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**RESEARCH**

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## **Risk Factors for Dengue Fever in Sungai Pinang Subdistrict in Samarinda City**

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### **Abstract**

Dengue hemorrhagic fever (DHF) is a disease spread by the *Aedes aegypti* mosquito, a species that reproduces very quickly and infects around 390 million people each year. The objective of this research is to identify risk factors associated with the occurrence of DHF in the village of Sungai Pinang, located in the city of Samarinda. This study employs a quantitative approach and uses an observational method with a case-control design, which allows for the analysis of the relationship between the disease or health condition and specific risk factors. The sample consisted of 74 participants, divided into 37 cases and 37 controls, selected through purposive sampling. Odds ratios were used for data analysis. The results indicated that the presence of a lid on the water container represented a risk factor (OR = 1.135; 95% CI: 0.424–3.039). Similarly, the habit of emptying water containers was shown to be a risk factor (OR = 1.556; 95% CI: 0.617–3.928), as was the type of container material (OR = 1.268; 95% CI: 0.487–3.301) for the incidence of dengue in the village of Sungai Pinang Dalam, Samarinda City. In conclusion, the water container cover, the practice of emptying it, and the container material were identified as factors that influence the occurrence of dengue cases in this area.

**Keywords:** Algorithm A, Balgorithms, Complexity.

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## 1. INTRODUCTION

Suriami reported that dengue hemorrhagic fever (DHF) is a dengue virus infection transmitted through the bites of *Aedes aegypti* and *Aedes albopictus*, which serve as the primary vectors. Clinically, DHF is characterized by an abrupt high fever accompanied by headache, myalgia and arthralgia, nausea and/or vomiting, and the emergence of hemorrhagic skin manifestations resulting from changes in vascular integrity and platelet function. Inadequate or delayed management of dengue hemorrhagic fever may lead to progression into a more severe condition known as dengue shock syndrome, which is characterized by acute circulatory failure and can be life-threatening (Suriami et al., 2020). The dengue virus typically has an incubation period in humans of 4 to 10 days after the bite of an infected mosquito. To date, dengue hemorrhagic fever continues to pose a serious public health challenge in numerous tropical and subtropical countries, including Indonesia, frequently causing outbreaks (KLB) with high morbidity and mortality rates. Transmission of this disease occurs through the bite of mosquitoes of the genus *Aedes*, particularly *Aedes aegypti* and *Aedes albopictus* (Ishak et al., 2020).

WHO stated Dengue fever is a viral disease transmitted by mosquitoes and has spread rapidly. It is found throughout the tropics, with the risk level influenced by rainfall, temperature, and urbanization levels. Over the past few decades, the number of dengue cases has increased rapidly worldwide. Most cases are asymptomatic, resulting in underreporting of cases. Based on reported data, the number of dengue cases increased from 2.2 million in 2010 to over 3.34 million in 2016 (WHO, 2018). In Indonesia, dengue fever remains a major health problem, with a prevalence rate among the highest among Southeast Asian countries. Indonesia was once recorded as the country with the highest number of dengue fever cases in Southeast Asia in 2009. The first dengue fever case in Indonesia was discovered in 1968 and has now spread to 472 districts/cities across 34 provinces, including Yogyakarta City.

The government has implemented various efforts to prevent and control dengue fever, such as the 3M Plus National Population and Immunization (PSN) program through the 1 House 1 Mosquito Net Movement (1 Jumantik), planting mosquito repellent plants, using mosquito repellent lotion, and administering larvicides to reduce morbidity and mortality due to dengue fever. To combat the spread of dengue fever outbreaks, the Indonesian Ministry of Health has implemented various efforts, one of which is the 3M Plus program, which includes draining, covering, and reusing water storage containers. Draining refers to the process of cleaning and emptying containers that hold water, such as bathtubs, elevated tanks, and other similar receptacles. Covering involves properly sealing these containers to prevent them from becoming breeding grounds for mosquitoes. Reusing, on the other hand, consists of repurposing used items that could potentially serve as mosquito breeding sites. The Plus Program also includes the use of repellents and the application of larvicides in water containers that cannot be easily emptied.

The East Kalimantan (Kaltim) Health Office recorded 2,898 dengue fever cases in East Kalimantan in 2021, with 22 deaths. This represents an increase compared to the previous year, with 5,841 cases and 39 deaths in 2022. In 2023, 5,616 dengue fever cases were recorded, a slight decrease from 5,841 cases in 2022. Kutai Kartanegara topped the list with 1,118 cases, followed by Balikpapan with 1,019 cases, and Samarinda with 868 cases. In the past three years, Samarinda City has ranked third highest in the number of dengue fever cases. In 2021, 1,366 cases were recorded, followed by 1,688 in 2022, and 1,867 in 2023. North Samarinda District recorded the highest number of cases, with Bengkuring Community Health Center reporting 117 cases, followed by Temindung Community Health Center in Sungai Pinang District with 66 cases, and Sempaja Community Health Center in North Samarinda District with 55 cases (Dinas Kesehatan Provinsi Kalimantan Timur, 2023).

Previous research has shown that various individual and environmental factors play a significant role in the incidence of Dengue Hemorrhagic Fever (DHF). A study by Buntubatu

et al. (2017) highlighted that nutritional status is a significant risk factor for the emergence of Dengue Shock Syndrome, where individuals with malnutrition are more susceptible to experiencing severe complications due to decreased immunity. Meanwhile, Arianti et al. (2019) found a relationship between age, gender, and laboratory parameters with the length of treatment for DHF patients, indicating that biological characteristics also influence the severity of the disease."Previous research by Sandra et al. (2019) showed that the appearance of cases of dengue hemorrhagic fever (DHF) in children between 6 and 12 years of age was conditioned by several factors, including the characteristics of the environment, family behavior, and habits of maintaining cleanliness of the residence, which contribute to the presence of *Aedes aegypti* larvae."Outcomes of that study strengthen the view that community behavior and environmental factors are important determinants in the spread of DHF. Meanwhile, Ardat et al. (2024) emphasized that the relationship between the environment, host (humans), and vector (mosquitoes) is complex and mutually influences the dynamics of dengue transmission. Research by Nisa et al. (2021) revealed that container material also plays a significant role in the development of dengue fever, with ceramic containers accounting for 43%. The Chi-square analysis showed a p-value of 0.163, indicating a significant relationship between container material and dengue fever incidence.

Temindung Community Health Center (Puskesmas) is one of the health centers with the highest number of dengue fever cases in Samarinda City, and researchers were interested in conducting research there because cases continue to increase annually. In 2021, Temindung Community Health Center reported the highest number of dengue fever cases, with 121 cases. The following year, in 2022, the number increased to 153 cases, but in 2023, the number decreased to 66 cases. In 2024, from January to November, the number increased again to 78 cases. The Temindung Community Health Center's working area covers two sub-districts: Sungai Pinang Dalam, with a population of 47,721, and Mugirejo, with a population of 24,810. In 2024, the highest number of dengue fever cases was found in Sungai Pinang Dalam, with 47 cases."Based on this, researchers were interested in conducting research in Sungai Pinang Dalam."

Based on observations at the Temindung Community Health Center in Samarinda City, it was discovered that the Community Health Center has implemented various initiatives have been implemented to reduce dengue cases in the village of Sungai Pinang Dalam, such as the Dengue Fever Control Program (PE DBD), the provision of larvicides, and community education. However, several factors still contribute to the high incidence of dengue fever in Sungai Pinang Dalam Village, including loosely closed water containers, which become breeding grounds for mosquitoes. Some homes also do not routinely empty water containers every week, which should prevent the breeding of new mosquitoes. Given this background, this study has purpose to identify factors related to the incidence of DHF in Sungai Pinang Dalam Subdistrict, Samarinda City.

## 2. RESEARCH METHOD

"This study employed a quantitative approach using a case-control design to analyze the association between individual and environmental factors and the occurrence of Dengue Hemorrhagic Fever (DHF) in Sungai Pinang Dalam Village, Samarinda City. The case-control design was selected to compare exposure factors between individuals who had experienced DHF and those who had not."

The study population consisted of all confirmed DHF cases recorded in Sungai Pinang Dalam Village. Cases were defined as respondents who had previously been diagnosed with DHF by a health facility within the last one year prior to data collection, based on medical records from the local health center. Controls were respondents who had never been diagnosed with DHF and were living in the same village at the time of the study. Matching was conducted

based on sex and residential area (same village) to minimize differences in environmental conditions between the case and control groups. A 1:1 ratio was applied between cases and controls. Initially, total sampling was used, including all 47 DHF cases and 47 non-DHF controls, resulting in 94 respondents. However, due to field constraints such as refusal to participate, relocation, and difficulty in contacting some respondents, only 74 respondents were included in the final analysis, consisting of 37 cases and 37 controls.

The research variables included water reservoir cover, classified as high risk when containers were uncovered or inadequately covered and low risk when properly covered; the habit of draining water containers, categorized as high risk when performed less than once per week and low risk when conducted at least once weekly; and water reservoir material, classified as high risk for rough or porous surfaces and low risk for smooth, non-porous materials.

Data were collected using a structured questionnaire and an observation checklist. The questionnaire consisted of several sections covering respondents demographic characteristics and behavioral factors, particularly practices related to water storage and maintenance. The observation checklist was used to directly assess environmental conditions, including the presence and condition of water reservoir covers, frequency of water drainage, and the type of materials used for water containers. Data were analyzed using the Chi-square test to determine the association between independent variables and DHF incidence. Statistical significance was set at  $p < 0.05$ . This study received ethical approval from the Health Research Ethics Committee with approval number No. 224/KEPK-SI/VIII/2025. All respondents provided informed consent prior to participation.

### 3. RESULTS AND DISCUSSION

Based on the distribution of respondents, dengue fever cases were predominantly found among individuals in the young and productive age groups. The largest proportion of respondents was aged 11–20 years (25 respondents), followed by those aged 21–30 years (22 respondents), while the 51–60 years age group represented the smallest proportion (1 respondent). This finding suggests that dengue fever tends to affect younger populations who are more active and potentially more exposed to mosquito bites. In terms of gender, the distribution was relatively balanced, with 38 male respondents and 36 female respondents, indicating no substantial difference in dengue incidence between sexes. Regarding educational level, most respondents had completed senior high school (37 respondents), followed by junior high school (18 respondents), suggesting that the majority of participants had a secondary education background. Employment status was also evenly distributed, with 38 respondents employed and 36 unemployed. These characteristics indicate that dengue fever in Sungai Pinang Dalam Subdistrict is not strongly determined by demographic factors alone, but is more likely associated with environmental conditions and household health-related behaviors.

For better clarity and precision, respondent characteristics are more appropriately presented in a tabular format rather than a pie chart, as tables allow readers to clearly observe numerical differences and proportions.

**Table 1.** Distribution of Dengue Fever Incidents in Sungai Pinang Dalam Subdistrict.

| Age   | Dengue Fever Incidents |      |                |      | Total |      |
|-------|------------------------|------|----------------|------|-------|------|
|       | Case (n=37)            |      | Control (n=37) |      | N     | %    |
|       | f                      | %    | f              | %    |       |      |
| 1-10  | 12                     | 32.4 | 4              | 10.8 | 16    | 43.2 |
| 11-20 | 17                     | 45.9 | 8              | 21.6 | 25    | 67.5 |
| 21-30 | 6                      | 16.2 | 6              | 16.2 | 12    | 32.4 |
| 31-40 | 1                      | 2.7  | 16             | 43.2 | 17    | 45.9 |
| 41-50 | 0                      | 0    | 3              | 8.1  | 3     | 8.1  |

|       |    |     |    |     |    |     |
|-------|----|-----|----|-----|----|-----|
| 51-60 | 1  | 2.7 | 0  | 0   | 1  | 2.7 |
| Total | 37 | 100 | 37 | 100 | 74 | 100 |

As shown in Table 1, the study included 37 respondents (50.0%) in the case group (DHF sufferers) and 37 respondents (50.0%) in the control group (non-DHF respondents). All respondents represented adult household members responsible for daily household activities, including water storage management, rather than exclusively the head of the household.

The distribution of water storage-related risk factors indicates that high-risk conditions dominated both groups across all three variables studied. For the water reservoir cover, 70.3% of cases and 67.6% of controls were classified as high risk, indicating that uncovered or poorly covered containers may facilitate *Aedes aegypti* breeding. Regarding the habit of draining water containers, 62.2% of case respondents demonstrated high-risk behavior, compared to 51.4% in the control group, suggesting that infrequent draining increases the likelihood of mosquito larvae survival. Similarly, water reservoir materials categorized as high risk were observed in 67.6% of cases and 62.2% of controls, indicating that porous materials such as cement or ceramic containers may provide favorable conditions for mosquito breeding. These findings reinforce the role of environmental and behavioral factors in increasing dengue fever risk at the household level.

**Table 2.** Distribution of Water Storage Risk Factors.

| Risk Factors                      | Group Type |      |         |      | Odd Ratio | 95% CI        | p-value |
|-----------------------------------|------------|------|---------|------|-----------|---------------|---------|
|                                   | Case       |      | Control |      |           |               |         |
|                                   | f          | %    | f       | %    |           |               |         |
| Water reservoir cover             |            |      |         |      |           |               |         |
| Low Risk                          | 11         | 29.7 | 12      | 32.4 | 1.135     | 0.424 – 3.039 | 0.802   |
| High Risk                         | 26         | 70.3 | 25      | 67.6 |           |               |         |
| The Habit of Draining Water Tanks |            |      |         |      |           |               |         |
| Low Risk                          | 14         | 37.8 | 18      | 48.6 | 1.556     | 0.617 – 3.928 | 0.348   |
| High Risk                         | 23         | 62.2 | 19      | 51.4 |           |               |         |
| Water Reservoir Materials         |            |      |         |      |           |               |         |
| Low Risk                          | 12         | 32.4 | 14      | 37.8 | 1.268     | 0.495 – 3.247 | 0.612*  |
| High Risk                         | 25         | 67.6 | 23      | 62.2 |           |               |         |

Note:

- p-values were obtained from Pearson Chi-Square tests.
- OR and 95% CI were calculated using Risk Estimate analysis.
- Statistical significance was defined as  $p < 0.05$ .

The Chi-square analysis showed that none of the water storage-related variables were statistically significantly associated with the incidence of Dengue Hemorrhagic Fever (DHF) in Sungai Pinang Dalam Subdistrict ( $p > 0.05$  for all variables). For the water reservoir cover, the Pearson Chi-square test indicated no significant association with DHF incidence ( $p = 0.802$ ). Although a higher proportion of DHF cases was observed among respondents with high-risk water reservoir covers, this difference was not statistically meaningful.

Similarly, the habit of draining water containers showed no statistically significant association with dengue hemorrhagic fever (DHF) incidence ( $p = 0.348$ ). Respondents who infrequently drained water containers demonstrated a higher odds ratio (OR = 1.556; 95% CI: 0.617–3.928), indicating a possible tendency toward increased risk; however, the wide confidence interval and the non-significant p-value suggest that this finding may be influenced by sampling variability rather than reflecting a true association. In addition, the type of water reservoir material was not significantly associated with DHF incidence ( $p > 0.05$ ). Although

containers made of materials classified as high risk were more frequently observed among DHF cases, the statistical analysis did not provide sufficient evidence to confirm a significant relationship.

## DISCUSSION

### Risk Factors for Closing Water Reservoirs

The presence of a proper water reservoir cover is one of the key components of dengue prevention as emphasized in the 3M Plus strategy (draining, covering, and recycling water containers), which aims to eliminate mosquito breeding sites at the household level (Makrufardi et al., 2021). According to environmental health theory, uncovered or improperly covered water containers provide ideal habitats for *Aedes aegypti* mosquitoes to lay eggs, allowing larvae to develop in stagnant water. This condition increases the potential for dengue virus transmission, particularly in densely populated residential areas (Alhamda & Barlian, 2019).

Based on the results of research on the risk factors of water reservoir covers with the incidence of dengue fever in Sungai Pinang Dalam Village, Samarinda City, it can be seen from the group that has high risk factors or does not meet the requirements for water reservoir covers as many as 51 respondents, most of the case group as many as 26 respondents and the control group 25 respondents. This is due to the lack of public awareness to cover water reservoirs at home, many were also found when researchers visited respondents' homes, water reservoir covers that should be used according to their function were not used properly such as water reservoir covers that were only placed next to the water reservoir, therefore they can be categorized as not meeting the requirements. There is a group that has low risk factors or meets the requirements in water reservoir covers but is not a dengue fever sufferer, namely 23 respondents. It can be seen from the closed water reservoir so that it can be categorized as meeting the requirements.

The results of the odds ratio test using a confidence interval showed that the OR value =  $1.135 > 1$ , which indicates that respondents who had water reservoir covers that did not meet the requirements tended to have a 1.135 times greater likelihood of experiencing dengue fever compared to respondents whose water reservoir covers met the requirements. However, the Chi-Square test showed that this association was not statistically significant ( $p > 0.05$ ), suggesting that although the direction of risk was positive, the relationship could not be confirmed statistically in this study. Therefore, the water reservoir cover variable demonstrates a tendency toward increased risk, rather than a definitive risk factor. The results of this study are in accordance with previous research conducted by Poene et al. (2025) that the availability of lids on water reservoirs (TPA) has been shown to play a protective factor against the occurrence of dengue fever. Respondents whose water storage containers are covered have a 0.370-fold lower risk of developing dengue fever compared to those without a lid because the presence of a water reservoir lid can prevent the *Aedes aegypti* mosquito from breeding, thereby reducing the risk of dengue cases.

In addition, this study is also in line with the study conducted by Mawaddah et al. (2022) regarding the Analysis of the Relationship between Environmental Sanitation Conditions and Family Behavior with Dengue Fever Incidents. Their study stated if statistical test, the Chi-Square test value with a P value =  $0.002 < 0.05$  means that there is a relationship between water reservoirs and dengue fever incidents in Pontianak City in 2020, with an OR value or risk factor of 7.48 which means that respondents whose homes have water reservoirs that do not meet the requirements are at 7.48 times risk of contracting dengue fever compared to those whose homes have water reservoir covers that meet the requirements.

An inspection of water-container management in Sungai Pinang Dalam revealed that merely 23 of the 74 residents secured their tanks with proper lids, while 51 lacked compliant usage. Based on the variable of the existence of reservoir covers according to Government Regulation Number 66 of 2014 concerning Environmental Health, namely efforts to prevent

disease and/or health problems from environmental risk factors to realize a healthy environmental quality from physical, chemical, biological, and social aspects. Based on the findings of researchers in the Sungai Pinang Dalam Village area regarding water reservoir covers, many still do not use reservoir covers.

Water stored for extended periods of time should be tightly covered to prevent mosquitoes from entering and breeding. Uncovered water containers can make it easier for mosquitoes to lay their eggs on the sides of the container. Therefore, efforts should be made to tightly cover water containers to prevent mosquitoes from entering or landing on the walls of bathtubs or water drums. Conversely, uncovered water containers can become potential breeding grounds for mosquitoes, thus increasing the spread of dengue fever. Open landfills can become breeding grounds for vectors (Aung et al., 2023).

A study by Wang et al. (2023) suggests that climate change-related variations in temperature, precipitation, and humidity play a significant role in shaping dengue transmission patterns in South and Southeast Asia. Increased temperatures and higher humidity levels were found to enhance breeding conditions for *Aedes aegypti*, especially in open and uncovered water storage containers. This finding aligns on research by Nuraini et al. (2021) who developed a climate-based model in Semarang City, Indonesia, and found that increased rainfall and average temperatures increase the risk of dengue fever outbreaks, as more stagnant water can potentially become breeding grounds for mosquitoes. Hossain et al. (2023) employing a regression analysis in Dhaka, Bangladesh, demonstrated a strong association between temperature, rainfall, and humidity and the incidence of dengue cases. Their findings indicate that higher rainfall increases the availability of uncovered natural and artificial water reservoirs, thereby creating favorable breeding sites for mosquito larvae.

Meanwhile, a systematic review by Abdullah et al. (2022) strengthens the evidence that climate factors significantly contribute to dengue fever incidence in various tropical regions and emphasizes the importance of behavioral and environmental interventions to reduce this risk. This study suggests that tightly covering water reservoirs is a crucial preventive measure in addressing the impacts of climate change, as it prevents the formation of ideal breeding grounds for mosquitoes when rainfall and humidity increase. Therefore, simple behaviors such as regularly using water-tight covers play a strategic role in reducing the risk of dengue transmission, which is exacerbated by humid tropical climates.

### **Risk Factors for the Habit of Draining Water Tanks**

The habit of draining water reservoirs is a fundamental component of dengue prevention based on vector control theory and the mosquito life-cycle concept. The *Aedes aegypti* mosquito undergoes egg, larval, pupal, and adult stages in stagnant water, with the larval stage typically completing within 5–7 days (Annan et al., 2023). Environmental health theory emphasizes that routine removal of stagnant water through regular draining and cleaning of water reservoirs can disrupt this life cycle and prevent mosquito population growth (Aung et al., 2023). Therefore, household behavior related to water reservoir maintenance is considered a key determinant in reducing dengue transmission risk.

An examination of water-reservoir draining habits in relation to dengue fever cases in Sungai Pinang Dalam, Samarinda, shows that 42 respondents fell into the high-risk category or did not meet the criteria for proper draining practices. Of these, 23 individuals belonged to the case group, while 19 were part of the control group. This is due to the lack of public awareness to drain water reservoirs at home regularly. When the researcher visited, many respondents stated that they did not drain their water reservoirs once a week because they waited until a significant amount of sediment accumulated at the bottom of the container. This condition can potentially allow new mosquitoes to develop, as female mosquitoes can lay eggs in water reservoirs and, within 3–4 days, these eggs may develop into larvae. If draining is not carried

out within this period, larvae may continue to breed and eventually become adult mosquitoes that transmit dengue fever. Therefore, this behavior can be categorized as not meeting the recommended requirements.

There is also a group that has a low-risk factor or meets the requirements for proper water reservoir draining and is not a dengue sufferer, consisting of 32 respondents. This can be observed from the condition of clean water reservoirs that are drained regularly at least once a week, allowing them to be categorized as meeting the requirements. The odds ratio analysis with its confidence interval indicates an OR of 1.556, meaning that individuals who seldom drain their water reservoirs or fail to meet proper draining standards have a tendency toward a 1.556-fold higher likelihood of contracting dengue fever compared to those who regularly drain their reservoirs or follow recommended practices. However, the Chi-square statistical test showed that this association was not statistically significant ( $p > 0.05$ ).

This indicates that while poor draining habits show a positive direction of risk, the relationship could not be statistically confirmed in this study. Therefore, the habit of draining water reservoirs should be interpreted as a potential risk factor, rather than a definitive determinant, for dengue fever incidence in Sungai Pinang Dalam Village, Samarinda City. This is also in line with research conducted by (Saputra et al., 2023) regarding factors related to the physical environment and family habits towards Dengue Hemorrhagic Fever (DHF), that respondents who have poor behavior in cleaning water reservoirs are more likely to be positive for DHF 23 (79.3%). Based on statistical tests with chi-square, a P-value of  $0.000 < 0.05$  was obtained, so there is a significant relationship between the act of cleaning water reservoirs and DHF in the Sako Palembang Health Center Area.

Rosdawati (2021) that stated there is a significant relationship between the variable of draining water reservoirs with the incidence of Dengue Hemorrhagic Fever in the working area of the Ma. Kumpeh Health Center in 2020. The size of the exposure association or OR value is  $= 3.857$  (95% CI = 1.526- 9.750), indicating that respondents who do not drain water reservoirs have a 3.857 times greater risk of suffering from DHF than respondents who drain water reservoirs. Their study in line with this result and the habit of draining water reservoirs regularly plays an important role in preventing DHF because it can eliminate eggs and larvae of *Aedes aegypti* mosquitoes that nest in the walls of water reservoirs at least once a week routinely will break the mosquito life cycle and reduce the risk of DHF transmission.

In Sungai Pinang Dalam, Samarinda, an assessment of residents' habits in draining water reservoirs revealed that only 32 of the 74 respondents fulfilled the criteria by having and properly using a reservoir cover, while the remaining 42 did not meet these standards. Based on the variable of the habit of draining water reservoirs according to the Minister of Health Regulation Number 50 of 2017 concerning Guidelines for the Prevention and Control of Dengue Hemorrhagic Fever (DHF), mosquito nest eradication is the main strategy carried out through the 3M Plus method, one of which is by draining water reservoirs to close access for mosquitoes to lay eggs in stagnant water and aims to break the life cycle of the *Aedes aegypti* mosquito, which is the main vector of dengue fever transmission.

Deforestation and climate change play a significant role in expanding the spatial and temporal spread of dengue fever (DHF) cases in Mexico (Galeana-Pizaña et al., 2024). Land use changes lead to increased waterlogging and ecosystem changes, which increase the breeding habitat for the *Aedes aegypti* mosquito. This condition is exacerbated by increased rainfall and air temperature, which prolong the mosquito's life cycle. Meanwhile, Annan et al. (2023) demonstrated through a Bayesian inferential model that ecological determinants such as population density, humidity, and the availability of artificial water containers contribute to increasing the risk of severe dengue, indicating that household environmental management is an important factor in prevention. These two studies confirm that uncontrolled environmental factors, including the presence of water containers that are rarely cleaned, are key to the increasing incidence of dengue.

Next, research [Altassan et al. \(2019\)](#) in Saudi Arabia and [Giesen et al. \(2022\)](#) in Africa also found a strong relationship between environmental factors, climate change, and community behavior in water management and the spread of dengue fever. Altassan highlighted that the accumulation of unmaintained water containers in densely populated areas is a major source of mosquito larvae, while Giesen emphasized the importance of household-based preventive measures, particularly the routine of regularly draining and cleaning water containers to break the mosquito life cycle. Community habits in draining water containers are a crucial behavioral variable. Not draining water at least once a week can allow mosquito eggs to survive and hatch into larvae, thus increasing the potential for dengue transmission. Therefore, the behavior of regularly draining water containers is a key strategy in preventing this disease, especially in tropical regions with high humidity levels.

Draining and cleaning landfills at least once a week can reduce the breeding grounds for *Aedes aegypti* larvae. The mosquito life cycle is known to show that *Aedes aegypti* larvae can reproduce for 6-8 days. If the draining time is carried out correctly by draining the water reservoir and scrubbing the walls of the reservoir with soap, mosquito eggs will be damaged and cannot develop into mosquito larvae, and will reduce the risk of *Aedes aegypti* larval populations in the home environment. Therefore, the implementation of draining and cleaning landfills once a week has an impact on the presence of *Aedes aegypti* larvae ([Daulay et al., 2024](#)).

### **Risk factors for water reservoir materials**

The material composition of water reservoirs plays a crucial role in dengue prevention based on environmental sanitation theory and vector ecology principles. Water container materials influence water retention, ease of cleaning, light reflection, and moisture accumulation, all of which affect the survival and development of *Aedes aegypti* larvae ([Hemme et al., 2009](#)). Porous and rough materials, such as cement and ceramic, are more likely to retain organic matter and moisture, creating favorable microhabitats for mosquito breeding. In contrast, smooth and non-porous materials, such as plastic, are easier to clean and less conducive to larval development. Therefore, water reservoir material is considered an important environmental determinant in dengue transmission dynamics.

An assessment of water-storage materials as a contributing factor to dengue fever in Sungai Pinang Dalam, Samarinda, identified 48 respondents whose storage containers were considered high risk or did not meet established standards. Among these individuals, 25 were classified as cases and 23 as controls. This condition is largely attributed to the unavailability of plastic water containers in many households; therefore, these containers were categorized as not meeting the recommended requirements. There was also a group of 26 respondents who had low-risk water container materials primarily plastic and were not dengue fever sufferers. Based on field observations, 26 respondents used plastic containers, 20 used ceramic containers, and 28 used cement containers. As cement containers were more commonly used than plastic ones, the overall condition was categorized as not meeting the recommended standards.

The interpretation of the odds ratio within its confidence interval framework showed that the OR value was 1.268 ( $>1$ ), indicating that respondents who used water containers not made of plastic or that did not meet the requirements had a tendency toward a 1.268-fold greater likelihood of contracting dengue fever compared to respondents who used plastic containers or materials that met the requirements. However, the Chi-Square test indicated that this association was not statistically significant ( $p > 0.05$ ). Therefore, water container material in this study should be interpreted as a potential risk factor, rather than a definitive determinant, for dengue fever incidence in Sungai Pinang Dalam Village, Samarinda City.

The results of this study are discussed in relation to research conducted by Nisa et al. (2021) which found that ceramic container materials accounted for 43% of water storage types in their study area. Based on Chi-Square analysis, their study reported a *p*-value of 0.163, which indicates that the relationship between water container materials and dengue fever incidence was not statistically significant. Nevertheless, their findings highlighted that cement and ceramic materials were more commonly found and had the potential to support microorganism growth, such as moss, which serves as food for mosquito larvae. Additionally, minimal light reflection from these materials creates favorable conditions for larval development. These findings support the ecological plausibility of water container materials as a contributing factor, even when statistical significance is not achieved. The habit of managing water reservoirs in Sungai Pinang Dalam Subdistrict also showed that out of 74 respondents, only 26 met the requirements for safe water storage materials, while the remaining 48 did not. Field observations revealed that cement and ceramic materials were predominantly used, reinforcing the classification of water reservoir materials as a potential environmental risk factor for dengue fever in the area.

Study of Yue et al. (2018) in Guangzhou, China, identified that physical environmental and socioeconomic factors significantly influence the spatial distribution of dengue fever (DHF) cases. Through spatial analysis, they found that areas with high population density, poor sanitation, and a high number of open water containers made of porous materials have a greater risk of dengue transmission. These observations are consistent with previous work, which emphasized that ecological factors and socioeconomic conditions play a crucial role in sustaining long-term dengue transmission and triggering severe outbreaks in endemic regions of China. Materially unsuitable water containers such as those made of cement, clay, or ceramic are more likely to retain water and are difficult to clean, potentially providing ideal breeding grounds for *Aedes aegypti* mosquitoes. Both studies emphasize that the characteristics of water container materials play a crucial role in maintaining mosquito vector populations, particularly in densely populated environments with limited sanitation.

Furthermore, research by Chen et al. (2020) highlights that a combination of natural factors (such as rainfall and temperature) and socioeconomic factors (such as water storage practices and housing quality) contribute to an increased risk of dengue transmission, particularly in areas where water containers made from traditional materials are often used, which are non-slip and difficult to clean. This finding is reinforced by a study by Adnan et al. (2021) in Kuala Lumpur, Malaysia, which found that social conditions and the use of water containers made from inappropriate materials were the main determinants of high dengue fever cases. Water container material is an important risk factor that requires attention. Water containers made from smooth, non-porous, and easy-to-clean materials such as plastic or fiberglass have been shown to be safer than porous materials like cement or ceramic. Therefore, selecting the right water container material is part of an effective environment-based vector control strategy to reduce dengue fever incidence.

Water reservoir materials that pose a risk to the presence of larvae are cement and ceramics. This occurs because cement and ceramics tend to be unable to reflect light, so no light enters the reservoir. In addition, low light conditions can cause water reservoirs to become mossy and difficult to clean because cement can absorb water and can create moisture that is difficult to see, which triggers mosquito breeding grounds (Khan et al., 2023). Low light reflection and temperature can cause the breeding of dengue vector mosquitoes. Meanwhile, plastic materials are safer to use because plastic has a slippery surface so it does not easily store dirt or mud that can become a breeding ground for *Aedes aegypti* mosquitoes. In addition, plastic materials also do not absorb water so they cannot leave hidden puddles. Also, plastic reservoirs are generally designed with covers to reduce the risk of mosquitoes entering and laying eggs (Ali, 2024).

Dengue vector control requires a multidimensional approach encompassing environmental, technological, and biological aspects. Environmental conditions in water tanks or reservoirs have been shown to significantly impact the density of *Aedes aegypti* larvae, particularly if the water is rarely changed, not tightly closed, and contains high levels of organic matter (Procopio et al., 2024). Technology-based control efforts are also beginning to be developed through semi-supervised detection based on geospatial imagery to map water tanks or containers that have the potential to become mosquito breeding grounds, allowing for early intervention (Knoblauch et al., 2023). The application of these research results indicates that changes in community behavior in maintaining cleanliness and covering water reservoirs, when combined with spatial data-based mapping technology, can increase the effectiveness of dengue control in densely populated areas.

Innovative biological approaches, such as the use of *Wolbachia* bacteria, have been explored as strategies to inhibit the ability of mosquitoes to transmit dengue virus (Safaei et al., 2025). Other research has shown a spatial association between *Aedes aegypti* mosquito density and dengue hotspots, making mapping high-risk areas a crucial step in prioritizing interventions (Sharif et al., 2022). Wastewater surveillance has also been implemented to detect dengue virus circulation in communities early, thus serving as an early warning system before an outbreak occurs (Thakali et al., 2022). Therefore, effective dengue prevention strategies rely not only on community behaviors such as covering and draining water reservoirs but also need to integrate technology-based environmental monitoring and innovative biological approaches to create an adaptive and sustainable disease control system.

This study has several limitations. First, the relatively small sample size may limit the generalizability of the findings to other areas. Second, data on behavioral variables were collected using self-reported questionnaires, which may be subject to recall bias. Third, this study focused only on selected water storage-related factors and did not include other potential determinants such as larvicidal use, mosquito density, or climatic factors.

#### 4. CONCLUSION

This study indicates that three main household-related factors water reservoir cover use, draining habits, and water reservoir materials contribute to dengue risk patterns in Sungai Pinang Dalam, Samarinda City. Although statistical analysis did not show significant associations ( $p > 0.05$ ), all variables demonstrated Odds Ratio values greater than 1 and were commonly observed under high-risk conditions. Improperly covered water containers, infrequent draining practices, and the use of porous materials such as cement or ceramic may facilitate *Aedes aegypti* breeding and increase environmental vulnerability to Dengue Hemorrhagic Fever (DHF). Based on these findings, the community is encouraged to consistently cover water containers, drain and scrub them at least once a week, and use smooth, easy-to-clean materials such as plastic or fiberglass. Local governments and community health centers can strengthen existing dengue prevention efforts by reinforcing the 3M Plus strategy, supporting community-based larval monitoring programs such as Jumantik Mandiri, and providing practical education to reduce household-level dengue risk in a sustainable manner.

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