



Behavioral and Environmental Determinants of Dengue Hemorrhagic Fever Occurrence in North Semarang District

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ABSTRACT

Background: DHF remains a public health problem in coastal areas. This study aimed to identify behavioural and environmental factors associated with DHF incidence in North Semarang District.

Methods: An analytic observational study with a case-control design was conducted from April to June 2026 in North Semarang District. The final dataset used for multivariable analysis comprised 100 respondents, consisting of 58 respondents in the DHF group and 42 respondents in the non-DHF group. Data were collected using structured interviews and environmental observations. Variables analysed included knowledge of DHF, PSN 3M Plus practice, and environmental risk. Bivariate analysis used the Chi-square test, while multivariable analysis used binary logistic regression.

Result: Knowledge level and environmental risk were significantly associated with DHF occurrence. Respondents with high knowledge had lower odds of DHF than those with low knowledge (AOR = 0.186; 95% CI = 0.069–0.502; $p < 0.001$). Respondents living in risky environmental conditions had higher odds of DHF (AOR = 6.005; 95% CI = 2.182–16.521; $p < 0.001$). PSN 3M Plus practice was not statistically significant after adjustment (AOR = 0.495; 95% CI = 0.182–1.343; $p = 0.167$). The final model was statistically significant (Omnibus test $p < 0.001$), with Nagelkerke $R^2 = 0.429$ and overall classification accuracy of 81.0%.

Conclusion: Risky environmental conditions, low knowledge, and poor PSN 3M Plus practices increase the risk of DHF. Integrated vector control and community involvement are essential.

Keywords: Dengue haemorrhagic fever ; Behavioural factors ; Environmental factors ; Cross sectional study

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Introduction

Dengue Hemorrhagic Fever (DHF) is an acute infectious disease caused by the dengue virus and transmitted through the bites of *Aedes aegypti* mosquitoes.¹ The disease is characterized by high fever and hemorrhagic manifestations resulting from increased vascular permeability and disturbances in the hemostatic system.¹ Central Java Province is considered one of the regions in Indonesia with a high burden of DHF. In 2025, the incidence rate (IR) of DHF in the province was 27.41 per 100,000 population, with a case fatality rate (CFR) of 0.89%.²

Semarang City has been identified as one of the areas with a high burden of DHF in Central Java.^{3–7} Within Semarang City, North Semarang District is an area with a relatively high incidence of DHF. According to reports from the Semarang City Health Office, 2,955 DHF cases were recorded in 2020, followed by a decrease to 2,074 cases in 2021. In 2022, the number of cases increased substantially to 6,509 before declining to 4,066 cases in 2023 and increasing again to 7,093 cases in 2025.⁸ These figures indicate that the burden of DHF remains high in North Semarang District.

North Semarang District is a coastal area of Semarang City with a population density of 10,348.11 people/km² and is vulnerable to tidal flooding (*rob*), creating ecological conditions that may support increased *Aedes aegypti* transmission.^{9–11} Previous studies have demonstrated that DHF occurrence is multifactorial and influenced by individual, behavioral, and environmental factors. Behavioral factors, such as inadequate implementation of the Mosquito Nest Eradication (Pemberantasan Sarang Nyamuk/PSN) 3M Plus practices, as well as environmental factors, including poor sanitation and stagnant water storage containers, play an important role in increasing the risk of transmission.¹²

Various studies have demonstrated that DHF occurrence is multifactorial and influenced by interactions among individual, behavioral, and environmental factors. Behavioral factors, such as the level of knowledge and implementation of PSN 3M Plus practices, as well as environmental

factors, including the condition of water storage containers, sanitation, drainage, and the presence of stagnant water, have been reported to be associated with DHF occurrence.^{12,16,19} However, previous studies have tended to assess behavioral or environmental factors separately, and therefore have not fully captured the relationship between these two groups of factors within coastal residential environments characterized by specific ecological conditions.

This gap is particularly relevant in North Semarang District, a densely populated coastal area vulnerable to tidal flooding. These conditions may create an environment conducive to the presence of vector breeding sites, while household practices related to DHF prevention through PSN 3M Plus may vary between households. Although DHF control programs, including PSN 3M Plus, larval surveillance, and health education, have been implemented, DHF cases continue to occur in the area.¹³ Therefore, empirical evidence is still needed regarding behavioral and environmental factors that are simultaneously associated with DHF occurrence at the household level in North Semarang District.

This study contributes to the existing evidence by simultaneously analyzing three interrelated aspects: knowledge of DHF, PSN 3M Plus practices, and household environmental conditions, and by examining the association of each factor with DHF occurrence through multivariable analysis. This approach enables the study not only to identify factors associated with DHF occurrence in bivariate analyses but also to determine which factors remain associated after accounting for other variables. Thus, the findings are expected to provide a more specific understanding of the behavioral and environmental factors associated with DHF occurrence among communities in the coastal area of North Semarang District and to serve as a basis for determining DHF control intervention priorities that are appropriate to the characteristics of the area.

Therefore, this study aimed to analyze behavioral and environmental factors associated with DHF occurrence in North

Semarang District, particularly knowledge of DHF, PSN 3M Plus practices, and household environmental conditions.

Methods

This analytical observational study employed a cross-sectional design and was conducted from April to June 2026 in North Semarang District, Semarang City. Primary data were collected through structured interviews using questionnaires, observation of household environmental conditions, and inspection of water containers for mosquito larvae.

The study population consisted of all households residing in North Semarang District. The inclusion criteria were households that had resided in the area for at least six months, had a family member who had been diagnosed with DHF between 2020 and 2025, and were willing to participate in all study procedures. The sample was selected using purposive sampling from a list of eligible households.

The study variables consisted of a dependent variable, namely the occurrence of dengue hemorrhagic fever (DHF) at the household level, which was measured based on whether any household member had received a medical diagnosis of DHF within the previous five years. The independent variables included behavioral factors, namely PSN 3M Plus practices, the use of mosquito nets or mosquito repellents, waste management practices, the habit of hanging clothes, and knowledge and attitudes regarding DHF. Environmental factors included the presence and condition of water storage containers, larval indices (House Index and Container Index), drainage conditions, household ventilation and lighting, and housing density. Data analysis included univariate analysis to describe the characteristics of the respondents, bivariate analysis using the Chi-square test, and multivariable analysis using binary logistic regression. Ethical approval for this study was obtained from the Health Research Ethics Committee, Faculty of Public Health, Universitas Diponegoro, under Ethical Clearance No. 169/EA/KEPK-FKM/2026.

Results

A total of 100 respondents residing in North Semarang District who met the study criteria were included in this study. The study variables included knowledge of DHF, PSN 3M Plus practices, and environmental conditions. Knowledge was categorized as high or low based on respondents' knowledge of DHF, including its definition, symptoms, causes, and prevention. PSN 3M Plus practices were categorized as high or low based on preventive practices undertaken by respondents, including draining and covering water storage containers, burying or recycling used items that could potentially serve as mosquito breeding sites, using mosquito nets and repellents, and the habit of hanging clothes for more than one day. Environmental conditions were categorized as low-risk or high-risk based on the presence of stagnant water around the house, yard cleanliness, household ventilation and lighting, the presence of ceilings, used items capable of collecting water, drainage conditions around the house, and the presence of DHF cases within a radius of <100 meters from the respondent's residence.

Table 1. The Distribution of Respondents According to Each Variable and Category

Variable	n	%
Sex		
Female	64	64
Male	36	36
Age		
5-11 age	8	8
12-17 age	24	24
17-25 age	32	32
26-35 age	30	30
35-45 age	4	4
>45 age	2	2

Based on Table 1, the univariate analysis showed that, by sex, the case group consisted of 64 respondents (64.0%) who were male and 36 respondents (36.0%) who were female, whereas the control group consisted of 56 respondents (56.0%) who were male and 44 respondents (44.0%) who were female. Regarding age, among the 100 respondents, 8 respondents (8.0%) were aged 5–11 years, 24 respondents (24.0%) were aged 12–17 years, 32 respondents (32.0%) were aged 17–25 years, 30 respondents (30.0%) were aged 26–35 years, 4 respondents (4.0%) were aged 35–45 years, and 2 respondents (2.0%) were aged >45 years. The largest proportion was observed in the 17–25-year age group (32.0%), while the smallest proportion was observed among respondents aged >45 years (2.0%).

The results from the 100 respondents showed the distribution of DHF knowledge, PSN 3M Plus practices, and environmental conditions. Regarding DHF knowledge, 55 respondents (55.0%) had low knowledge, whereas 45 respondents (45.0%) had high knowledge. Regarding PSN 3M Plus practices, 58 respondents (58.0%) had inadequate PSN 3M Plus practices, whereas 42 respondents (42.0%) had adequate practices. These findings indicate that the majority of respondents had inadequate PSN 3M Plus practices.

Regarding environmental conditions, 66 respondents (66.0%) lived in high-risk environmental conditions, whereas 34 respondents (34.0%) lived in low-risk environmental conditions. Thus, the majority of respondents lived in environments considered to pose a risk for DHF occurrence. Overall, the univariate analysis showed that most respondents had low levels of DHF knowledge, inadequate PSN 3M Plus practices, and high-risk environmental conditions. These findings provided the basis for subsequent bivariate analysis of the factors associated with DHF occurrence.

Among the 100 respondents, 59 respondents (59%) had high levels of DHF knowledge, whereas 41 respondents (41%) had low levels of knowledge. Regarding PSN 3M Plus practices, 55 respondents (55%) had high levels of practice, whereas 45 respondents

(45%) had low levels of practice. Regarding environmental conditions, 39 respondents (39%) lived in low-risk environments for DHF vector breeding, whereas 61 respondents (61%) lived in high-risk environments.

Table 2. Distribution of respondents according to study variables

Variable	n	%
DHF Knowledge		
Low	55	55
High	45	45
PSN 3M Plus Practices		
Low	58	58
High	42	42
Environmental Condition		
Low Risk	34	34
High Risk	66	66

Multivariable analysis using binary logistic regression showed that the overall model was statistically significant based on the Omnibus Test ($\chi^2 = 38.390$; $df = 3$; $p < 0.001$). The Nagelkerke R^2 value of 0.429 indicated that the model explained approximately 42.9% of the variation in DHF occurrence, while the remaining variation was associated with other factors not included in the model.

Knowledge level was significantly associated with DHF occurrence. Respondents with high levels of knowledge had 0.186 times the odds of DHF occurrence compared with respondents with low levels of knowledge after controlling for PSN 3M Plus practices and environmental conditions (AOR = 0.186; 95% CI = 0.069–0.502; $p < 0.001$). Conversely, based on the reciprocal of the AOR, the low-knowledge group had approximately 5.38 times the odds of DHF occurrence compared with the high-knowledge group.

PSN 3M Plus practices were not statistically significantly associated with DHF occurrence after adjustment for the other variables in the model (AOR = 0.495; 95% CI = 0.182–1.343; $p = 0.167$). Because the confidence interval included 1 and the p-value was greater than 0.05, these findings did not support an independent association between

PSN 3M Plus practices and DHF occurrence in the final model.

High-risk environmental conditions were significantly associated with DHF occurrence (AOR = 6.005; 95% CI = 2.182–16.521; $p < 0.001$). Respondents living in high-risk

environmental conditions had approximately six times the odds of DHF occurrence compared with those living in low-risk environmental conditions after controlling for knowledge level and PSN 3M Plus practices.

Table 2. Bivariate and Multivariable Analysis of Risk Factors for DHF Occurrence

Variable	DHF		Non DHF		Bivariate Analysis			Multivariate Analysis		
	n	%	n	%	COR (95% CI)	<i>p-value</i>	AOR (95% CI)	<i>p-value</i>		
DHF Knowledge										
Low	28	28	13	13	0,144 (0.059–0.352)	<0,01	0,186 (0,69-0,502)	<0,001		
High	14	14	45	45	Ref.		Ref.			
PSN 3M Plus Practices										
Low	26	26	19	19	0.300 (0.131–0.687)	>0,05	0,495 (0,182-1,343)	0,167		
High	16	16	39	39	Ref.		Ref.			
Environmental Condition										
Low Risk	28	28	11	11	8,545 (3.413–21.398)	<0,001	6,005 (2,182-16,521)	<0,001		
High Risk	14	14	47	47	Ref		Ref.			

Discussion

The multivariable analysis showed that high-risk environmental conditions had the strongest positive association with DHF occurrence in the final model (AOR = 6.005; 95% CI = 2.182–16.521). This finding indicates that household and surrounding environmental conditions remained associated with DHF occurrence after accounting for knowledge level and PSN 3M Plus practices. In coastal areas such as North Semarang, settlement characteristics, drainage conditions, stagnant water, and the presence of containers capable of holding water are relevant aspects to consider in vector control.

Knowledge level also showed a statistically significant association with DHF occurrence. The AOR of 0.186 for the high-knowledge category indicates lower odds of DHF occurrence compared with the low-knowledge category after adjustment for the other variables. This finding highlights the importance of knowledge regarding the causes, modes of transmission, symptoms, and

prevention of DHF as part of efforts to promote preventive behaviors. However, because this study used a case-control design, the observed associations should be interpreted as associations and do not directly establish causal relationships.

In contrast to these two variables, PSN 3M Plus practices were not statistically significant in the multivariable model ($p = 0.167$). This finding should be interpreted cautiously. The lack of statistical significance after adjustment does not indicate that PSN 3M Plus practices are unimportant for DHF control; rather, it indicates that, within this dataset and study model, there was insufficient statistical evidence to demonstrate an independent association between PSN 3M Plus practices and DHF occurrence after controlling for knowledge and environmental conditions.

Differences between bivariate and multivariable findings, when observed in the final analysis, may occur because the association between a particular variable and DHF occurrence can be influenced by other variables included in the model. Therefore, the

primary interpretation of this study should be based on the final multivariable model, particularly because the analysis aimed to identify factors that remained associated with DHF occurrence after simultaneous adjustment for other variables.

The contribution of this study lies in the simultaneous examination of knowledge, PSN 3M Plus practices, and environmental conditions in the context of North Semarang District as a coastal area. The findings indicate that DHF control approaches should not focus solely on individual behaviors but should also consider the environmental conditions in which people live. Nevertheless, the explanatory contribution of the model remains limited, as indicated by the Nagelkerke R^2 of 42.9%, suggesting that other factors not included in the model may also be associated with DHF occurrence.

Based on the findings, environmental conditions represent a major ecological factor associated with DHF transmission in North Semarang. The relatively high adjusted odds ratio for the environmental variable may be related to the distinctive ecological characteristics of coastal areas, including high settlement density, inadequate or obstructed drainage systems, tidal flooding, and the presence of neglected artificial water storage containers. These conditions may provide suitable breeding sites for *Aedes aegypti* mosquitoes. This finding is consistent with previous studies emphasizing that environmental ecological factors and limitations in sanitation within coastal settlements are consistently associated with increased dengue vector populations.¹⁴

North Semarang is characterized by densely populated settlements, intensive commercial and port-related activities, and vulnerability to tidal flooding. These conditions may disrupt drainage systems in some areas and contribute to the formation of stagnant water during the rainy season and periods of high tide. In addition, high population density may increase household waste generation. When waste management is inadequate, accumulated waste may become capable of collecting rainwater.¹⁵ These environmental characteristics may support the development of *Aedes aegypti*

vectors and consequently be associated with an increased risk of DHF occurrence.^{14, 15}

In addition to environmental factors, low levels of knowledge regarding DHF transmission and prevention may also be associated with DHF occurrence in this area. Adequate knowledge regarding disease causes, modes of transmission, symptoms, and preventive measures may increase individual awareness of environmental cleanliness and mosquito breeding-site elimination. Conversely, individuals with limited knowledge may have less understanding of the importance of preventive measures and may consequently have a higher risk of disease.^{16–18} Previous research has also reported that increased knowledge is associated with dengue prevention practices, including efforts to control mosquito breeding sites and maintain environmental cleanliness.¹⁸

PSN 3M Plus is a strategy recommended by the Indonesian Ministry of Health for DHF control. The program includes draining and covering water storage containers, recycling used items that may collect water, and additional measures such as the use of larvicides, installation of window screens, use of mosquito repellents, and regular monitoring of mosquito larvae. Low implementation of PSN 3M Plus practices may also be associated with DHF occurrence in this area. Previous studies have reported that consistent implementation of PSN 3M Plus practices within communities is associated with dengue control outcomes.^{16, 19}

Overall, the findings indicate that DHF occurrence in North Semarang District is associated with environmental conditions, knowledge levels, and PSN 3M Plus practices. These findings highlight the importance of DHF control strategies that consider environmental and behavioral factors simultaneously, particularly in densely populated coastal areas.

This study has several limitations. First, the use of retrospective data may have introduced recall bias, particularly when respondents were asked to recall previous disease episodes or preventive practices. Second, accidental sampling may have introduced selection bias because respondents who were encountered

and willing to participate may not fully represent all households in North Semarang District. Third, the case-control design and the measurement of some variables at the time of the study limit the ability to establish the temporal sequence between exposure and disease occurrence; therefore, the observed associations should not be interpreted as causal relationships. Fourth, other factors were not included in the model, as reflected by the Nagelkerke R^2 of 42.9%.

Conclusion

In the final multivariable model, knowledge level and environmental conditions were significantly associated with DHF occurrence in North Semarang District. Respondents with high levels of knowledge had lower odds of DHF occurrence compared with those with low levels of knowledge (AOR = 0.186; 95% CI = 0.069–0.502; $p < 0.001$). Conversely, respondents living in high-risk environmental conditions had approximately six times the odds of DHF occurrence compared with those living in low-risk environmental conditions (AOR = 6.005; 95% CI = 2.182–16.521; $p < 0.001$). PSN 3M Plus practices were not significantly associated with DHF occurrence after adjustment (AOR = 0.495; 95% CI = 0.182–1.343; $p = 0.167$). The final model was statistically significant overall and demonstrated a classification accuracy of 81.0%.

These findings indicate that DHF control in North Semarang District should pay attention to environmental management and efforts to improve community knowledge. The finding regarding PSN 3M Plus practices should be interpreted as a statistical finding within the present study model and should not be interpreted as indicating that PSN activities are unnecessary for DHF control.

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Reference

1. World Health Organization (WHO). Dengue and Severe Dengue. 2025. Accessed September 21, 2026. <https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue>
2. Kementerian Kesehatan Republik Indonesia. *Profil Kesehatan Indonesia 2025*. 2026.
3. Dinas Kesehatan Provinsi Jawa Tengah. *Buku Saku Kesehatan age 2021*. 2022.
4. Dinas Kesehatan Provinsi Jawa Tengah. *Buku Saku Kesehatan age 2025*. 2026.
5. Dinas Kesehatan Provinsi Jawa Tengah. *Buku Saku Kesehatan age 2024*. 2025.
6. Dinas Kesehatan Provinsi Jawa Tengah. *Buku Saku Kesehatan age 2023*. 2024.
7. Dinas Kesehatan Provinsi Jawa Tengah. *Buku Saku Kesehatan age 2022*. 2023.
8. Dinas Kesehatan Kota Semarang. *Profil Kesehatan 2025 Dinas Kesehatan Kota Semarang*. 2026.
9. BPS Kota Semarang. *Jumlah Penduduk Menurut Kecamatan, Luas Wilayah, Dan Kepadatan Penduduk (Jiwa/Km2) 2025*. 2026. Accessed September 21, 2026. <https://semarangkota.bps.go.id/id/statistics-table/2/NDgjMg==/jumlah-penduduk-menurut-kecamatan--luas-wilayah--dan-kepadatan-penduduk--jiwa-km2-.html>
10. Yunarto Y, Sari AM. Relokasi Penduduk Terdampak Banjir/Rob di Kota Semarang. *MAJALAH ILMIAH GLOBE*. 2017;19(2):123. doi:10.24895/MIG.2017.19-2.624
11. Sury IA, Martini M, Yuliawati S, Hestningsih R. Gambaran Epidemiologi Kejadian Demam Berdarah Dengue: Karakteristik Penderita, Waktu dan Faktor Lingkungan di Kecamatan Tembalang age 2019. *Jurnal Kesehatan Masyarakat (Undip)*. 2021;9(6):816-821. doi:10.14710/jkm.v9i6.31602
12. Erwina BW, Pakki IB, Anggraeni G JI. Analisis Determinan Kejadian Demam Berdarah Dengue di Wilayah Kerja UPT Blud Puskesmas Kaliorang Kutai Timur. *Jurnal Sehat Indonesia (JUSINDO)*. 2025;7(2):675-691. doi:10.59141/jsi.v7i2.308

13. Pemerintah Kota Semarang. *Peraturan Daerah (Perda) Kota Semarang Nomor 5 age 2010 Tentang Pengendalian Penyakit Demam Berdarah Dengue*. 2010.
14. Chaizarit J, Sriwongsuk K, Putepapas S, Intarasaksit P. Environmental health factors influencing dengue: a systematic review with thematic categorization. *Int J Environ Health Res*. 2026;36(7):1622-1636. doi:10.1080/09603123.2025.2589371
15. Saskia Diah Nisa. Optimizing Environmental Sanitation as an Effort to Control Dengue Fever (DBD) Vectors. *Journal Health of Indonesian*. 2025;3(01):33-41. doi:10.58471/health.v3i01.147
16. Basuki YR, Indriyanti DR, Wijayanti Y. Analysis of Factors Influencing The Incidence of DanguHemorrhagic Fever (DBD) In Semarang City. *Public Health Perspective Journal*. 2024;8(1):1-11. doi:10.15294/phpj.v8i1.2795
17. Chng JW, Parvathi T, Pang J. Knowledge, attitudes and practices of dengue prevention between dengue sustained hotspots and non-sustained hotspots in Singapore: a cross-sectional study. *Sci Rep*. 2022;12(1):18426. doi:10.1038/s41598-022-22776-y
18. Phuyal P, Kramer IM, Kuch U, et al. The knowledge, attitude and practice of community people on dengue fever in Central Nepal: a cross-sectional study. *BMC Infect Dis*. 2022;22(1):454. doi:10.1186/s12879-022-07404-4
19. Sutriyawan A, Wirawati K, Suherdin S. Kejadian Demam Berdarah Dengue dan Hubungannya dengan Perilaku 3M Plus: Studi Kasus Kontrol. *Promotif: Jurnal Kesehatan Masyarakat*. 2021;11(2):172-180. doi:10.56338/pjkm.v11i2.2024