



RESEARCH ARTICLE

Environmental, preventive behavioral, and socioeconomic determinants of dengue hemorrhagic fever at Haji General Hospital Medan

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ABSTRACT

Background: Dengue hemorrhagic fever (DHF) remains a serious public health problem in Indonesia. The incidence of DHF is influenced by interacting factors, including physical environmental conditions, community preventive behavior, and socioeconomic conditions. This study aimed to analyze the factors associated with the incidence of DHF at Haji General Hospital Medan and to determine the most dominant determinant.

Methods: This study used an observational analytic quantitative design with a cross-sectional approach. It was conducted at Haji General Hospital Medan with 81 respondents. Data were collected through interviews using structured questionnaires and observation sheets. Analysis was performed using univariate methods, bivariate analysis with the Pearson chi-square test, and multivariate analysis with binary logistic regression.

Results: The majority of respondents lived in poor environmental conditions (55.6%), exhibited inadequate preventive behavior (55.6%), and had low socioeconomic status (55.6%). A total of 26 respondents (32.1%) were diagnosed with DHF. Bivariate analysis revealed a significant association between environmental factors ($p = 0.000$) and preventive behavior factors ($p = 0.009$) with DHF incidence. Conversely, socioeconomic status did not show a statistically significant association ($p = 0.089$). Multivariate analysis indicated that environmental factors were the most dominant determinant associated with DHF incidence ($p = 0.004$; OR = 6.377; 95% CI: 1.808 to 22.494). Respondents living in poor physical environmental conditions were 6.377 times more likely to contract DHF compared with those in good environmental conditions.

Conclusion: Physical environmental factors related to residential areas are the primary determinants influencing the incidence of DHF among patients treated at Haji General Hospital Medan. It is recommended that the community intensify 3M Plus mosquito breeding site eradication activities and maintain the cleanliness of the physical environment. The hospital and the Health Office should intensify education regarding environmental management for DHF prevention.

Keywords: dengue hemorrhagic fever, environmental factors, prevention behavior, socioeconomic status

Introduction

Dengue hemorrhagic fever (DHF) is a mosquito-borne viral infection caused by dengue virus and transmitted primarily through the bites of infected female *Aedes aegypti* and, to a lesser extent, *Aedes albopictus* mosquitoes¹. Tropical and subtropical environments, including much of Indonesia, provide favorable conditions for vector proliferation, sustaining endemic transmission and periodic outbreaks, particularly in densely populated urban and peri-urban areas with inadequate environmental sanitation^{2,3}.

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National surveillance data indicate that DHF incidence in Indonesia fluctuates annually, with seasonal peaks during the rainy season and in regions characterized by high humidity. The disease imposes a substantial burden on individuals, households, communities, and health systems, affecting all age groups, although vulnerability varies according to local transmission intensity and population immunity profiles ^{2,4,5}. The clinical spectrum ranges from undifferentiated febrile illness to severe manifestations, including plasma leakage, hemorrhage, and shock, which can be fatal without timely and appropriate case management ^{6,7}. Consequently, prevention and control remain public health priorities, emphasizing integrated vector management, early detection, and standardized clinical care ⁸.

Hospitals as referral health care facilities have an important role in the surveillance and management of DHF. Medical records from Haji General Hospital Medan for the period January to June 2025 recorded a total of 137 DHF cases. The highest number of cases occurred in January 2025 with 28 cases. The trend of increasing cases at the beginning of the year shows a correlation with rainy season conditions, which support the breeding of *Aedes aegypti* mosquitoes ⁹. The early-year increase in cases corresponds with rainy-season conditions that promote *Aedes aegypti* breeding. This pattern aligns with World Health Organization reports indicating that DHF incidence rises in areas with high rainfall and suboptimal environmental management. These findings indicate that DHF does not occur randomly but is influenced by multiple interrelated factors ^{10,11}. Previous studies demonstrate that demographic characteristics; environmental conditions such as housing type and the presence of mosquito breeding sites; behavioral practices including draining, covering, and recycling of water containers; and knowledge and attitudes all contribute to increased DHF risk ^{12–15}. Because the strength and direction of these associations vary by setting and health care facility, context-specific studies are needed to guide local prevention and control efforts.

Multiple studies have examined risk factors for DHF in Indonesia and other endemic settings. Ismail et al.¹⁶ conducted a case-control study in Borobudur Subdistrict, Magelang, Indonesia, and reported that the presence of open water containers and low participation in mosquito nest eradication (PSN) were significantly associated with household dengue infection. Mamenun et al.⁵ performed a spatiotemporal analysis and demonstrated that climate factors, particularly rainfall and temperature, were correlated with dengue incidence patterns. Rakhmani et al.¹⁷ conducted a knowledge, attitudes, and practices (KAP) survey and found that a substantial proportion of respondents exhibited inadequate knowledge and suboptimal preventive practices. Rahman et al.¹⁸ carried out a case-control study and identified travel history to endemic areas and unfavorable house conditions as significant risk factors. In Medan, Purba et al.¹⁹ and Hutahaeen et al.²⁰ reported that environmental and behavioral factors, including participation in mosquito nest eradication and support from health workers, were associated with DHF incidence. Nevertheless, most of these investigations were community-based and did not utilize medical record data from referral hospitals with multivariate analysis.

The Health Belief Model (HBM) offers a robust framework for understanding preventive behaviors related to dengue hemorrhagic fever (DHF). The model comprises six core constructs: perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy ^{21,22}. In the context of DHF, individuals who perceive themselves as susceptible to infection and recognize the benefits of preventive measures are more likely to adopt protective behaviors. Conversely, low self-efficacy and perceived barriers, such as limited resources or unclear guidance, may hinder adherence to preventive practices. Preventive behavior is not solely determined by individual choice; it is also shaped by environmental conditions, access to information, and available resources. Therefore, examining preventive behaviors in conjunction with environmental and socioeconomic factors yields a more comprehensive understanding of DHF risk and informs targeted public health interventions ^{23–25}.

Socioeconomic factors are frequently considered in studies of dengue hemorrhagic fever (DHF). Education, income, occupation, and household density can influence knowledge, resources, and opportunities to undertake preventive actions ^{26,27}. Studies conducted in Demak and Pekanbaru found that physical environmental factors and community behaviors related to cleaning water containers strongly influenced DHF risk ²⁸. However, the association between socioeconomic status and DHF is not always consistent, suggesting that other factors may be more dominant in certain settings. In urban areas, DHF can affect individuals across socioeconomic strata because mosquito vectors are mobile and can breed in both well-maintained and poorly maintained environments. Socioeconomic status may influence access to preventive resources, but it does not necessarily determine exposure if environmental conditions remain favorable for vector breeding ^{26,27}.

The research gap addressed by this study concerns the need for local evidence from a referral hospital in Medan regarding the relative contribution of environmental, behavioral, and socioeconomic factors to DHF incidence. Most previous local studies were community-based and did not simultaneously examine these three domains using multivariate analysis. Furthermore, the incidence of DHF at Haji General Hospital Medan remains high, and a contextual analysis is needed to inform hospital and public health interventions. By identifying the most dominant determinant, this study can help prioritize limited resources for prevention and control.

This study aimed to analyze the factors associated with the incidence of DHF at Haji General Hospital Medan and to determine the most dominant determinant. The specific objectives were to analyze the association between environmental factors and DHF incidence, to analyze the association between preventive behavior and DHF incidence, and to analyze the association between socioeconomic factors and DHF incidence. The findings are expected to provide evidence for hospitals, health offices, and communities in designing more effective and targeted DHF prevention strategies.

Method

This study employed an observational analytic cross-sectional design to assess independent and dependent variables simultaneously without intervention. This approach is commonly used in dengue epidemiological research to efficiently map environmental and behavioral risk factors. The research was conducted from October 2025 to March 2026 at Haji General Hospital in Medan, North Sumatra. This facility was purposively selected as a regional DHF referral center with a high case volume in 2025, providing optimal access to compare exposure characteristics between confirmed DHF and non-DHF patients.

The study population comprised 19,860 patients treated at Haji General Hospital Medan between January and December 2025, consisting of 423 confirmed DHF cases (ICD-10 codes A90 and A91) and 19,437 non-DHF cases. Applying the Slovin formula with a 0.10 margin of error yielded a target sample of 81 DHF patients. Although initially planned with a 1:1 case-control ratio, the final purposive sample consisted of 81 total respondents with complete data, comprising 26 DHF cases and 55 non-DHF controls. The study utilized purposive sampling to integrate secondary data from 2025 medical records with primary questionnaire data gathered between March and April 2026. Participants were included if they possessed complete, verifiable medical records for the studied variables, had a definitive diagnosis, and consented to complete the questionnaire. Conversely, patients were excluded if their records were illegible or incomplete, if they suffered from confounding infectious diseases, or if they were unable or unwilling to participate in primary data collection.

The dependent variable was DHF incidence, established through clinical criteria and laboratory examination results, while independent variables encompassed environmental factors, preventive behavior, and socioeconomic status. Environmental factors evaluated physical home conditions influencing *Aedes aegypti* breeding, including standing water, cleaning frequency, and overall cleanliness, measured via a 1–5 observation sheet and categorized as good or poor. Preventive behavior measured 3M Plus practices, DHF knowledge, and self-efficacy using a 1–5 Likert-scale questionnaire, applying the same threshold for good versus poor categories. Socioeconomic factors assessed education, occupation, monthly income, and household density; for statistical analysis, overall socioeconomic status was categorized into low (combining low and medium tiers) and high based on data distribution.

Primary data were obtained through direct interviews and questionnaire completion by respondents or family members using structured instruments. The questionnaire contained questions on environmental factors, preventive behavior based on Health Belief Model constructs, and socioeconomic conditions. The observation sheet was used to assess physical environmental conditions. Secondary data were obtained from medical records of Haji General Hospital Medan, DHF epidemiological data from the Medan City Health Office, and relevant articles and journals. Secondary data were used to strengthen the analysis and support the discussion of external environmental factors.

Data collection was carried out after obtaining ethical clearance and research permission. Respondents were approached during their visit or hospitalization. They were informed about the purpose of the study, and written informed consent was obtained. For respondents who were unable to complete the questionnaire independently, family members assisted with the answers. The researcher ensured that all questions were understood and that responses reflected actual conditions. Observation of the home environment was not conducted directly at the residence; instead, environmental information was obtained through structured

questions and observation of available information. This is a limitation because direct observation may provide more objective data.

Data analysis comprised univariate, bivariate, and multivariate procedures. Univariate analysis derived frequency distributions and percentages to describe variable characteristics. Bivariate analysis examined associations using the chi-square test, reporting odds ratios or prevalence ratios with 95% confidence intervals. Multivariate analysis employed binary logistic regression to identify independent predictors and the strongest influences. Variables with $p < 0.25$ during bivariate selection or high substantive importance entered the initial model. Model refinement involved backward elimination of non-significant variables ($p > 0.05$), while retaining any variable that altered remaining odds ratios by over 10% as a confounder. Linearity and interactions were evaluated to establish the final model.

Results

A total of 81 respondents participated in this study. Respondent characteristics are summarized in Table 1. The majority of respondents were female ($n = 43$; 53.1%), while male respondents accounted for 38 (46.9%). The largest age group was younger than 20 years ($n = 34$; 42.0%), followed by 20 to 35 years ($n = 25$; 30.9%) and older than 35 years ($n = 22$; 27.2%). Education was dominated by senior high school ($n = 48$; 59.3%), followed by D3 or S1 ($n = 30$; 37.0%) and elementary school ($n = 3$; 3.7%). Occupation was mostly self-employed ($n = 30$; 37.0%), followed by farmer ($n = 24$; 29.6%), housewife ($n = 14$; 17.3%), and civil servant ($n = 13$; 16.0%). Income was mostly in the 1 to 3 million rupiah category ($n = 34$; 42.0%), followed by less than 1 million rupiah ($n = 33$; 40.7%) and more than 3 million rupiah ($n = 14$; 17.3%). A history of DHF was reported by 39 respondents (48.1%), while 42 respondents (51.9%) had no prior DHF.

Table 1. Frequency distribution of respondent characteristics

Variable / Category	n	%
Sex		
Male	38	46.9
Female	43	53.1
Age		
Less than 20 years	34	42.0
20 to 35 years	25	30.9
More than 35 years	22	27.2
Education		
Elementary school	3	3.7
Senior high school	48	59.3
D3 or S1	30	37.0
Occupation		
Housewife	14	17.3
Farmer	24	29.6
Self-employed	30	37.0
Civil servant	13	16.0
Income		
< 1 million rupiah	33	40.7
1–3 million rupiah	34	42.0
> 3 million rupiah	14	17.3
History of DHF		
Yes	39	48.1
No	42	51.9
Total	81	100.0

The distribution of factor categories associated with DHF is presented in Table 2. Environmental factors were mostly in the poor category ($n = 45$; 55.6%) compared with the good category ($n = 36$; 44.4%). Preventive behavior was also dominated by the poor category ($n = 45$; 55.6%) compared with the good category ($n = 36$; 44.4%). Socioeconomic factors were mostly in the low category ($n = 45$; 55.6%) compared with the high category ($n = 36$; 44.4%). A total of 26 respondents (32.1%) had DHF, while 55 respondents (67.9%) did not.

Table 2. Frequency distribution of factor categories associated with DHF

Variable / Category	n	%
Environmental Factor		
Good	36	44.4
Poor	45	55.6
Preventive Behavior		
Good	36	44.4
Poor	45	55.6
Socioeconomic Factor		
Low	45	55.6
High	36	44.4
DHF Incidence		
Yes	26	32.1
No	55	67.9
Total	81	100.0

The results of the bivariate analysis examining the relationship between environmental factors, preventive behavior, socioeconomic status, and DHF incidence are summarized in Table 3. Of the 81 respondents, 26 (32.1%) were diagnosed with DHF and 55 (67.9%) were non-DHF controls. Among the 36 respondents categorized as having good environmental conditions, 4 (11.1%) had DHF, whereas 32 (88.9%) did not. In contrast, among the 45 respondents with poor environmental conditions, 22 (48.9%) had DHF compared with 23 (51.1%) who did not. The Pearson chi-square test yielded a p-value of 0.000, indicating a statistically significant relationship between environmental conditions and DHF incidence. Respondents living in poor environmental conditions had a substantially higher proportion of DHF than those residing in favorable physical environments.

Table 3. Bivariate analysis of independent variables and DHF incidence

Variable	DHF: Yes n (%)	DHF: No n (%)	Total n (%)	p-value
Environmental Factors				0.000
Good	4 (11.1)	32 (88.9)	36 (100.0)	
Poor	22 (48.9)	23 (51.1)	45 (100.0)	
Preventive Behavior				0.009
Good	6 (16.7)	30 (83.3)	36 (100.0)	
Poor	20 (44.4)	25 (55.6)	45 (100.0)	
Socioeconomic Factors				0.089
Low	18 (40.0)	27 (60.0)	45 (100.0)	
High	8 (22.2)	28 (77.8)	36 (100.0)	
Total	26 (32.1)	55 (67.9)	81 (100.0)	

Regarding preventive behavior, among the 36 respondents with good practices, 6 (16.7%) had DHF while 30 (83.3%) did not. Among the 45 respondents with poor preventive behavior, 20 (44.4%) had DHF compared with 25 (55.6%) who did not. The Pearson chi-square test revealed a p-value of 0.009, confirming a statistically significant association between preventive behavior and DHF incidence. Respondents with inadequate preventive behaviors had a higher occurrence of DHF than those who consistently practiced good preventive measures.

For socioeconomic factors, in the low socioeconomic group (n = 45), 18 (40.0%) had DHF while 27 (60.0%) did not. Among the 36 respondents in the high socioeconomic group, 8 (22.2%) had DHF whereas 28 (77.8%) did not. Although the proportion of DHF cases was higher in the low socioeconomic group, the Pearson chi-square test yielded a p-value of 0.089. Thus, there was no statistically significant relationship between socioeconomic factors and DHF incidence in this study. Overall, environmental factors and preventive behavior were identified as significant risk factors associated with DHF incidence, whereas socioeconomic factors did not show a statistically significant relationship.

Multivariate analysis was performed using binary logistic regression. The results are presented in Table 4. Of the three variables included in the model, only the environmental factor category had a significant relationship with DHF incidence (p = 0.004). The Exp(B) value of 6.377 indicates that respondents in the poor environmental factor category had 6.377 times higher odds of DHF than respondents in the good environmental factor category (95% CI: 1.808 to 22.494). The Wald value of 8.297 indicates the strongest statistical contribution compared with the other two variables in the model.

Preventive behavior did not show a significant relationship with DHF incidence after adjustment for other variables (p = 0.576). The Exp(B) value of 1.420 indicates a tendency toward 1.420 times higher odds

of DHF in the poor preventive behavior category compared with the good category, but this result was not statistically significant because the 95% confidence interval (0.416 to 4.849) included 1.

Table 4. Binary logistic regression results of factors associated with DHF incidence

Variable	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for Exp(B)
Environmental Factor	1.853	0.643	8.297	1	0.004	6.377	1.808 to 22.494
Preventive Behavior	0.351	0.627	0.313	1	0.576	1.420	0.416 to 4.849
Socioeconomic Factor	0.704	0.558	1.591	1	0.207	2.022	0.677 to 6.037
Constant	-3.478	1.222	8.096	1	0.004	0.031	

Socioeconomic factors also did not show a significant relationship with DHF incidence after adjustment for other variables ($p = 0.207$). The Exp(B) value of 2.022 indicates a tendency toward 2.022 times higher odds of DHF in the low socioeconomic category compared with the high category, but this relationship was not statistically significant because the 95% confidence interval (0.677 to 6.037) included 1. Thus, environmental factors were the most dominant variable associated with DHF incidence in this research model.

Discussion

This study found that environmental factors were the most dominant determinant of DHF incidence at Haji General Hospital Medan. Bivariate analysis showed a statistically significant relationship between environmental factors and DHF incidence ($p = 0.000$). Respondents with poor physical environmental conditions had a much higher proportion of DHF (48.9%) compared with respondents in the good environmental category (11.1%). After controlling for preventive behavior and socioeconomic factors in the multivariate model, environmental factors remained significantly associated with DHF incidence ($p = 0.004$; OR = 6.377; 95% CI 1.808 to 22.494). This finding indicates that respondents living in poor physical environmental conditions had 6.377 times higher odds of DHF compared with those in good environmental conditions. This result is consistent with the Agent-Host-Vector-Environment model, which places environmental conditions as a key determinant of vector-borne disease transmission. The physical environment provides the necessary conditions for vector survival and reproduction. Without suitable breeding sites, the vector population cannot be sustained, and transmission risk declines^{29–31}.

Physical environmental factors, such as the presence of open water containers, piles of used goods, and drainage cleanliness around residential areas, are the main media for the development of *Aedes aegypti* mosquito vectors. *Aedes aegypti* mosquitoes prefer clear water that is not in direct contact with the soil for laying eggs. When physical environmental sanitation conditions in respondents' settlements are poor, the number of mosquito breeding places increases, and the density of adult mosquitoes also increases. This is directly proportional to the increased risk of dengue virus transmission to humans through female mosquito bites. This finding is consistent with Ismail et al.¹⁶, who reported that the presence of open water containers and poor household environmental sanitation were closely associated with dengue virus infection. Similarly, Hendayani et al.³² and Anliyanita et al.³³ found that physical environmental factors and water-container cleaning behavior strongly influenced DHF risk. Hutahaeen et al.²⁰ in Medan also found that environmental factors were associated with DHF incidence. The consistency of these findings across different settings suggests that environmental management is a key pillar in DHF prevention. It also suggests that interventions focusing only on individual behavior without addressing environmental conditions may have limited effectiveness.

The second main finding is that preventive behavior was significantly associated with DHF incidence in bivariate analysis ($p = 0.009$). The proportion of respondents who experienced DHF in the group with poor preventive behavior was 44.4%, while in the group with good preventive behavior it was 16.7%. Preventive behavior measured in this study included the implementation of 3M Plus mosquito nest eradication, namely draining, covering, recycling or burying, and additional preventive actions such as using mosquito repellent or bed nets. Lack of discipline or consistency in draining water containers at least once a week allows the mosquito life cycle from egg to adult to proceed, which takes approximately 9 to 10 days. The Health Belief Model perspective explains that low preventive behavior is often influenced by a lack of perceived susceptibility and perceived severity of DHF attacks, as well as low self-efficacy in carrying out preventive actions routinely. This finding is consistent with Rakhmani et al.¹⁷ and Pasang et al.³⁴, who reported that inadequate knowledge and self-efficacy directly affect low adherence to 3M Plus mosquito nest

eradication. The finding is also consistent with Hutahaean et al.²⁰, who found that mosquito nest eradication behavior and health worker support played a major role in DHF incidence in Medan Johor District.

However, after multivariate analysis, preventive behavior was no longer significant ($p = 0.576$). This suggests that its effect may be mediated or confounded by environmental factors. In other words, even individuals with good preventive behavior may remain at risk if their surrounding environment supports mosquito breeding. The environment sets the boundary conditions for transmission. If breeding sites remain available, the effect of individual behavior is attenuated. This interpretation is supported by the fact that environmental factors remained significant while behavior did not. It also highlights the need for collective environmental management rather than relying solely on individual action³⁵. Community-level interventions that reduce breeding sites can complement individual preventive practices³⁶. The combination of environmental management and behavior change is likely to be more effective than either approach alone.

The third main finding is that socioeconomic factors were not significantly associated with DHF incidence ($p = 0.089$). Although the low socioeconomic group had a higher proportion of DHF (40.0%) compared with the high socioeconomic group (22.2%), the difference was not statistically significant. Socioeconomic factors in this study included education level, type of occupation, and family income level. The absence of a significant relationship indicates that DHF in urban areas such as Medan can affect anyone regardless of socioeconomic status. A person with a high level of education or income remains at risk of dengue infection if the environmental conditions around their home are poor or if the mosquito vector is active in places of activity outside the home, such as school or workplace³⁷. *Aedes aegypti* mosquitoes are anthropophilic and active during the day, so individual mobility outside the home also plays a role. This result is consistent with previous studies showing that socioeconomic factors are indirect determinants. Socioeconomic status plays a greater role in shaping access to information and purchasing power for preventive tools, but is not a direct risk factor for the biological transmission of dengue virus when compared with the physical presence of mosquito vectors and sanitation conditions³⁸.

This finding also aligns with the results of Rahman et al.¹⁸, who found that house conditions and travel history were more important than socioeconomic status in determining dengue risk. Similarly, Liu et al.³⁹ found that community-based environmental factors were stronger predictors of dengue infection than socioeconomic variables. The lack of a significant socioeconomic effect in this study may also be due to the relatively homogeneous socioeconomic distribution of the sample, with most respondents having low to moderate income. When the distribution is narrow, statistical power to detect differences is reduced. Moreover, socioeconomic status may influence the ability to modify the environment, but it does not determine whether the environment is suitable for vector breeding. A high-income household can still have containers that collect water, and a low-income household can maintain a clean environment. Therefore, targeted environmental interventions may be more effective than socioeconomic-based targeting.

The multivariate model confirmed that environmental factors were the most dominant determinant. The odds ratio of 6.377 indicate a strong association. The Wald value of 8.297 was the highest among the variables, indicating the strongest statistical contribution. The confidence interval did not include 1, confirming statistical significance. The practical implication is that DHF prevention programs should prioritize environmental management. This includes regular draining of water containers, proper waste disposal, and improvement of drainage systems⁴⁰. Fogging may be useful during outbreaks, but it has temporary effects and does not address the root cause⁴⁰. Sustainable environmental improvement is necessary to reduce vector breeding sites. Community participation is essential^{41,42}. Health education should emphasize not only knowledge but also skills and self-efficacy to perform preventive actions. Health workers can support community efforts by providing information, facilitating clean-up campaigns, and monitoring larval indices⁴³.

This study has several limitations, including a cross-sectional design that precludes causal inference, self-reported data subject to recall and social desirability biases, and a small single-hospital sample size that limits generalizability and statistical power. Furthermore, environmental assessments lacked direct home observation, and key vector determinants, such as entomological indices (house, container, and Breteau indices) and climatic variables, were not evaluated. To address these gaps, future studies should adopt prospective cohort designs, integrate GIS spatial analysis, measure field larval indices directly, and account for climatic factors. Developing predictive risk-stratification models and evaluating community-based environmental management interventions will also strengthen evidence for targeted policy. Ultimately, this research confirms that poor physical environmental conditions are the primary determinant of DHF incidence

at Haji General Hospital Medan, whereas preventive behavior is significant only at the bivariate level, and socioeconomic factors show no statistically significant association.

Conclusion

Environmental factors ($p = 0.000$) and preventive behavior ($p = 0.009$) showed significant associations with DHF incidence at Haji General Hospital Medan, whereas socioeconomic factors demonstrated no statistical significance ($p = 0.089$). Multivariate analysis identified physical environmental conditions as the dominant determinant ($p = 0.004$; OR = 6.377), with poor environments increasing DHF risk 6.377 times after controlling for behavioral and socioeconomic variables. To address these findings, community members should consistently implement 3M Plus mosquito nest eradication measures, particularly weekly water-container draining and environmental sanitation. The local Health Office and Community Health Centers should strengthen vector surveillance, conduct periodic larval monitoring, and emphasize proactive environmental management over temporary fogging. Additionally, Haji General Hospital Medan should enhance its medical record system by incorporating detailed spatial and domicile data to enable hotspot mapping and deliver targeted health education to patients and families. Finally, future researchers are advised to utilize prospective cohort designs, integrate spatial GIS and climate data, and perform direct field measurements of larval indices to further refine DHF determinants.

References

1. Wang WH, Urbina AN, Chang MR, Assavalapsakul W, Lu PL, Chen YH, et al. Dengue hemorrhagic fever – A systemic literature review of current perspectives on pathogenesis, prevention and control. *J Microbiol Immunol Infect*. 2020 Dec;53(6):963–78.
2. Haryanto B, Dwirahmadi F, Nurlambang T, Asyary A. Spatial Analysis on Dengue Fever Vulnerability in the Provinces of South Sulawesi and East Nusa Tenggara in Indonesia. *Ann Glob Heal*. 2025 Dec 15;91(1).
3. Nasirian H. Factors influencing establishment of dengue fever vectors in urban areas. *East Mediterr Heal J*. 2025 Mar 26;31(3):163–5.
4. Pasaribu AP, Tsheten T, Yamin M, Maryani Y, Fahmi F, Clements ACA, et al. Spatio-Temporal Patterns of Dengue Incidence in Medan City, North Sumatera, Indonesia. *Trop Med Infect Dis*. 2021 Mar 5;6(1):30.
5. Mamenun, Koesmaryono Y, Sopaheluwakan A, Hidayati R, Dasanto BD, Aryati R. Spatiotemporal Characterization of Dengue Incidence and Its Correlation to Climate Parameters in Indonesia. *Insects*. 2024 May 17;15(5):366.
6. Wilder-Smith A, Ooi EE, Horstick O, Wills B. Dengue. *Lancet*. 2019 Jan;393(10169):350–63.
7. Rodrigo C, Sigera C, Fernando D, Rajapakse S. Plasma leakage in dengue: a systematic review of prospective observational studies. *BMC Infect Dis*. 2021 Dec 20;21(1):1082.
8. Petzold S, Rosenberger KD, Wills B, Deen J, Weber MW, Jaenisch T. Dengue algorithms integrated into the IMCI guidelines: An updated assessment in five Southeast-Asian countries. Carabali M, editor. *PLoS Negl Trop Dis* [Internet]. 2022 Oct 11;16(10):e0010832. Available from: <https://dx.plos.org/10.1371/journal.pntd.0010832>
9. Rumah Sakit Umum Haji Medan. Data Rekam Medis Rumah Sakit Umum Haji Medan. Medan: Rumah Sakit Umum Haji Medan; 2025.
10. Abdullah NAMH, Dom NC, Salleh SA, Salim H, Precha N. The association between dengue case and climate: A systematic review and meta-analysis. *One Heal*. 2022 Dec;15:100452.
11. James MM, Manikandan S, Balabaskaran Nina P, Balasubramani K, Gopalan N, Behera SK. Associations between climatic variables and dengue incidence in high-burden countries: a systematic review and meta-analysis. *Front Clim*. 2026 May 20;8.
12. Islam ARMT, Limon MAR, Islam MM. Unveiling Knowledge, Attitudes, and Preventive Practices Toward Dengue Among Residents of Rangpur City, Bangladesh: A Cross-Sectional Study. *Heal Sci Reports*. 2026 Jun;9(6).
13. Arham AF, Mokhtar MI, Zainal N, Jaafar MH, Amin L, Rusly NS, et al. Asian households' dengue-related knowledge, attitudes, and practices: a systematic review. *Humanit Soc Sci Commun*. 2025 May 23;12(1):702.
14. Ajibola LSA, Shohaimi S, Adam MB, Nadzir MNHM, Segun OE. Systematic review of knowledge, attitude, and practices regarding dengue in Malaysia. *J Appl Pharm Sci*. 2018 Dec;8(12):80–91.
15. Arfan I, Sulistyorini L, Sulistyowati M, Rizky A. Dengue Prevention Behaviour from a Social Ecological Model Perspective. *Heal Educ Heal Promot* [Internet]. 2026;14(2):225–37. Available from: https://hehp.modares.ac.ir/article_29075.html
16. Ismail NA, Haikhah J, Fauziah ET, Prabasunu MA, Rahma FH, Siswanto S, et al. Investigation of risk factors for household-based dengue virus infection in Borobudur Subdistrict, Magelang, Indonesia. *Germs*. 2024 Sep;14(3):277–86.
17. Rakhmani AN, Zuhriyah L. Knowledge, Attitudes, and Practices Regarding Dengue Prevention Among Health Volunteers in an Urban Area – Malang, Indonesia. *J Prev Med Public Heal*. 2024 Mar 31;57(2):176–84.
18. Rahman MS, Mehejabin F, Rahman MA, Rashid R. A case-control study to determine the risk factors of dengue fever in Chattogram, Bangladesh. *Public Heal Pract*. 2022 Dec;4:100288.
19. Purba IE, Nababan D, Adiansyah, Kaban ES. Risk Factors of Dengue Hemorrhagic Fever. *J Penelit Pendidik IPA*. 2023 Oct 25;9(10):8131–9.
20. Hutahaean SHRL, Nababan D, Sinaga J, Manurung K, Sinaga TR. Determinants of Dengue Hemorrhagic Fever Incidents in Medan District, Johor in 2023. *Open Access Heal Sci J*. 2025 Feb 28;6(1):130–40.
21. Banik R, Islam MS, Mubarak M, Rahman M, Gesesew HA, Ward PR, et al. Public knowledge, belief, and preventive practices regarding dengue: Findings from a community-based survey in rural Bangladesh. Mallhi TH, editor. *PLoS Negl Trop Dis*. 2023

- Dec 7;17(12):e0011778.
22. Siddiqui TR, Ghazal S, Bibi S, Ahmed W, Sajjad SF. Use of the Health Belief Model for the Assessment of Public Knowledge and Household Preventive Practices in Karachi, Pakistan, a Dengue-Endemic City. Rabaa MA, editor. *PLoS Negl Trop Dis*. 2016 Nov 10;10(11):e0005129.
 23. Wong LP, AbuBakar S, Chinna K. Community Knowledge, Health Beliefs, Practices and Experiences Related to Dengue Fever and Its Association with IgG Seropositivity. Alexander NDE, editor. *PLoS Negl Trop Dis*. 2014 May 22;8(5):e2789.
 24. Wong LP, AbuBakar S. Health Beliefs and Practices Related to Dengue Fever: A Focus Group Study. Halstead SB, editor. *PLoS Negl Trop Dis*. 2013 Jul 11;7(7):e2310.
 25. Thongkham J, Kanrew K, Wongkumthi C, Intasan N, Saita S, Vittaporn S, et al. Health beliefs and housing environmental factors affecting dengue prevention and Aedes larvae in rural northern Thailand: a cross-sectional study. *Discov Soc Sci Heal*. 2025 Jul 9;5(1):104.
 26. Mulligan K, Dixon J, Joanna Sinn CL, Elliott SJ. Is dengue a disease of poverty? A systematic review. *Pathog Glob Health*. 2015 Feb;109(1):10–8.
 27. Zellweger RM, Cano J, Mangeas M, Taglioni F, Mercier A, Despinoy M, et al. Socioeconomic and environmental determinants of dengue transmission in an urban setting: An ecological study in Nouméa, New Caledonia. Messer WB, editor. *PLoS Negl Trop Dis*. 2017 Apr 3;11(4):e0005471.
 28. Syawie MK, Sintiadewi IDR, Nisa TZ, Rahman A, Wowor RE. Literature Review: Faktor Sosial, Lingkungan, dan Perilaku Sebagai Risiko Demam Berdarah Dengue. *J Lentera Sehat Indones* [Internet]. 2026 Apr 11;5(1):10–7. Available from: <https://ejournal.ybli.or.id/index.php/jlsi/article/view/255>
 29. Abbasi E. Aedes aegypti and dengue: insights into transmission dynamics and viral lifecycle. *Epidemiol Infect*. 2025 Aug 1;153:e88.
 30. Barkhad A, Lecours N, Stevens-Uninsky M, Mbuagbaw L. The Relationships Between the Eco-Bio-Social Determinants of Dengue Epidemiology in Latin America and the Caribbean: A Scoping Review of the Literature. *Ecohealth*. 2026 Jan 30;23(2):348–66.
 31. Pascoe L, Nyambo DG, Bradshaw K, Clemen T. Understanding the life cycle of dengue vector (Aedes Aegypti) through an agent-based modelling approach. *J Simul*. 2025 Sep 4;1–22.
 32. Hendayani N, Faturrahman Y, Aisyah IS. Hubungan faktor lingkungan dan kebiasaan 3M plus dengan kejadian demam berdarah dengue (DBD) di wilayah kerja Puskesmas Manonjaya. *J Kesehat Komunitas Indones* [Internet]. 2022 Apr 4;18(1). Available from: <https://jurnal.unsil.ac.id/index.php/jkki/article/view/4729>
 33. Anliyanita R, Anwar C, Fajar NA. Effect of physical environment and community behavior on dengue hemorrhagic fever (DHF): A literature review. *Community Res Epidemiol*. 2023 Jun 28;74–6.
 34. Pasang M, Rakinaung NE, Wetik SV. Perilaku ibu dalam pencegahan demam berdarah dengue (DBD) pada balita dipengaruhi oleh level pengetahuan dan self-efficacy. *Media Ilm Kesehat Indones*. 2025 May 29;3(2).
 35. Mazariego-Longoria M, Rojas-Arbeláez C, Vélez-Santamaria H, Jiménez-Alejo A, Dor A, Rúa-Urbe G. Implementation fidelity of a community-based Aedes aegypti breeding site elimination program for dengue control in southeastern Mexico. Vall-Ilosera Camps M, editor. *PLoS One*. 2026 Apr 17;21(4):e0345163.
 36. Sim S, Ng LC, Lindsay SW, Wilson AL. A greener vision for vector control: The example of the Singapore dengue control programme. Kittayapong P, editor. *PLoS Negl Trop Dis*. 2020 Aug 27;14(8):e0008428.
 37. Wijayanti SPM, Porphyre T, Chase-Topping M, Rainey SM, McFarlane M, Schnettler E, et al. The Importance of Socio-Economic Versus Environmental Risk Factors for Reported Dengue Cases in Java, Indonesia. Carvalho MS, editor. *PLoS Negl Trop Dis*. 2016 Sep 7;10(9):e0004964.
 38. Santhi H, Marsaulina I, Nurmaini. Revenue, Knowledge, Attitudes, and Implementation Regarding the Dengue Fever Prevention Program in Medan, Indonesia. *Britain Int Exact Sci J*. 2020 Jan 3;2(1):77–83.
 39. Liu D, Guo S, Zou M, Chen C, Deng F, Xie Z, et al. A dengue fever predicting model based on Baidu search index data and climate data in South China. Samy AM, editor. *PLoS One*. 2019 Dec 30;14(12):e0226841.
 40. Chaiyarit J, Sriwongsuk K, Putepapas S, Intarasaksit P. Environmental health factors influencing dengue: a systematic review with thematic categorization. *Int J Environ Health Res*. 2026 Jul 3;36(7):1622–36.
 41. Hahm M, Guthula VB, Chilaule R, Gominiński D, Limwagu A, Chaki E, et al. High-resolution automated mapping of potential Aedes larval container habitats using drone imagery and supervised machine learning in Dar es Salaam, Tanzania. Hol F, editor. *PLoS Negl Trop Dis*. 2026 May 26;20(5):e0014361.
 42. Isnaeni RN, Musthofa SB, Indraswari R. Strategies to increase community participation in controlling dengue mosquito breeding sites: A scoping review. *Ber Kedokt Masy*. 2025 Dec 31;41(12):e22283.
 43. Nontapet O, Mancerattanasak S, Jaroenpool J, Phumee A, Krachai W, Napet P, et al. Understanding dengue solution and larval indices surveillance system among village health volunteers in high- and low-risk dengue villages in southern Thailand. *One Heal*. 2022 Dec;15:100440.