
Education						
No school	23	29.5	0	0.0	23	14.7
SD	14	17.9	1	1.3	15	9.6
Junior High School	12	15.4	10	12.8	22	14.1
High School/Vocational	22	28.2	54	69.2	76	48.7
D3/Bachelor/Master	7	9.0	13	16.7	20	12.8
Work						
Toddler	22	28.2	0	0.0	22	14.1
Teacher	0	0.0	2	2.6	2	1.3
housewife	5	6.4	44	56.4	49	31.4
Private sector employee	4	5.1	8	10.3	12	7.7
Student	2	2.6	3	3.8	5	3.2
Trader	0	0.0	3	3.8	3	1.9
Student	37	47.4	0	0.0	37	23.7
Nurse	2	2.6	0	0.0	2	1.3
Farmer	1	1.3	0	0.0	1	0.6
civil servant	1	1.3	4	5.1	5	3.2
Self-employed	4	5.1	14	17.9	18	11.5



Availability of Water Reservoirs (TPA)

Based on the data in Table 2, most respondents in the case group (87.2%) had water reservoirs in their homes, while 12.8% did not. In contrast, nearly all respondents in the control group (98.7%) were reported to have water reservoirs. Of the total 145 respondents with water containers at home, 77 (53.10%) were from the control group.

The results of the chi-square test showed a significant relationship between the presence of water reservoirs and the incidence of dengue fever ($p = 0.012$). Respondents who had water reservoirs in their homes were 11.36 times more likely to contract dengue fever compared to those who did not. In other words, the presence of a reservoir increases the risk of dengue fever by 91% ($OR = 0.088$; 95% CI: 0.011–0.708).

Types of Water Reservoirs (TPA)

The types of reservoirs analyzed included open and closed containers. In the case group, 52.6% of respondents used open reservoirs, while 47.4% used closed ones. Meanwhile, the control group was dominated by respondents using open reservoirs (76.9%). The chi-square test results indicated a significant relationship between the type of reservoir and the incidence of dengue fever ($p = 0.003$). Using closed reservoirs reduced the risk of dengue fever by 67%, while using open reservoirs increased the risk threefold compared to closed ones ($OR = 0.332$; 95% CI: 0.167–0.662).

Frequency of Reservoir Draining

The data show that 52.6% of respondents in the case group drained their water reservoirs less than once a week, while 47.4% did so at least once a week. In contrast, 70.5% of respondents in the control group drained their reservoirs at least once a week, while 29.5% did so less frequently. Among the 92 respondents who routinely drained their reservoirs weekly, 55 (59.78%) were from the control group. Meanwhile, of the 64 respondents who drained their reservoirs less frequently, 41 (64.06%) were in the case group.

The chi-square test showed a significant relationship between the frequency of draining and the incidence of dengue fever ($p = 0.006$). Respondents who drained their reservoirs less than once a week had a 2.65 times greater risk of contracting dengue fever than those who drained them routinely ($OR = 2.650$; 95% CI: 1.371–5.122).

Habit of Closing Water Reservoirs



Among the case group, 75.6% of respondents did not have the habit of covering their water reservoirs, while only 24.4% did. In contrast, the majority of respondents in the control group (53.8%) routinely covered their reservoirs. Of the 104 respondents who were not in the habit of covering their reservoirs, 59 were from the case group. Meanwhile, of the 52 respondents who did cover their reservoirs, 33 were in the control group.

The chi-square test showed a significant relationship between the habit of covering water reservoirs and the incidence of dengue fever ($p = 0.027$). Respondents who did not cover their reservoirs had a 2.28 times greater risk of contracting dengue fever compared to those who regularly did so ($OR = 2.277$; 95% CI: 1.148–4.517).

Table 2. Results of Univariate and Bivariate Analysis Using the Chi-Square Test on Host Factors and DHF Incidence in Pematangsiantar City

Host Variables	dengue fever				p	OR	95%CI
	Case		Control				
	n	%	n	%			
Container availability							
Yes	68	87.2	77	98.7	0.012	0.088	0.011-0.708
No	10	12.8	1	1.3			
Types of landfills							
Open	41	52.6	60	76.9	0.003	0.332	0.167-0.662
Closed	37	47.4	18	23.1			
Frequency of Landfill Drainage							
< 1x a week	41	52.6	23	29.5	0.006	2,650	1,371-5,122
1x a week	37	47.4	55	70.5			
The habit of closing landfills							
Yes	19	24.4	33	42.3	0.027	2,277	1,148-4,517
No	59	75.6	45	57.7			

Discussion

The Relationship Between the Availability of Water Reservoirs (TPA) and the Incidence of Dengue Fever in Pematangsiantar City

The results of the bivariate test using the chi-square method showed that the presence of water reservoirs (TPA) at home had a significant relationship with the incidence of dengue fever in Pematangsiantar City ($p = 0.012$). Households with water containers showed a higher risk of



developing dengue fever than those without, with a 91% increased risk (OR = 0.088; 95% CI: 0.011–0.708). This finding aligns with the study by Oktaviani, Muhammad, and Tri (2021), which found that houses with TPAs had a 5.12 times greater risk of dengue infection ($p = 0.01$; 95% CI: 1.47–17.86).

Water reservoirs are potential breeding grounds for *Aedes aegypti* mosquito larvae, especially if not properly managed. Clean, stagnant water in open bathtubs, buckets, or drums serves as an ideal habitat for these mosquitoes. The more uncovered reservoirs present, the higher the potential for increased mosquito population density and, consequently, a greater risk of dengue transmission—especially in areas with poor sanitation and high population density.

The Relationship Between the Type of Reservoir (Open/Closed) and Dengue Fever Incidence in Pematangsiantar City

The type of reservoir—open or closed—was also found to have a statistically significant relationship with dengue incidence ($p = 0.001$). Respondents who used closed reservoirs had a 67% lower risk of contracting dengue fever compared to those using open reservoirs (OR = 0.332; 95% CI: 0.167–0.662). These results are supported by research from Oktaviani, Muhammad, and Tri (2021), which found that open reservoirs increased the risk of dengue fever 2.7 times (95% CI: 0.946–7.842; $p = 0.063$).

Aedes aegypti mosquitoes lay eggs in clear, stagnant water—especially in open containers like buckets, drums, and jars. Therefore, securely covering water containers is crucial to prevent mosquito entry and egg-laying. In areas with many open reservoirs, particularly where sanitation is poor and population density is high, the risk of dengue transmission is significantly elevated. Public education on the importance of using covers for water containers is an essential component of dengue control, in addition to other measures like fogging and maintaining environmental hygiene.

The Relationship Between Frequency of Draining Reservoirs and Dengue Fever Incidence in Pematangsiantar City

The frequency of draining water reservoirs was shown to be significantly associated with the incidence of dengue fever ($p = 0.003$). Respondents who drained their reservoirs less than once a week had a 2.65 times higher risk of dengue infection compared to those who did so routinely at least once a week (OR = 2.650; 95% CI: 1.371–5.122). Multivariate analysis also confirmed this finding, indicating that individuals who regularly drained their reservoirs had a significantly reduced risk of dengue infection (OR = 2.616; 95% CI: 1.261–5.427; $p = 0.010$).



Previous research by Ambar and Widya (2022) also found a strong association between the practice of draining water containers and the incidence of dengue fever ($p < 0.002$; OR = 3.088). Similar findings were reported by Patricia, Apriyani, and Ilham (2023), and by Anggraini, Huda, and Agushybana (2021), who emphasized that draining frequency is closely linked to mosquito larval development. Infrequently drained containers provide ample time for larvae to mature into adult mosquitoes. Therefore, educating the public on the importance of draining water containers at least once a week is vital in interrupting the life cycle of dengue vectors.

The Relationship Between the Habit of Covering Water Reservoirs and the Incidence of Dengue Fever in Pematangsiantar City

The habit of covering water reservoirs was also found to have a significant relationship with dengue fever incidence ($p = 0.017$). According to Patricia and colleagues (2023), the behavior of covering water containers is associated with a reduced incidence of dengue fever. Covering reservoirs prevents mosquitoes from entering and laying eggs, thereby disrupting the mosquito breeding cycle.

Uncovered water containers are potential breeding grounds for larvae that eventually become adult mosquitoes capable of transmitting the virus. Covering reservoirs significantly reduces mosquito-human contact and the likelihood of bites from infected mosquitoes. In densely populated areas, this simple behavior becomes a highly effective intervention. Therefore, community education on the importance of covering water reservoirs must be continuously promoted as a key element of behavior-based prevention efforts.

Conclusion

Based on the results of the study, it can be concluded that there is a significant relationship between several host variables and the incidence of Dengue Hemorrhagic Fever (DHF) in Pematangsiantar City. The availability of water containers showed a significant association ($p = 0.012$), where households with containers had a lower risk of DHF (OR = 0.088; 95% CI: 0.011–0.708). The type of water reservoir (TPA) also had a significant impact ($p = 0.003$), with open reservoirs increasing the risk of DHF (OR = 0.332; 95% CI: 0.167–0.662). In addition, draining water reservoirs less than once a week was associated with an almost threefold increase in DHF risk ($p = 0.006$; OR = 2.650; 95% CI: 1.371–5.122). The habit of covering water reservoirs was also significantly related to DHF incidence ($p = 0.027$), with the absence of this habit increasing the risk of infection (OR = 2.277; 95% CI: 1.148–4.517). Therefore, water reservoir management practices—including availability, type, frequency of drainage, and covering habits—are crucial factors in preventing dengue fever and should be prioritized in public health interventions.



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