Original article

Investigation of risk factors for household-based dengue virus infection in Borobudur Subdistrict, Magelang, Indonesia

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Abstract

Introduction **Dengue infection poses a serious threat to global public health, including Indonesia. The rapid spread and significant economic impact are crucial concerns for control efforts. Investigating risk factors of dengue virus infection is necessary to formulate effective strategies, particularly at the household level. This study aims to investigate contributing risk factors to dengue virus transmission in the Borobudur Subdistrict, Magelang, Indonesia, an area with persistently high dengue infection mortality rates.**

Methods **This study adopted a case-control design and utilized secondary data collected from six villages in the Borobudur Subdistrict. A total of 111 households (37 cases and 74 controls) participated in the study and completed a questionnaire encompassing: 1) Sociodemographic data; 2) Healthy housing components; 3) Sanitation and behavioral components; and 4) Dengue infection prevention practices. Data were analyzed bivariately using statistical software to identify differences in group proportions.**

Results **The findings of this study indicate that the presence of stagnant water (odds ratio [OR]: 5.02) and mosquito larvae (OR: 4.80) around the house, morning sleep habits (OR: 6.97), and lack of participation in anti-dengue programs (OR: 3.23) are significant risk factors ($p<0.05$) for dengue infection. However, no significant differences ($p>0.05$) were found in healthy housing components between the case and control groups.**

Conclusions **This study has identified contributing risk factors to dengue virus transmission in the Borobudur Subdistrict. These results can serve as a foundation for designing more effective intervention programs for dengue infection and future prevention efforts.**

Keywords **Dengue, prevention programs, risk factors, stagnant water.**

Introduction

Dengue infection is a contagious illness resulting from the infection with any of the four serotypes of dengue virus (DENV 1-4). These viruses belong to the *Flavivirus* genus and possess a single-stranded RNA structure. The disease is transmitted through the bite of *Aedes aegypti* or *Aedes albopictus* mosquitoes that have been infected with the dengue virus.[1] Dengue infection is still a serious threat in various countries, including Indonesia, which is endemic-epidemic due to its rapid transmission; furthermore, the disease can cause death in a short time.[2,3]

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In 2020, the dengue case fatality rate (CFR) in Indonesia (0.69%) reached the national target indicator (<1%) and has met the World Health Organization (WHO) neglected tropical disease roadmap target of less than 0.8%.[4,5] However, there are still 7 provinces that have a mortality rate of more than 1%, including Central Java (1.9%).[5] In 2021, there was a decrease in dengue cases (4470 cases) in Central Java Province compared to 2020 (5678 cases). However, there was an increase in the CFR of dengue in 2021 (2.7%) compared to 2020 (1.9%).[6]

Dengue infection can have a significant economic impact on society due to medical treatment costs, decreased productivity, and increased health burden.[5] Therefore, the Indonesian government, through the Ministry of Health, enforces the mosquito nest eradication program by covering, draining, and recycling used goods plus preventing mosquito bites and breeding (called PSN 3M Plus) and the mosquito larvae surveyors (called Jumantik).[5,7,8] However, the implementation is often hampered by low levels of knowledge, motivation, and community participation.[9-11]

Controlling dengue virus infection is a complex challenge, as it involves various interrelated risk factors. These factors may vary from individual to environmental level, including aspects of behavior, sanitation, physical environment, and socio-economic factors.[4,5] To design an effective strategy, it is imperative to thoroughly investigate the risk factors associated with dengue virus infection, especially at the household level. In this context, this study aims to identify and analyze the risk factors that contribute to dengue virus transmission in the Borobudur Subdistrict, Magelang District, Central Java Province, Indonesia, where this rural area has a dengue infection CFR of 2.9% in 2021, which is still higher than the national target (<1%) and strategic plan target (<2%).[6]

Methods

Geographical and demographic profile

Magelang Regency, situated within Central Java Province, is located approximately 40 km from the center of Yogyakarta City in Yogyakarta Province. The Regency covers an area of 1,085.73 km^2. In 2022, Magelang District's population was recorded at 1,312,573 individuals, yielding a population density of approximately 1,209 people per km^2. The demographic breakdown by age group in Magelang District is as follows: 21.35% are aged 0-14 years, 69.49% fall within the 15-64 year age bracket, and 9.33% are above 65 years of age. Notably, within Magelang District lies Borobudur Subdistrict, a predominantly rural area encompassing an area of 54.55 km^2. This subdistrict is renowned for housing the Borobudur Temple, a significant tourist attraction. In 2022, it reported a population density of 1,155 individuals per km^2. The total population recorded was 63,028, exhibiting an annual growth rate of 0.72%. The sex ratio in the subdistrict stands at 101, indicating that for every 100 female residents, there are 101 male residents. This is reflected in the population figures, with males numbering 31,743 and females at 31,285.[12] Most of the residents in this subdistrict work as laborers, traders, and farmers. In 2021, there were 105 cases of dengue infection in Magelang Regency. However, there are no data reported for the number of cases in the following year or specifically for Borobudur Subdistrict.[13]

In Borobudur Subdistrict, the residential structures are generally situated in close proximity to each other. The area's drainage is primarily facilitated by a network of small rivers and sewers, which often receive both household and industrial waste, such as by-products from tofu production. This condition is prevalent across the majority of villages within this subdistrict. Additionally, the presence of bushes and gardens in the vicinity of these residences creates an environment conducive to the breeding of mosquitoes. For daily water needs, the residents rely on water supplied by the Public Water Company or utilize well water.

Study design and data collection

This case-control study used secondary data collected by the surveillance team of Borobudur Community Health Center (BCHC), Magelang. The surveillance team collected data between 11-27 July 2023, on people with a history of dengue infection in June 2022 - June 2023. The surveillance team visited homes directly in 6 villages with the highest prevalence of dengue infection based on recorded surveillance data from BCHC, consisting of Borobudur, Tanjungsari, Wanurejo, Candirejo, Ngargogondo, and Tuksongo villages. The surveillance team utilized a questionnaire comprising 4 sections: 1) Sociodemographic data; 2) Healthy house components; 3) Sanitation and behavior components; and 4) Dengue infection prevention practices. The questions related to healthy home components, sanitation, and behavior were sourced from the Regulation of the Minister of Health of the Republic of Indonesia No.829/Menkes/VII/1999 with some modifications. Furthermore, questions related to dengue infection prevention practices were based on the anti-dengue PSN 3M Plus and Jumantik programs from the Indonesian Ministry of Health.[5,7,8]

Participants and sampling

Cluster sampling was applied in this study. All available secondary data on dengue infection cases in the 6 villages in the Borobudur Subdistrict were included as samples. The case-control sample ratio was 1:2, consisting of 37 cases and 74 controls. Cases are households with family members with a history of dengue infection diagnosis between June 2022 - June 2023. Controls were the closest neighbors of the cases who were not diagnosed with dengue infection between June 2022 and June 2023. Incomplete secondary data were excluded from the study.

Data analysis

The analysis of all secondary data collected involved the utilization of SPSS version 25 (IBM, Chicago, IL, USA). Frequencies and percentages were used to present categorical data, while mean ± standard deviation was used to present numerical data. To compare differences in proportions between groups, bivariate analysis was conducted using either the Chi-Square or Fisher's Exact tests. A p-value of less than 0.05 was deemed statistically significant.

Ethics approval

Before data collection, this study underwent a thorough evaluation and received approval from the Ethics Committee of the Faculty of Medicine at Universitas Islam Indonesia. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki (Approval no: 12/Ka.Kom.Et/70/KE/IX/2023). Informed consent was not required as the study utilized pre-existing secondary data.

Results

Participants

Table 1 presents a comparison of demographic characteristics between the case and control groups. A total of 111 households were enrolled in this study, consisting of 37 cases and 74 controls. Significant differences ($p<0.05$) were observed in age, gender, occupation, and marital status. However, it is important to note that these differences are not clinically meaningful as one sample represents a household.

Components of healthy homes, sanitation, and behavior

Regarding the components of a healthy home (Table 2), no significant differences were found between the case and control groups in the evaluated households. Based on the results of component and behavior analysis, the presence of stagnant water around the house was a significant risk factor for dengue infection (odds ratio [OR]: 5.02, 95% confidence interval [CI]: 1.87-13.51) compared to those without stagnant water. Furthermore, families living in a house with mosquito larvae were 4.8-fold more likely to get dengue infection significantly (95%CI: 1.61-14.30) than those without mosquito larvae (Table 3).

Practices to prevent dengue infection

Table 4 presents dengue infection prevention practices. The habit of sleeping in the morning (05.00-11.00) contributed to dengue infection making it 6.97-fold more likely (95%CI: 1.33-36.45) than those who did not have the habit of sleeping in the morning. Lack of participation in the anti-dengue program campaign (PSN 3M Plus

Table 1. Sociodemographic data of participants (n=111)

Variable	Control (n=37)	Case (n=74)	P-value
Age, mean ± standard deviation	47.50 ± 11.69	36.73 ± 13.207	**0.000**‡
Sex			
Male	26 (44.1%)	33 (55.9)	**0.011**
Female	11 (21.2)	41 (78.8)	
Occupation			
Housewife	1 (4.8)	20 (95.2)	**0.001**
Student	7 (87.5)	1 (12.5)	
Retiree	0 (0.0)	1 (100.0)	
Trader	4 (26.7)	11 (73.3)	
Farmer	2 (22.2)	7 (77.8)	
Military/police	0 (0.0)	2 (100.0)	
Employee/laborer	8 (44.4)	10 (55.6)	
Entrepreneurs	13 (37.1)	22 (62.9)	
Teacher	2 (100.0)	0 (0.0)	
Education			
Not educated	1 (33.3)	2 (66.7)	0.239
Elementary school or equivalent	4 (23.5)	13 (76.5)	
Middle school or equivalent	7 (24.1)	22 (75.9)	
High school or equivalent	17 (35.4)	31 (64.6)	
College	8 (57.1)	6 (42.9)	
Marital status			
Married	27 (30.3)	62 (69.7)	**<0.001**
Widower/widow	0 (0.0)	10 (100.0)	
Unmarried	10 (83.3)	2 (16.7)	
Household income per month			
IDR ≤2.5 million	27 (30.0)	63 (70.0)	0.123
IDR >2.5 million	10 (47.6)	11 (52.4)	

Bolded p-values indicate statistical significance (p<0.05).
‡Analyzed with Mann-Whitney U test.
IDR – Indonesian Rupiah (1 USD = 15,102 IDR at July 27, 2023).

Table 2. Healthy home components

Variable	Group		P-value, OR (95%CI)
	Case	Control	
Ceiling			
None	22 (41.5)	31 (58.5)	0.115, 1.93 (0.85-4.38)
Existing and dirty	1 (16.7)	5 (83.3)	1.000§, 0.54 (0.06-5.06)
Existing and clean	14 (26.9)	38 (73.1)	Ref.
Wall			
Unplastered brick	33 (33.3)	66 (66.7)	1.000§, 1.00 (0.28-3.56)
Plastered brick	4 (33.3)	8 (66.7)	Ref.
Flooring			
Earth	1 (50.0)	1 (50.0)	0.526§, 2.27 (0.14-37.46)
Rough plaster	6 (54.5)	5 (45.5)	0.173§, 2.72 (0.77-9.61)
Smooth plaster/tile/ceramic	30 (30.6)	68 (69.4)	Ref.
Bedroom windows			
No	5 (62.5)	3 (37.5)	0.114§, 3.70 (0.83-16.42)
Yes	32 (31.1)	71 (68.9)	Ref.
Living room windows			
No	1 (33.3)	2 (66.7)	1.000§, 1.00 (0.09-11.40
Yes	36 (33.3)	72 (66.7)	Ref.
Vent			
No	4 (57.1)	3 (42.9)	0.219§, 2.87 (0.61-13.55)
Yes	33 (31.7)	71 (68.3)	Ref.
Kitchen smoke vent			
No	9 (33.3)	18 (66.7)	1.000, 1.00 (0.40-2.51)
Yes	28 (33.3)	56 (66.7)	Ref.
Lighting			
Less	13 (40.6)	19 (59.4)	0.300, 1.57 (0.67-3.68)
Enough	24 (30.4)	55 (69.6)	Ref.

Bolded p-values indicate statistical significance (p<0.05).
§Analyzed using Fisher's Exact test.
OR – odds ratio; **95%CI** – 95% confidence interval.

Table 3. Components of sanitation and behavior

Variable	Group		P-value, OR (95%CI)
	Case	Control	
Source of water for bathing and washing			
Tap water	9 (33.3)	18 (66.7)	1.000, 1.00 (0.40-2.51)
Well water	28 (33.3)	56 (66.7)	Ref.
Has a latrine/toilet			
No	1 (50.0)	1 (50.0)	1.000§, (0.12-33.36)
Yes	36 (33.0)	73 (67.0)	Ref.
Has a septic tank			
No	1 (50.0)	1 (50.0)	1.000§, 2.03 (0.12-33.36)
Yes	36 (33.0)	73 (67.0)	Ref.
Has a trash can			
No	7 (35.0)	13 (65.0)	0.861, 1.10 (0.40-3.03)
Yes	30 (33.0)	61 (67.0)	Ref.
Do you open your windows often?			
No	5 (62.5)	3 (37.5)	0.114§, 3.70 (0.83-16.42)
Yes	32 (31.1)	71 (68.9)	Ref.
Do you sweep and mop your house often (>3 times/week)?			
No	3 (60.0)	2 (40.0)	0.331§, 3.18 (0.51-19.90)
Yes	34 (32.1)	72 (67.9)	Ref.
Do you think there are mosquitoes in the house?			
No	36 (35.6)	65 (64.4)	0.160§, 4.99 (0.61-40.94)
Yes	1 (10.0)	9 (90.0)	Ref.
There is stagnant water around the house			
Yes	14 (63.6)	8 (36.4)	**0.001**, 5.02 (1.87-13.51)
No	23 (25.8)	66 (74.2)	Ref.
Have you seen mosquito larvae around the house?			
Yes	11 (64.7)	6 (35.3)	**0.003**, 4.80 (1.61-14.30)
No	26 (27.7)	68 (72.3)	Ref.

Bolded p-values indicate statistical significance ($p<0.05$).
§Analyzed using Fisher's Exact test.
OR – odds ratio; **95%CI** – 95% confidence interval.

Table 4. Dengue infection prevention practices

Variable	Group		P-value, OR (95%CI)
	Case	Control	
Sleeping habits in the morning (05.00-11.00)			
Yes	6 (75.0)	2 (25.0)	**0.016**§, 6.97 (1.33-36.45)
No	31 (30.1)	72 (69.9)	Ref.
Sleep habits in the afternoon (15:00-19:00)			
Yes	4 (66.7)	2 (33.3)	0.094§, 4.36 (0.76-25.03)
No	33 (31.4)	72 (68.6)	Ref.
Habitual hanging of clothes			
Yes	22 (41.5)	31 (58.5)	0.081, 2.03 (0.91-4.54)
No	15 (25.9)	43 (74.1)	Ref.
Using wire mesh for ventilation			
No	29 (33.0)	59 (67.0)	0.868, 0.92 (0.35-2.42)
Yes	8 (34.8)	15 (65.2)	Ref.
Using mosquito nets			
No	35 (32.7)	72 (67.3)	0.600§, 0.49 (0.07-3.60)
Yes	2 (50.0)	2 (50.0)	Ref.
Using a fan to prevent mosquito bites			
No	13 (32.5)	27 (67.5)	0.889, 0.94 (0.41-2.15)
Yes	24 (33.8)	47 (66.2)	Ref.
Keep mosquito-eating fish			
No	21 (33.9)	41 (66.1)	0.892§, 1.06 (0.48-2.34)
Yes	16 (32.7)	33 (67.3)	Ref.
Dispose of used items that can collect water			
No	6 (54.5)	5 (45.5)	0.175§, 2.67 (0.76-9.42)
Yes	31 (31.0)	69 (69.0)	Ref.
Cover water containers			
No	18 (40.0)	27 (60.0)	0.219, 1.65 (0.74-3.67)
Yes	19 (28.8)	47 (71.2)	Ref.
Drain the water reservoir			
No	4 (40.0)	6 (60.0)	0.729§, 1.37 (0.36-5.20)
Yes	33 (32.7)	68 (67.3)	Ref.
Cover your body with clothing when in bushes, fields, or forests			
No	17 (44.7)	21 (55.3)	0.066, 2.15 (0.94-4.87)
Yes	20 (27.4)	53 (72.6)	Ref.
Cutting down bushes			
No	32 (31.7)	69 (68.3)	0.297§, 0.46 (0.13-1.72)
Yes	5 (50.0)	5 (50.0)	Ref.
Ensure the house drains smoothly			
No	8 (47.1)	9 (52.9)	0.192, 1.99 (0.70-5.68)
Yes	29 (30.9)	65 (69.1)	Ref.
Participate in anti-dengue program campaigns (PSN 3M Plus and Jumantik)			
No	25 (46.3)	29 (53.7)	**0.005**, 3.23 (1.41-7.43)
Yes	12 (21.1)	45 (78.9)	Ref.

Bolded p-values indicate statistical significance (p<0.05).
§Analyzed using Fisher's Exact test.
OR – odds ratio; **95%CI** – 95% confidence interval.

and Jumantik) was a significant risk factor for dengue infection (OR: 3.23, 95%CI: 1.41-7.43).

Discussion

This study reveals the risk factors contributing to dengue infection cases in Borobudur Subdistrict. The results of this study demonstrated some relevant findings related to factors associated with dengue infection in 111 households.

House components such as poor lighting, non-permanent walls, ventilation that is less than 10% of the floor area, and lack of water supply and not having a clean water source, which makes people store water in containers, were reported in a previous study to contribute to dengue infection in Kupang, East Nusa Tenggara.[14] Meanwhile, the houses evaluated in the Borobudur Subdistrict had healthy house components that were not statistically significantly different. This result indicates the homogeneity of characteristics among houses in the area. Furthermore, this result suggests that healthy home factors do not significantly affect the spread of dengue infection among households in this study area.

The presence of stagnant water around the house, such as puddles, fishless ponds, containers, used goods, tires, buckets, or trash cans, was a significant risk factor for dengue infection in Borobudur Subdistrict. Stagnant water has been known to become a breeding ground for dengue vectors, especially during the rainy season.[5] A study in Mozambique reported the same thing, where mosquito vectors develop in stagnant clean water.[15] However, several studies have also reported that *Aedes aegypti* mosquitoes are also able to thrive in domestic wastewater.[16-18] These findings are relevant to the condition of several small rivers and sewers in the Borobudur Subdistrict, many of which are not running smoothly. Therefore, keeping the environment clean and preventing stagnant water around the house with community cooperation is important.

In this study, it was found that the habit of sleeping in the morning (05.00-11.00) increased the risk of dengue infection 6.97-fold compared to people who did not have the habit of sleeping in the morning. In addition, a study in Bangladesh demonstrated that persons who slept during the day and walked around in the morning and evening are more susceptible to dengue infection.[19] In fact, *Aedes aegypti* is most active during the few hours after sunrise or before sunset.[20] However, the mosquito can also bite someone at night in well-lit areas with lights.[21] Therefore, it is necessary to take precautions, such as using anti-mosquito lotion when sleeping or walking around during these two vulnerable times.

PSN 3M Plus and Jumantik are national anti-dengue programs prioritizing community participation in preventing dengue infection.[5,7,8] However, the success of this program is hampered by the lack of active community participation. A previous study found that the low education level of the community led to a lack of knowledge about stagnant water and mosquito nests, thus reducing program implementation.[11] In addition, Sulistyawati et al.[9] concluded that motivation within the community is necessary for the program's success. Although some people know the dangers and ways to control dengue, many do not follow the 3M Plus PSN movement and believe in fogging as a solution.[10] To increase community participation following the health belief model theory, it is necessary to realize that PSN 3M Plus and Jumantik are more efficient and effective efforts than fogging to prevent dengue infection in Indonesia.

Recently, an innovative strategy using *Wolbachia* bacteria has been developed as a method to control and prevent dengue infection. *Wolbachia* is an intracellular bacterium that can infect the *Aedes aegypti* mosquito so that it becomes resistant to the dengue virus and can even paralyze it due to its innate immunity. Male mosquitoes infected with *Wolbachia* will spread the bacteria to female mosquitoes through mating. It should be noted that *Wolbachia* is not harmful to humans or the mosquito population itself. To implement this strategy, *Wolbachia*-infected mosquitoes would be released into the natural environment to breed and replace wild mosquito populations that still carry the dengue virus.[22] This strategy could potentially support or even replace the anti-dengue program (PSN 3M Plus and Jumantik).

The findings of this study are anticipated to assist governmental bodies, healthcare organizations, and local communities in developing enhanced intervention strategies that target the key factors driving the transmission of the dengue virus.

Conclusions

This study identified risk factors that affect the incidence of dengue infection in Borobudur District, Magelang, Central Java, Indonesia. Significant risk factors include the presence of stagnant water and mosquito larvae in the house, sleeping in the morning, and low participation in dengue fever prevention (PSN 3M Plus and Jumantik). This demonstrates the importance of increasing community knowledge, awareness, and motivation to prevent dengue infection incidents. Policymakers must sharpen vector control strategies, potentially integrating innovation with the spread of the *Aedes aegypti* mosquito, which contains *Wolbachia*.

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Conflicts of interest: SS is affiliated with the Borobudur Community Health Center, which may be considered a potential conflict of interest. However, this affiliation did not influence the design, execution, or interpretation of the study results.

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Data availability: Borobudur Community Health Center provided the data. The datasets are not publicly available but are available from the corresponding author upon reasonable request.

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