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Journal of Environmental Health
Journal Home Page:
https://e-journal.unair.ac.id/JKL
Vol. 15 No. 4
DOI: 10.20473/jkl.v15i4.2023.291-299
ISSN: 1829 - 7285 | E-ISSN: 2040 - 881X

ORIGINAL RESEARCH Open Access

THE KEY ASSOCIATED FACTOR OF THE EMERGENCE OF THE DENGUE VECTOR IN PERI-URBAN AND RURAL SETTLEMENTS

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Article Info

Submitted	: 10 July 2023
In reviewed	: 12 September 2023
Accepted	: 24 October 2023
Available Online	: 31 October 2023

Keywords : *Aedes indices, Dengue endemic area, Favorable microhabitat, Larval density, Mosquito vector*

Published by *Faculty of Public Health Universitas Airlangga*

Abstract

Introduction: *The population density of Aedes mosquitoes is a risk factor for dengue in endemic areas. Therefore, it is necessary to understand the risk factors for mosquito vector emergence in settlements. This study aimed to determine the key factors associated with the occurrence and population density of dengue vectors in peri-urban and rural settlements.* ***Methods:*** *A cross-sectional study was conducted in two dengue-endemic villages, Bergas-Kidul and Gebugan, representing peri-urban and rural settlements, respectively. A cluster-based larval survey was conducted in the dengue-case house and in 18–20 houses around a radius of 100 m. All water containers and their characteristics and mosquito larvae emergence were recorded in each house to calculate Aedes indices. The geographic coordinates, altitude, air temperature, and humidity were mapped and analyzed using GIS and SPSS software.* ***Results and Discussion:*** *Dengue vectors were found in peri-urban and rural with HI, CI, BI, and DF indices of 29.3%, 32.2%, 35.4, and 6.0; then 12.2%, 14.3%, 14.6, and 3.0, respectively. In peri-urban areas, larval occurrence was associated with air temperature, air humidity, container type, and open microhabitat, whereas in rural areas, it was associated with only open microhabitat.* ***Conclusion:*** *The Aedes indices represent a high density of mosquito populations, and the existence of open microhabitats is the key factor for larval occurrence in both peri-urban and rural settlements. Community participation in vector control needs to be increased in addition to studying the resistance of Aedes mosquitoes to a number of insecticide groups.*

INTRODUCTION

The incidence of dengue infection has continued to increase threefold in the last three decades, while the number of cases has increased 4.5 times, especially in the West Pacific to South Asia regions, where the four countries with the highest number of cases are Barbados, Dominica, Indonesia, and India (1–2). In a global context, these areas contribute to the highest number of imported dengue cases, in addition to an important new phenomenon, namely the importation of dengue from Latin America and travel to Asia, Africa, and Oceania to European countries, especially Sweden, Germany, and Belgium, and the United States (3). The incidence of dengue infection in an area is influenced by three important determinants: vector population density, imported cases, and average air temperature (4–5). Areas with a high average air temperature show a higher incidence of dengue infection (6), especially among people with high socioeconomic classes in urban settlements (7). In addition to imported cases, dengue occurrence is also associated with entomological index conditions (8), both the traditional *Aedes* index, Density Score, and Maya Index (9), as well as household density factors, efforts to eradicate mosquito breeding sites, and the use of repellents (10).

Dengue vectors are widely distributed worldwide, with varying densities due to urbanization, connectivity, and climate change. This distribution occurred through two different phenomena, where *Aedes aegypti* was affected by long-distance importation, whereas *Aedes albopictus*

Cite this as :
Wiyata AD, Handoyo W, Sayono S. The Key Associated Factor of the Emergence of the Dengue Vector in Peri-Urban and Rural Settlements. *Jurnal Kesehatan Lingkungan*. 2023;15(4):291–299. https://doi.org/10.20473/jkl.v15i4.2023.291-299

has spread even further (11). This phenomenon corresponds to population density, where entry points and decorative plants are determinants (12). In addition to the number of occupants, the density of female *Aedes* mosquitoes in a house is also determined by several factors, such as the average minimum temperature, humidity, and rainfall (13–14). Physical factors have different influences on dengue occurrence in an area, such as rainfall in urban areas and air humidity in peri-urban areas, whereas air temperature does not have a significant influence in both areas and rural areas (15). Microhabitat factors also affect dengue vector density in settlements, in terms of both their physical and chemical characteristics (16). Environmental factor conditions, especially the altitude of the area, also affect the type of breeding places where there are many massive large-volume water reservoirs in hilly areas and mountain slopes (17).

Geographical factors contributed to the density of the *Aedes* mosquito population. This phenomenon is indicated by a decrease in the container index in the breeding habitat as the area moves further away from urban areas (18). *Aedes* density is higher in urban areas than in suburban and rural areas (19), and this condition is also affected by heterogeneity of land use (20). The existence of natural habitats combined with water temperature also significantly influences positive larval breeding sites (21). Other reports have shown that the presence and distribution of *Aedes* mosquito breeding habitats are influenced by education, household and premises conditions, number and location of water containers, open ventilation, and vector control measures (22). The *Aedes aegypti* mosquito is more dominant in urban and residential areas than in rural and non-domestic areas because of the availability of permanent breeding sites, high temperatures, and neutral pH. In contrast, *Aedes albopictus* is more dominant in nondomestic areas outside settlements where nonpermanent breeding places, low temperatures, and high pH are found (23). Another study reported that the presence and density of the dengue vector were not associated with the knowledge and skills of the community in environmental management efforts, but the condition was significantly associated with the incidence of dengue (24). *Aedes* mosquito infestation is related to the presence, number, and characteristics of breeding habitats (25), and there are different types of favorable containers in various countries (26–28). This complex phenomenon is a burden and an obstacle in efforts to control dengue vectors. Two cases of dengue in the Bergas District area emerged in two endemic villages in December 2021, after almost a year of absence. It is necessary to know clearly the existence and density of dengue vectors in peri-urban and rural endemic areas and related local-specific conditions so that vector control efforts can be carried out optimally. This study aimed to determine the key factors associated with the occurrence and density of dengue vectors in peri-urban and rural settlements based on sociodemographic conditions, breeding habitat characteristics, and physical factors.

METHODS

Study Sites

The Bergas Subdistrict of Semarang District consists of 14 villages that are classified into downhill and plain areas. We carried out an observational study on the emergence and population density of the dengue vectors in the two dengue endemic villages in the east part of the hilly areas of Mount Ungaran (2,050 m asl), Central Java Province, Indonesia namely the Bergas Kidul (7°14'0"–7°30'0" S and 110°24'0"–110°25'0" E) and Gebugan (7°10'0"–7°14'0" S and 110°21'0"–110°24'0" E) villages with an altitudinal range and average of 480–495 and 483 and 494–541 and 506 meter above sea levels (m asl), respectively (Fig.1). Both villages represent peri-urban and rural settlements, respectively. Bergas Kidul Village has a relatively flat topography throughout the area. This village lies on the edge of the Semarang-Solo roadway. The area consists of suburban settlements, offices, and markets, and is partly used as agricultural land. This condition is different from that of Gebugan village. This village is further away from the roadway, with different topographies between the eastern and western parts. In general, the topography of Gebugan village is higher than that of Bergas Kidul. The western part of Gebugan Village is on the slope of Mount Ungaran (2,050 m asl.) and is in the form of a perennial plantation. The temperature ranges of the two villages were 28.0°C–31.9°C and 26.2°C–32.0°C, respectively and the humidity ranges were 60–79% and 60–82%, respectively. The amount of rainfall and rainy days in the Bergas District area are 3,870 mm and 168 days per year, respectively, in 2021.

Participant Selection and Data Collection

This cross-sectional study was conducted for three months, from January to March 2022, to determine the emergence and density of the dengue vector in the villages of Bergas Kidul and Gebugan, where there were two cases of Dengue Hemorrhagic Fever (DHF) in December 2021, and almost a year later, there were no reported cases. Rainfall gradually decreased during the January–March period and provided the maximum number of *Aedes* mosquito microhabitats. Vector surveys were conducted in the locations of the dengue outbreak in 82 selected houses. The house samples were 18–20 houses (house clusters) within a radius of 100 m from the house of the dengue case. The respondents were household or adult family members who were at home when the survey was conducted. The presence of *Aedes* mosquito larvae was observed in all indoor and outdoor water containers, followed by structured interviews with households regarding individual characteristics, history of dengue occurrence, and vector control efforts. The collected data included respondent characteristics, presence of dengue cases, altitudinal area, air temperature and humidity, geographical coordinates, characteristics of containers, and emergence of mosquito larvae in water containers. A previous study found 14 types of favorable water containers (17). Data collection was carried out after obtaining the Ethical Clearance Certificate (number 610/KEPK-FKM/UNIMUS/2022) issued by the Ethics Committee of Health Research, Faculty of Public Health, Universitas Muhammadiyah Semarang, following an ethical review of the research protocol. dengue vector density was calculated using the *Aedes* indices, namely the House Index (HI), Container Index (CI), Breteau Index (BI), and Density Figure (DF).

Questionnaire Development and Data Analysis

The observation sheet was designed according to the data needs of the dengue vector survey, which included the types and characteristics of indoor and outdoor water containers, the emergence of mosquito larvae in water containers, the incidence of dengue cases, and the personal characteristics of respondents in each household. The other collected data included altitudinal conditions, geographical coordinates, temperature, and humidity. Data were analyzed descriptively to describe each research variable and analytically to identify the social, behavioral, and physical factors that determine the presence of mosquito larvae in houses and water containers. Data analysis was performed using Quantum GIS and SPSS software and displayed in the form of maps and tables to answer the research objectives.

RESULTS

The analysis results of the socio-demographic conditions of the study participants are summarized in Table 1. This study involved 82 participant households from Bergas Kidul and Gebugan villages in equal proportions, although the gender composition differed. In Bergas Kidul village, the proportion of participants based on gender showed an almost equal condition, with a very close difference (2.4%). This condition is different from the proportion of participants in Gebugan village, where there are almost three times as many women as men. The proportion of participants by age was dominated by the adult and middle age categories in both villages, although the conditions in Bergas Kidul village were more varied than those in Gebugan. The distribution of participants based on education levels showed a contradictory condition between the two villages, where the participant proportion in Gebugan village decreased according to the increase in education levels. This phenomenon was not found in peri-urban areas, where the proportion of respondents increased with increasing levels of education. The peri-urban participants had variations in occupations that were dominated by labor and households, while in the rural area, there were only five job categories: household, self-employee, labor, private employee, and civil servants.

Table 1. Personal Characteristics of Participants based on the Study Sites

Characteristics of Participants	Study Sites				p-value
	Bergas Kidul		Gebugan		
	n	%	n	%	
Gender					
Male	21	51.2	11	26.8	0.041
Female	20	48.8	30	73.2	
Age Group					
Teenager	1	2.4	0	0.0	
Adult	22	53.7	18	43.9	0.554
Middle age	14	34.1	17	41.5	
Elderly	4	9.8	6	14.6	
Level of Education					
Elementary School	4	9.8	13	31.7	
Junior High School	7	17.1	13	31.7	
Senior High School	15	36.6	10	24.4	0.012
Diploma III	5	12.2	1	2.4	
Undergraduate (S1)	10	24.4	4	9.8	
Occupations					
Household	10	24.4	18	43.9	
Labourer	2	4.9	8	19.5	
Teacher	1	2.4	0	0.0	
Civil servants	1	2.4	1	2.4	
Retired civil servant	2	4.9	0	0.0	0.059
Motorcycle taxi driver	3	7.3	0	0.0	
Self-employee	12	29.3	9	22.0	
Employee of state company	2	4.9	0	0.0	
Private sector employee	8	19.5	5	12.2	

Dengue vectors were found in both village classifications, and generally showed a high population density. Specifically, the population density of *Aedes* mosquitoes in Bergas Kidus was more than twice that in Gebugan for HI, CI, BI, and DF indices (Table 2). The traditional *Aedes* indices showed that the population density of the dengue vector in peri-urban areas was almost 2.5 times higher than that in rural areas. Although the data were different, the two villages showed a high vector density index.

Table 2. *Aedes* Indices in the Study Sites

Aedes Indices	Bergas Kidul (peri-urban)	Gebugan (rural)	p
House Index [HI] (%)	29.3	12.2	0.059
Container Index [CI] (%)	32.2	14.3	0.009
Breteau Index [BI]	35.4	14.6	-
Density Figure [DF]	6.0	3.0	-

Three of the seven types of water containers found in 82 houses became breeding sites for dengue vectors. Six types of water containers were found as microhabitats of dengue vectors in both villages, where the rubbish bin was a special container in peri-urban areas, while the pond was a special water container in rural areas. Buckets and bathroom cement tubs dominated the distribution of microhabitats, particularly containers made of plastic and ceramics. There are two types of water containers that do not become mosquito breeding habitats: fishponds in peri-urban areas and trash cans in rural areas. The proportion of open breeding places was higher than that of closed ones, both in urban and rural areas, whereas indoor placements were significantly more common in rural areas (Table 3).

Table 3. Characteristics of Water Containers in the Study Sites

Characteristics of Water Containers	Study Sites				p
	Bergas Kidul		Gebugan		
	n	%	n	%	
Type of Water Containers					0.058
Cement tank	10	11.1	15	17.9	
Bucket	57	63.3	55	65.5	
Drum	12	13.3	5	6.0	
Earther jar	4	4.4	5	6.0	
Aquarium	2	2.2	1	1.2	
Fish pond	0	0.0	3	3.6	
Rubbish bin	5	5.6	0	0.0	
Material of Water Containers					0.188
Ceramic	9	10.0	12	14.3	
Plastic	77	85.6	65	77.4	
Cement	1	1.1	6	7.1	
Metal	1	1.1	0	0.0	
Glass	2	2.2	1	1.2	
Cover of Water Containers					0.992
Opened	46	51.1	43	51.2	
Covered	44	48.9	41	48.8	
Position of Water Containers					0.032
Indoors	64	71.1	72	85.7	
Outdoors	26	28.9	12	14.3	

Both villages are located at a medium altitude, although Gebugan is higher than Bergas Kidul, and even the western part of the Gebugan village area climbs on the eastern slope of Mount Ungaran (Figure 1). The topographic and altitudinal conditions in Gebugan village have a significantly lower average air temperature and higher air humidity than those in Bergas Village.

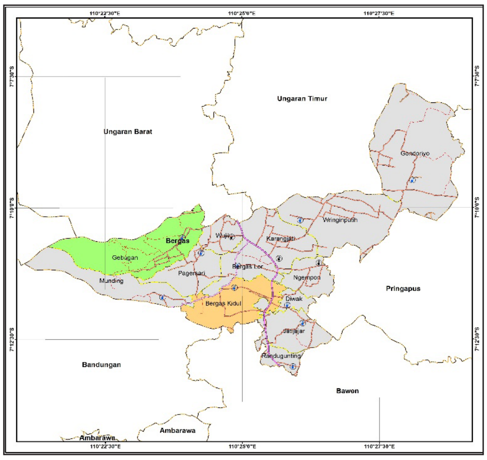

Figure 1. The Map of Study Sites

= Rural Area and = Peri-Urban Area

The temperature and humidity in the two villages were significantly different (Table 4), which affected the appearance of mosquito larvae in the breeding sites.

Table 4. The Condition of Physical Factors in the Study Sites

Physical Factors	Bergas Kidul			Gebugan			p
	Min-max	Mean	Std. dev	Min-max	Mean	Std. dev	
Altitude (m asl)	480-495	483.85	3.403	494-541	506.61	11.347	0.000
Air temperature (°C)	28-31	29.55	1.261	26.2-32.0	28.54	1.443	0.001
Air humidity (%)	60-79	72.80	6.055	60-82	77.29	4.776	0.000

The lowest air temperature in Bergas Kidul was higher than in Gebugan. Consequently, there was no low air temperature category (<27°C) in Bergas Kidul, so no water containers were found in this category. Different conditions were found in Gebugan, where flickering water containers were found in air temperature categories of <27°C and 27–30°C. This shows that the air temperature range that is effective in triggering the reproduction of *Aedes* mosquitoes is the range of 27–30°C.

Table 5. The Emergence of Mosquito Larvae in Premises/ Building based on the Study Sites and Indoor Air Temperature and Humidity

Study sites	Indoor Physical Factors	The Emergence of Mosquito Larvae in House/Building				p
		Yes	%	No	%	
Bergas Kidul (peri-urban)	**Air temperature (°C)**					0.001
	<27	0	0.0	0	0.0	
	27–30	12	52.2	11	47.8	
	>30	0	0.0	18	100.0	
	Air humidity (%)					0.007
	<70	0	0.0	13	100.0	
	70–80	12	42.9	16	57.1	
	>80	0	0.0	0	0.0	

Study sites	Indoor Physical Factors	The Emergence of Mosquito Larvae in House/Building				p
		Yes	%	No	%	
Gebugan (rural)	**Air temperature (^{0}C)**					
	<27	1	20.0	4	80.0	0.562
	27–30	4	13.3	26	86.7	
	>30	0	0.0	6	100.0	
	Air humidity (%)					
	<70	0	0.0	4	100.0	0.392
	70–80	3	10.3	26	89.7	
	>80	2	25.0	6	75.0	

However, a significant association only occurred in Bergas Kidul village, which is in a peri-urban area, and not in Gebugan village, which is located in a rural area (Table 5). The data showed that there were more houses/buildings with larvae in peri-urban areas (29.3%) than in rural areas (12.2%). Bathroom cement tanks and buckets are favorable breeding habitats in both peri-urban and rural areas, while rubbish bins are only favorable microhabitats in peri-urban areas. As many as 63% and 27.9% of the water containers were uncovered so they were significantly associated with the presence of mosquito larvae in both villages. The most favorable types of water containers in rural areas were bathroom cement tanks and buckets, whereas rubbish bins were also found in the peri-urban area. In both villages, larval-positive breeding habitats were dominated by outdoor water containers.Uncovered water containers are more common in peri-urban areas than in rural ones. Most importantly, mosquito larvae were not found in the covered water containers in either peri-urban or rural areas (Table 6).

Open water containers are key factors associated with the emergence of dengue vectors in peri-urban and rural areas. Bathroom cement tanks are open microhabitats found only inside houses. Outdoor open water containers are buckets, trashcans (in peri-urban areas only), and fish pools (in rural areas). Drums were only found outside the house and were covered.

Table 6. The Association of Water Container Characteristics and the Emergence of Mosquito Larvae in the Study Sites

Study Sites	Characteristics of Water Container	The Emergence of Mosquito Larvae in Water Container				p
		Yes	%	No	%	
Bergas Kidul	**Type of water container**					
	Bathroom cement tank	6	60.0	4	40.0	0.000
	Bucket	18	31.6	39	68.4	
	Drum	0	0.0	12	100.0	
	Earthen jar	0	0.0	4	100.0	
	Aquarium	0	0.0	2	100.0	
	Rubbish bin	5	100.0	0	0	
	Material of water container					
	Ceramic	6	66.7	3	33.3	0.137
	Plastic	23	29.9	54	70.1	
	Cement	0	0.0	1	100.0	
	Metal	0	0.0	1	100.0	
	Glass	0	0.0	2	100.0	
	Condition of water container					
	Opened	29	63.0	17	37.0	0.000
	Covered	0	0.0	44	100.0	
	Position of water container					
	Indoor	18	28.1	46	71.9	0.291
	Outdoor	11	42.3	14	57.7	
Gebungan	**Type of water container**					
	Bathroom Cement tank	4	26.7	11	73.3	0.519
	Bucket	8	14.5	47	85.5	
	Drum	0	0.0	5	100.0	
	Earthen jar	0	0.0	5	100.0	
	Aquarium	0	0.0	1	100.0	
	Fish pond	0	0.0	3	100.0	
	Material of water container					
	Ceramic	4	33.3	8	66.7	0.177
	Plastic	8	12.3	57	87.7	
	Cement	0	0.0	6	100.0	
	Metal	0	0.0	0	0.0	
	Glass	0	0.0	1	100.0	
	Condition of water container					
	Opened	12	27.9	31	72.1	0.000
	Covered	0	0.0	41	100.0	
	Position of water container					
	Indoor	9	12.5	63	87.5	0.366
	Outdoor	3	25.0	9	75.0	

Table 7. Type and Condition of Water Containers in Bergas Kidul and Gebugan

Type of Container	Bergas Kidul								Gebugan							
	Indoor				Outdoor				Indoor				Outdoor			
	Opened		Covered		Opened		Covered		Opened		Covered		Opened		Covered	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Bathroom Cement Tank	10	100.0	0	0.0	-	-	-	-	15	100.0	0	0.0	-	-	-	-
Bucket	23	46.0	27	54.0	7	100.0			22	42.3	30	57.7	3	100.0	0	0.0
Drum	-	-	-	-	0	0.0	12	100.0	-	-	-	-	0	0.0	5	100.0
Earthen jar	1	50.0	1	50.0	0	0.0	2	100.0	0	0.0	4	100.0	0	0.0	1	100.0
Aquarium	0	0.0	2	100.0	-	-	-	-	0	0.0	1	100.0	-	-	-	-
Trash can	-	-	-	-	5	100.0	0	0.0	-	-	-	-	-	-	-	-
Fishpool	-	-	-	-		-	-	-	-	-	-	-	3	100.0	0	0.0

Open earthen jars were only found in peri-urban areas (50%), while the rest were outdoors and closed (Table 7).

DISCUSSION

The Importance of Dengue Vector Surveillance in Endemic Areas.

This study is part of dengue vector surveillance to uncover factors that support the existence and distribution of dengue vectors in two endemic villages with different geographic conditions: peri-urban in Bergas Kidul and rural in Gebugan. Periodic monitoring by local health authorities regarding the presence of *Aedes* mosquitoes in residential areas can have a positive impact on efforts to control arboviral vectors (20). The form of this positive impact can be in the form of increased attention and community participation in cleaning up breeding places, which also affects the decrease in *Aedes* population density (29). These findings provide data on potential and favorable breeding sites for the dengue vector, which can be used as targets for eradicating *Aedes* mosquito larvae. Furthermore, several important factors that influence the emergence of the dengue vector in both village conditions can be considered when developing health communication strategies, materials, media, and methods to educate the public.

Socio-Demographic and Environmental Characteristics

Peri-urban residents have occupations and activities with more economic value than rural residents. Socioeconomic conditions influence the emergence of the dengue vector, where the *Aedes* index is higher in urban areas than in rural areas in January–March. This is related to the availability of various breeding sites, crowded housing, and low level of effort to control the *Aedes* mosquito (22). This is also influenced by the proportion according to educational level, where senior high school and higher education are more dominant than in rural villages, which are dominated by elementary and junior high school graduates. This contributes to information exposure, literacy levels, and community participation in efforts to control arboviral vectors. A similar phenomenon was reported in Peru, where community knowledge about dengue was influenced by demographic characteristics, especially women of mature and married age, and middle to high education, but not by rurality (30). Similar findings were reported in Laos and Thailand in 2011 and 2013, where dengue vector infestation was higher in suburban areas where the socio-demographic population was more economically valuable than in rural areas (19). A study in Yogyakarta, Indonesia 2014 reported that the knowledge, attitudes, and practices of the female population are better than those of the male population, especially the middle-aged group and the occupational category of housewives and retirees (31). Differences in sociodemographic and environmental conditions in this study are thought to have an impact on the presence and density of dengue vectors between the two villages. These findings are similar to those reported in Brazil, where the heterogenity of field conditions showed infestation by different arbovirus vectors (20). The dominance of *Aedes aegypti* in urban areas reaches more than 99% and *Aedes albopictus* <1%, while in rural areas it is 98.2% and 1.8%, where 80% is indoors with a density of 1.6 female mosquitoes per each house (13).

Characteristics of Water Containers, Existence, and Distribution of the Dengue Vector

This study identified seven water containers in households, of which three were found to contain mosquito larvae. The water containers are dominated by artificial breeding habitats, made of plastic, cement, and metal, in addition to non-artificial standing water, namely former fish ponds. These objects are goods used for daily life activities in the household, both of which are still used and used goods. The water containers found in this study were not as numerous as those reported in Thailand, where 17 types were reported. However, there are similarities in the identified favorable water containers, namely bathrooms and daily use water containers such as buckets and plastic materials (27). Similar findings were reported in Ethiopia, where the *Aedes* population density was slightly higher, and the most positive larvae containers used were tires and clay barrels (26). The results of a study of a more varied type of *Aedes* habitat breeding container was reported in Bangladesh, where 37 species were found, although only 7% were infested (28).

Dengue Vector Density

Based on the HI, CI, and BI values, these indices indicated a high dengue vector density, even though Bergas Kidul was higher than Gebugan. These indices can be early warning signals for the vulnerability of the two villages to the risk of dengue occurrence. The high population density of *Aedes* mosquitoes in dengue-endemic areas is an alarm for dengue virus transmission, where clusters of dengue cases form along with the abundance of the adult *Aedes* population. A study in Singapore in 2021 showed that high and very high abundance levels of adult *Aedes* mosquitoes correlated with a 3 to 4-fold increase in the formation of dengue case clusters compared to the abundance of adult *Aedes* mosquitoes at low levels (32). The high population density of *Aedes* provides an opportunity for a high proportion of female *Aedes* to exist. In contrast, female *Aedes* have the opportunity to carry the dengue virus. Reports in Thailand show that the proportion of female *Aedes* mosquitoes infected with the virus is strongly correlated with the incidence of dengue (33). Regarding the *Aedes* population density index, the House Index (HI) and Breteau Index (BI) have high consistency for predicting the incidence of dengue where if HI is higher than 4% and BI close to 5 is an appropriate indicator for the risk of dengue outbreaks and epidemics (34). These findings indicate that the potential for dengue virus transmission in both villages is still high, and various reports indicate that dengue cases occur when HI >5% (35–36).

The Associated Factors of Dengue Vectors Emergence in Settlements

In general, the presence of *Aedes* larvae in this study was only determined by the location of the containers where indoors were preferred over outdoors, particularly in rural areas. Other characteristics of containers, such as type, material, and presence of a container cover, do not determine the presence of *Aedes* larvae. The probability of emergence of *Aedes* larvae in various containers is not affected by the physical properties of the container and water but is determined by their location. This finding differs from previous reports that the appearance of *Aedes* larvae in water containers was not determined by the location and presence of the cover, but by the type, wall color, water pH, and presence of predators in the water containers (25). A more detailed analysis of these findings based on village conditions (peri-urban and rural) showed differences in the characteristics of positive larval water containers between the two village conditions. In peri-urban areas, the type of container and presence of a cover are the determining factors for the emergence of *Aedes* larvae, whereas in rural areas, it is only determined by the presence of a cover for the water container. This phenomenon indicates that all containers in rural areas have the potential to be exposed to *Aedes* mosquito larvae, except those that are tightly closed. This indicates that the key to the emergence of dengue vectors in endemic areas is the existence of open-breeding habitats. This condition is consistent with the findings in Sri Lanka, where the infestation of *Aedes* larvae included various open-water containers (37).

This study also found that temperature and humidity affect the emergence of *Aedes* mosquitoes in the home environment only in peri-urban areas, while in rural areas, it does not show a different phenomenon. The optimum local temperature that influences mosquito life span, egg production, egg viability, and larval development in adults is in the range of 25°C–30°C (38) and humidity >70% (39). This condition is in line with findings in Ecuador that the peak exposure of *Aedes* mosquitoes in the home environment occurs at high temperature and humidity (40). A similar finding in Mataram City, Indonesia in 2020 also reported that indoor and outdoor air temperature, low light, and high air humidity had a significant effect on the presence of *Aedes* mosquitoes in the house and dengue transmission (8). In contrast, the physical environment of rural areas showed lower air temperature and high air humidity. This condition allows *Aedes* mosquitoes to freely choose their breeding sites, both inside and outside the home, in open water containers, especially natural breeding sites (23). These findings provide interesting information for health workers and communities, especially in dengue-endemic areas, as an important input in planning dengue vector control efforts, preparing resources, and mobilizing community participation. However, this research does not include data and information about *Aedes* mosquito species, dengue virus infection, and susceptibility to a number of active insecticide ingredients in health programs, and needs to be studied.

ACKNOWLEDGMENTS

The authors would like to thank the Head of the Semarang District Health Office, the Head of the Bergas Health Center, the Head of Bergas Kidul, and Gebugan Villages, and all participants who have supported this research since they applied for research permission until data collection.

CONCLUSION

Sociodemographically, female respondents were higher than men and dominated by adults and middle-aged. The education level of peri-urban area respondents is dominated by tertiary education and senior high school, while in rural areas, it is dominated by primary education and junior high school. The respondents' occupations in peri-urban areas were more varied than in rural areas. A high population density of dengue vectors was found in both peri-urban and rural endemic areas, with three favorable types of breeding places, namely trash cans, buckets, and bathroom water containers, which are made of plastic and ceramic, without covers, and are especially outdoors. Indoor air temperature and humidity were also significantly associated with the appearance of mosquito larvae in water containers in peri-urban areas. The presence of an open breeding container is a key factor associated with dengue vector infestation. There are five types of open water containers that are favorable microhabitats for *Aedes* mosquito larvae: bathroom cement tanks, buckets, earthen jars, trashcans, and fish pools. Community participation in applying various integrated vector control methods, such as community involvement in closing and draining water containers combined with sowing temefos or predatory fish, as well as reuse and recycling of used goods that can be filled with rainwater are needed, in addition to further study on the resistance of dengue vectors to various classes of insecticides.

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