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LOGISTIC MODEL OF AEDES AEGYPTI LARVAL HABITATS BASED ON MODIFIABLE HOUSEHOLD ENVIRONMENTAL FACTORS IN BANJAR, INDONESIA

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Abstract

Introduction: *In endemic nations like Indonesia, dengue fever remains a serious public health concern. The majority of predictive models ignore modifiable risk factors at the home level in favor of macroenvironmental variables (rainfall and climate). The study aimed to develop a logistic regression model to forecast the presence of Aedes aegypti larvae based on water quality metrics and the household water containers characteristics.* ***Methods:*** *In Banjar Regency, Indonesia, 400 randomly chosen households participated in a cross-sectional survey. Water parameters (pH, temperature, salinity, and dissolved oxygen) and container attributes (color, cover availability, and type of water source) were evaluated. Significant predictors were identified using stepwise logistic regression. Model performance was assessed using the Receiver Operating Characteristic (ROC) curve and the Hosmer–Lemeshow goodness-of-fit test.* ***Results and Discussion:*** *The final model identified three significant predictors: container color (OR=14.45; 95% CI:2.93–71.16; p=0.001), cover availability (OR=8.02; 95% CI:1.53–42.01; p=0.014), and water source type (OR=16.78; 95% CI:3.18–88.44; p=0.001). The model equation was: logit(p)=-4.676+2.820(water source)+2.671(colour) +2.082(cover availability). The model exhibited outstanding discrimination (AUC=0.945; 95% CI:0.899–0.992) and good calibration (Hosmer-Lemeshow p=0.649).* ***Conclusion:*** *This household-based logistic model effectively identifies high-risk larval habitats using simple, context-specific indicators. Container color, cover availability, and water source type were key predictors of Aedes aegypti larvae presence, offering practical value for community vector control and early warning systems in resource-limited settings.*

INTRODUCTION

Particularly in tropical and subtropical regions like Southeast Asia, the Americas, and the Western Pacific, dengue fever remains a serious global health concern. Asia, including Indonesia, accounts for over 70% of the global disease burden (1). In 2022, 72.8% of Indonesian districts reported dengue cases, and several outbreaks continued into 2023. Eleven provinces recorded case fatality rates (CFRs) above 1%, including South Kalimantan (1.3%), where Banjar Regency consistently reports the highest incidence (2).

Effective dengue prevention depends on controlling *Aedes aegypti*, the primary vector, whose larval presence is a reliable indicator of transmission risk. Larval indices, such as the House Index (HI), Container Index (CI), and Breteau Index (BI), are widely used as indicators of dengue transmission risk. However, these indices provide only reflect quantitative aspects without

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considering the quality of the microenvironment conditions where the larvae breed, making them often defective in predicting transmission progressive at the household level. The distribution of dengue fever incidence is firmly related to larval density (3-4). These limitations emphasize the concern of considering more definite ecological aspects, including container conditions and water quality parameters, which directly determine the prosperity of *Aedes aegypti* oviposition.

Several studies have entrenched a relationship between environmental factors, pointedly the characteristics of water containers and the water quality of breeding sites, and the existence of larvae (5-6). Fundamental characteristics of water containers, including cover availability, colour, location, and type of water source, substantially influence mosquito oviposition (7).

Previous studies showed that larval density is also strongly affected by breeding site water quality (8). Water parameters such as temperature (9), salinity, pH (10-11), and Dissolved Oxygen (DO) (12–14) are crucial factors conditioning larval advancement. Saleh et al. (15) concluded that *Aedes aegypti* eggs evolve ideally within specific ranges of these variables. These parameters, resolved by physical and chemical factors (16–18), commit significantly to the ecological suitability of breeding habitats.

In spite of these findings, most existing predictive models confide on macro-environmental variables, such as rainfall, climate, topography, and air temperature. However, these models often have limited actual-time applicability, poor ecological particularity, and a lack of assimilation with modifiable household-level factors. Moreover, their technical intricacy can hinder adoption by local health systems, exceptionally in resource-constrained settings. Few predictive models have integrated household-level modifiable factors, especially in dengue-endemic regions like Banjar Regency (19-20).

To address this gap, the present study develops a predictive model assimilating water container characteristics and water quality parameters into vector control efforts. Unlike traditional models that rely mainly on reported cases or climatic data, this approach uses *Aedes aegypti* larvae as a direct, field-based indicator of transmission risk. Explicitly, the study aimed to build a logistic regression model to anticipate the existence of *Aedes aegypti* larvae based on water quality parameters and household water container characteristics. This household-based model is expected to strengthen environmentally focused vector control strategies. This recent study is the first study in Banjar Regency and among the few in Indonesia to accommodate container characteristics and water quality into a predictive model, contributing a practical and locally adaptable approach to dengue prevention.

METHODS

Study Design and Location

This study is an analytical observational study with a cross-sectional approach aimed at developing a predictive model for the environmental factors conditioning the existence of *Aedes aegypti* larvae. This design was chosen to identify associations between variables at a specific time (21). The study was conducted in Banjar Regency, South Kalimantan Province, a region endemic to Dengue Fever and recognized for having the highest incidence rate in the province, ensuring the relevance and applicability of the findings.

Study Variables

The dependent variable in this study is the presence of mosquito larvae. The independent variables comprise factors previously shown to influence the presence of larvae, including water containers characteristics (color, cover availability, water source type, and location) and water parameters (salinity, DO, temperature, and pH). Earlier studies have demonstrated that container color and placement affect mosquito oviposition preferences due to variations in light exposure and temperature regulation. The availability of covers significantly reduces breeding by limiting female access and decreasing organic debris input (7). Likewise, containers type and water source resolve nutrient composition and microbial content, both of which are demanding for larval development (8). Meantime, water parameters such as temperature (9), salinity (10), pH (11), and DO (12-14) have been widely reported to inflect larval survival and growth, with optimal ranges alternating by mosquito species. The inclusion of these variables thus enables an extensive assessment of ecological determinants of larval habitat suitability.

Population and Study Sample

The study population involved all households in Banjar Regency, scattered across twenty districts totaling 174,460 houses. Lemeshow's sample size calculation, with a 5% margin of error (e), allow a sample of 400 houses. Acceptable statistical power for identifying purposeful associations was guaranteed by this sample size. To assurance proportionate assistance from each district, stratified random sampling was used to choose these houses. This approach advances the generalizability of the results while addressing potential biases in district-level variability.

Instruments and Materials

Data collection used an observation sheet for container characteristics and laboratory-based analysis of water parameters. The observation sheet intended to capture dichotomous data for variables such as color (dark/light), cover availability (available/not available), water source type (well/tap), and location (inside/outside). The water parameters (salinity, DO, temperature, and pH) were assessed at the Banjarbaru Public Health Laboratory Centre, Ministry of Health of the Republic of Indonesia, which operates under the SNI ISO/IEC 17025 standard for measurement and calibration laboratories. All analyses were accomplished using calibrated instruments (YSI Professional Plus multiparameter meter) and standardized procedures in conformity with the Indonesian National Standard (SNI) protocols. The sample collection involved instruments for the water parameter variables, including a 250 ml dipper, a 600 ml glass or plastic container (bottle), a pipette, and an 8 L cooler box. The research material used sulfuric acid (H_2SO_4) as a sample preservative, ensuring the integrity of properties during transport. Because the instruments and laboratory methods were validated under the SNI ISO framework, no validity or reliability testing was required in this study.

Procedures and Measurements

Water samples were collected systematically and with care to prevent contamination. Water samples were collected using the dipper, transferred to the storage bottle, and preserved with 3-4 drops of H_2SO_4. The bottles were sealed and transported in a cooler box to the Laboratory of the Banjarbaru Center for Environmental Health Engineering and Disease Control for analysis. The parameters were measured using validated laboratory methods, and results were categorized based on established thresholds: salinity (potential: 4-6 gr/l; not potential: <4 or >6 gr/l) (22), DO (potential: 5.86-8.98 ppm; not potential: <5.86 or >8.98 ppm) (1), pH (potential ≤7.5; not potential >7.5) (23), and temperature (optimum: 27-30 °C; not optimum <27 or >30 °C) (19). These thresholds were derived from prior literature identifying optimal conditions for *Aedes aegypti* larval development, reinforcing their validity.

Data Analysis

Data were analyzed using continuity correction at a 95% confidence level. Logistic regression was used in multivariate analysis to find important determinants of the existence of larvae. Variables with p-wald values >0.05 were successively eliminated from the model, while those with a log-likelihood ratio significance of p<0.25 were added. This stepwise approach ensured the model's parsimony and predictive accuracy.

The quality of the predictive model was assessed through calibration (Hosmer and Lameshow test) and discrimination (Receiver Operating Curve, ROC). The ROC curve provided a visual representation of model performance, with the Area Under Curve (AUC) value indicating the model's predictive power (the ability to predict the presence of larvae with and without conditions based on measurement results): 0.5 indicates no discrimination; 0.7 to 0.8 is considered acceptable; 0.8 to 0.9 is considered very good, and more than 0.9 is considered excellent (24).

Ethical Clearance

Sari Mulia University's Research Ethics Commission granted ethical clearance and a permit for this study under number 045/UE-UNISM/VII/2024. This approval underscores the study's adherence to ethical principles, ensuring the integrity of the research process.

RESULTS

Water Container Attributes Associated with Larva Presence

Table 1 shows the characteristics of water containers and their relationship to the presence of *Aedes aegypti* larvae. Of the 400 containers observed, the majority were light-colored (64.0%), had covers (62.8%), were sourced from tap water (60.4%), and were located indoors (82.5%). The distribution of larvae digressed significantly based on container color. Larvae were more intermittently found in dark-colored containers (68.1%) than light-colored containers (7.4%). This difference was significant (p<0.001) with a relative risk (RR) of 0.037, indicating that container color is associated with larval presence.

Table 1. Water Container and Water Parameter Characteristics with Larvae Presence (n=400)

Variables	f (%)	Larvae presence		RR (95% CI)	p-value	Remarks
		Found (%)	Not found (%)			
Water container characteristics						
Colour						
Dark	144 (36.0)	98 (68.1)	46 (31.9)	0.037	0.000	Correlated
Light	256 (64.0)	19 (7.4)	237 (92.6)			

Variables	f (%)	Larvae presence		RR (95% CI)	p-value	Remarks
		Found (%)	Not found (%)			
Cover						
Available	149 (37.2)	74 (49.7)	75 (50.3)	0.200	0.002	Correlated
Not available	251 (62.8)	209 (83.3)	42 (16.7)			
Water Source						
Well water	158 (39.6)	102 (64.6)	56 (35.4)	0.033	0.000	Correlated
Tap water	242 (60.4)	14 (5.8)	228 (94.2)			
Location						
Indoor	330 (82.5)	93 (28.2)	237 (71.8)	0.784	0.757	Non-correlated
Outdoor	70 (17.5)	24 (34.3)	46 (65.7)			
Water parameter characteristics						
Salinity						
Potential	84 (21.0)	42 (50.0)	42 (50.0)	0.308	0.056	Non-Correlated
Not potential	316 (79.0)	74 (23.4)	242 (76.6)			
Dissolved Oxygen						
Potential	317 (79.1)	98 (30.9)	219 (69.1)	0.639	0.669	Non-Correlated
Not potential	83 (20.9)	18 (21.7)	65 (78.3)			
Temperature						
Optimum	223 (55.8)	144 (64.6)	79 (35.4)	0.486	0.042	Correlated
Not optimum	177 (44.2)	37 (20.9)	140 (79.1)			
pH						
Potential	153 (38.4)	93 (60.8)	60 (39.2)	0.450	0.046	Correlated
Not potential	247 (61.6)	56 (22.7)	191 (77.3)			

The availability of covers also determined larval presence. Containers without covers showed a significantly higher proportion of larvae (83.3%) than containers with covers (49.7%). This relationship was statistically significant (p=0.002; RR=0.200), indicating that the availability of covers protects mosquito oviposition. The water source is another important factor that influences larval presence. Containers filled with healthy water had more larvae (64.6%) than containers filled with tap water (5.8%). This relationship was significant (p<0.001; RR=0.033), indicating that healthy water is more conducive to larval development than tap water.

Meanwhile, container location (indoor or outdoor) did not show a significant difference in larval presence (p=0.757). Larvae were found in 28.2% of indoor containers and 34.3% of outdoor containers, with an RR=0.784. These results confirm that location factors are not correlated with larval presence, suggesting that the container's microenvironment is more influential than its geographic location.

Water Parameters Associated with Larva Presence

Table 1 also presents the characteristics of water quality parameters and their relationship to the presence of *Aedes aegypti* larvae. In general, the majority of containers were categorized as "not potential" for salinity (79.0%), Dissolved Oxygen/DO (79.1%), and pH (61.6%). In comparison, more than half of the containers showed temperatures within the optimum category (55.8%).

Based on the analysis, salinity was not significantly related to larval presence (p=0.056; RR=0.308). The proportion of larvae was found almost equally in containers with potential salinity (50.0%) and non-potential salinity (23.4%). Similarly, DO levels did not show a significant relationship (p=0.669; RR=0.639), with larvae found in 30.9% of containers with potential DO and 21.7% with non-potential DO. Both parameters were categorized as non-correlated with larval presence.

In contrast, water temperature was shown to significantly relate to larval presence (p=0.042; RR=0.486). More larvae were found in containers with optimum temperature (64.6%) compared to those with suboptimal temperature (20.9%), indicating that appropriate temperature is an important factor for larval survival.

Furthermore, pH was significantly associated with larval presence (p=0.046; RR=0.450). Containers with a potential pH showed a higher prevalence of larvae (60.8%) than containers with a non-potential pH (22.7%). These results confirm that water pH balance is an important determinant of *Aedes aegypti* larval ecology. Overall, these results indicate that of the four water quality parameters tested, only temperature and pH were significantly associated with larval presence, while salinity and DO show no significant relationship.

Predictive Modeling of Larva Presence

Table 2 shows the results of a stepwise logistic regression analysis to pinpoint factors associated with the presence of *Aedes aegypti* larvae in water containers. In the first stage, five variables were listed into the model: container color, cover availability, water source type, salinity, temperature, and pH. The results presented that container color (p=0.001; OR=14.555; 95% CI=2.819–75.149), cover availability (p=0.031; OR=8.953; 95%

CI=1.224–65.482), and water source type (p=0.001; OR=23.140; 95% CI=3.545–151.054) were significantly associated with the existence of larvae. In contrast, salinity, temperature, and pH revealed no significant relationship. This model had a Hosmer–Lemeshow χ^2 value of 6.145 (p=0.407), citing a good model fit.

Tabel 2. The Logistic Regression Model and Hosmer-Lameshow Test

	Logistic Regression Model				Hosmer-Lameshow Test	
Factors	**B**	**p-value**	**OR**	**95% CI**	χ^2	**p-value**
1st STEP						
Colour	2.678	0.001	14.555	2.819-75.149		
Cover existence	2.192	0.031	8.953	1.224-65.482		
Water source type	3.142	0.001	23.140	3.545-151.054	6.145	0.407
Salinity	-0.057	0.954	0.944	0.135-6.602		
Temperature	1.288	0.246	3.627	0.411-31.974		
pH	-0.888	0.370	0.412	0.059-2.865		
2nd STEP						
Colour	2.678	0.001	14.555	2.818-75.164		
Cover Availability	2.163	0.014	8.694	1.561-48.412		
Water source type	3.141	0.001	23.136	3.541-151.152	5.074	0.534
Temperature	1.290	0.245	3.634	0.413-31.976		
pH	-0.904	0.342	0.405	0.063-2.613		
3rd STEP						
Colour	2.558	0.002	12.910	2.597-64.176		
Cover Availability	2.006	0.019	7.432	1.387-39.827	3.794	0.705
Water source type	2.924	0.001	18.620	3.305-104.900		
Temperature	0.855	0.379	2.351	0.351-15.757		
4th STEP						
Colour	2.671	0.001	14.448	2.933 – 71.163		
Cover existance	2.082	0.014	8.022	1.532 – 42.006	2.473	**0.649**
Water source type	2.820	0.001	16.777	3.183 – 88.442		
Constant	-4.676					

B = Beta Coefficient; OR = Odd Ratio; 95% CI: Confident Interval 95% (0.05); χ^2: Chi-square

In the second stage, the insignificant salinity variable was eliminated from the model. The results were consistent with the previous stage, where container color (p=0.001; OR=14.555), cover availability (p=0.031; OR=8.694), and water source type (p=0.001; OR=23.136) remained significant. The Hosmer–Lemeshow test yielded a χ^2 value 5.074 (p=0.534), indicating model fit.

The third stage excluded the insignificant pH variable. The analysis revealed that container color (p=0.002; OR=12.910), cover availability (p=0.016; OR=7.432), and water source type (p=0.001; OR=18.620) remained significant influences on larval presence. The Hosmer–Lemeshow test yielded a χ^2 value of 3.794 (p=0.705), confirming model fit.

The temperature variable was also eliminated in the fourth stage due to its insignificance. The final model showed that three variables, container color (p=0.001; OR=14.448; 95% CI=2.933–71.163), cover availability (p=0.014; OR=8.022; 95% CI=1.532–42.065), and water source type (p=0.002; OR=16.777; 95% CI=3.183–88.442), remained significant. The Hosmer–Lemeshow test for this model yielded a χ^2=2.473 (p=0.649), indicating a perfect fit for the logistic regression model. Overall, the results of this analysis indicate that container color, cover availability, and water source type are strong predictors of *Aedes aegypti* larval presence. In contrast, water quality factors such as salinity, temperature, and pH did not play a significant role in the multivariate model.

DISCUSSION

The results of this study indicate that the characteristics of water containers are significantly associated with the presence of *Aedes aegypti* larvae. The three main influencing factors are container color, availability of a cover, and type of water source. The container's location (inside or outside the home) did not show a significant association.

Container color was shown to be significantly associated with the presence of larvae, with more larvae found in dark-colored containers than in light-colored containers. These results align with research showing that dark-colored containers attract mosquitoes due to their ability to retain heat, creating a favorable environment for egg-laying (25). However, this observation differs from findings reporting higher larval abundance in light-colored containers (31.25%) (26). This visual preference is related to an adaptive strategy mosquitoes use to increase larval survival. This difference could be due to differences in environmental conditions, container materials, or mosquito species.

The availability of covers on containers is a protective factor. Containers without covers have more larvae than those with covered containers. Uncovered containers were significantly more likely to contain larvae because they allowed mosquitoes easy access to deposit eggs. This finding supports which stated that simple interventions such as using container covers can significantly reduce larval density (27). Thus, the presence of the cover serves as an effective physical barrier in preventing mosquito oviposition.

The type of water source also plays a significant role. Larvae are more commonly found in well water containers than tap water. This may be due to well water's typically neutral pH (6–8). Low salinity and the presence of microorganisms that serve as food for developing larvae (28-29). Conversely, tap water's treatment processes often reduce microbial content and alter chemical parameters, making it less suitable for larval development. These findings confirm that microhabitat quality, including water sources, must be considered in vector control strategies.

In contrast, the container's location (inside or outside the house) was not significantly related to the presence of larvae. The non-correlation of container location with larva presence was unexpected. This may be because the *Aedes aegypti* mosquito is a highly adaptive species capable of laying eggs in both indoor and outdoor environments. Seeing the circumstances of the container support the survival of the larvae, like ambient temperature, humidity, and shading around the container, possibly having more impact than its location. Studied ambient temperature and humidity which have been permitted to affect the development of *Aedes aegypti* (19). In addition, found that the disclosure of the container to sunlight is approximately positively related to mosquito larva development (16). Farther study is needed to explore these variables and their role with mosquito breeding behaviors.

These results affirm the effect of household-based interventions in dengue vector control. Simple modifications, such as electing light-colored containers, applying covers, and leading water sources, can significantly diminish the risk of *Aedes aegypti* larval breeding. This strategy is inexpensive, easy to appliance, and suitable for use in resource-limited situations such as Banjar Regency and other endemic areas.

The results presented that of the four water quality parameters analyzed, only temperature and pH were significantly associated with the existence of *Aedes aegypti* larvae. Meanwhile, salinity and dissolved oxygen (DO) were not shown to affect larval distribution. Water parameters that are proven to be significantly related are temperature and pH. The results of this study are in line with several previous studies in Brazil (30), Ethiopia (31), Tanzania (32), Congo (33), and Colombia (34).

Water temperature proved to be an important determinant. More larvae were found in containers with optimal temperatures than in those with suboptimal temperatures. It will develop well at the optimum temperature but take longer at low temperatures and involves the physiological processes of the larvae (35-36). Temperatures within the optimum range support larval metabolism and accelerate the transition to the pupal phase, thereby increasing the potential of the vector population.

Water pH is also significantly related to larval presence. Containers with a potential pH tend to have higher larval densities than containers with a non-potential pH. The relationship between pH is where pH affects the levels of O_2 and CO in the water. It involves the formation of the cytochrome oxidation enzymes of *Aedes aegypti* larvae. The development of eggs to become larvae and adult mosquitoes is at a pH of 4-9 (37-38). A pH imbalance can reduce larval survival because it affects nutrient availability and the stability of the micro-ecosystem in the water container.

In contrast, salinity did not show a significant relationship with larval presence. This finding suggests that in the local context of the study, salinity variation across containers was relatively homogeneous or within a range tolerable to *Aedes aegypti* larvae. Other studies have reported that these mosquito larvae are adaptable to varying salinity levels, although they generally prefer low-salinity environments (39). This adaptation shows their flexibility to salinity, so salinity is not always a limiting factor.

Dissolved oxygen (DO) was not significantly related to mosquito larvae's presence. It may be attributed to the unique respiratory adaptations of mosquito larvae. Mosquito larvae have a unique structure, the siphon, which allows them to take oxygen directly from the air on the water's surface, reducing their dependence on DO levels (40). Therefore, the level of DO in the water is not critical for them.

Overall, these results confirm that temperature and pH are the most important physical-chemical water factors determining larval presence at the study site. These findings reinforce the urgency of incorporating water quality indicators into environment-based vector control programs. Therefore, public health interventions should focus on container management and consider microhabitat conditions that influence the ecology of *Aedes aegypti* larvae.

This study's stepwise logistic regression analysis identified three factors consistently significantly associated with *Aedes aegypti* larvae: container color, cover availability, and water source type. Other factors, such as salinity, temperature, and pH, were eliminated from the final model because they did not show significance in multivariate prediction. The final model had a good fit (p=0.649), indicating the validity of the prediction results. So far, previous studies have made models to predict the incidence of Dengue fever (41–43) as well as to predict Dengue fever incidence based on meteorological data, demonstrating significant correlations between weather variables and dengue outbreaks (44-45), but a larva prediction model is now being carried out.

This study's findings align with previous research emphasizing the importance of water container characteristics in mosquito breeding. Consistent studies in tropical regions have identified container color and the availability of covers as significant predictors influencing sunlight exposure and water evaporation rates, which subsequently affect larval habitat suitability (46). In contrast, salinity and pH were excluded from the final model due to their lack of statistical significance. These differences may be explained by variations in environmental conditions, water quality, or microclimatic factors across study sites (47).

The study's merits add its prosperous statistical approach and high model accuracy. Circumspections combine excluding potential confounding variables, such as container cleaning practices, which could further refine the model. Unexpectedly, temperature—often a decisive factor in mosquito development—did not endure significant in the final model, likely expected to its interaction with other variables.

Interestingly, despite the basic admittance of water parameters such as temperature, pH, and salinity in the model, these variables were conclusively excluded through stepwise regression due to statistical insignificance. While these factors have been highlighted as valuable larval determinants in many ecological studies, their predictive power in this definite setting of Banjar Regency was restricted. This may reverse local environmental dynamics where container characteristics dominate more than water chemistry.

The cut of salinity and pH adjust with the biological adaptation of *Aedes aegypti* larvae, which possess respiratory and osmoregulatory system that may buffer against minor fluctuations in water chemistry. Temperature, often treated critical in larval development, also showed no significant combined value in the final predictive model. This could be due to the narrow temperature range detected in the field or its collinearity with other factors such as container color and installation.

These findings underscore the importance of context-specific models. They highlight those factors traditionally considered universal may vary significantly depending on micro-environmental and behavioral contexts. Including only statistically robust, modifiable household variables enhances the model's parsimony and practical applicability for community-level vector control strategies.

The findings reinforce the critical role of household-level water container characteristics (particularly color, cover, and water source type) as primary determinants of *Aedes aegypti* breeding. These variables are not only statistically significant but also easily modifiable, making them ideal targets for community-based vector control programs. Unlike traditional models relying on climate or case surveillance data, this study offers a micro-environmental perspective that can be applied even in areas with limited meteorological infrastructure. The high AUC (0.945) demonstrates the model's strength in discriminating larval presence and provides a robust foundation for real-time, localized risk mapping. This model holds potential for integration into public health surveillance systems, particularly in resource-limited settings, as an early warning tool to guide proactive larval control.

Despite these strengths, several limitations should be considered. First, this study did not incorporate potential confounding behavioral variables, such as the frequency of container cleaning, household hygiene practices, or exposure to public health campaigns, which may influence larval presence. Second, the cross-sectional design limited the ability to assess temporal variations such as rainfall, humidity, and seasonality. Finally, spatial analysis was not conducted to detect potential clustering or spatial autocorrelation of larval distribution between households or neighborhoods. Future studies should integrate spatial and behavioral data using GIS-based or multilevel modeling approaches to improve the applicability and scalability of predictive tools in endemic settings.

Despite being widely reported as significant in other ecological settings, water parameters such as temperature, salinity, and pH were excluded from the final model due to their limited predictive power in this local context. This suggests regional variation in vector ecology and supports the importance of context-specific modeling.

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CONCLUSION

The predictive model developed in this study identified three statistically robust and modifiable predictors of *Aedes aegypti* larval presence: container colour, cover availability, and water source type. These findings underscore the significance of household-level initiatives in dengue vector control. Targeting dark-colored, uncovered containers filled with untreated water should become a public health priority in endemic regions. The logistic model offers a simple, scalable, and field-applicable tool for early detection of larval habitats, with high predictive accuracy. Future studies are encouraged to validate this model across diverse ecological settings and integrate behavioral factors (e.g., cleaning habits, water storage practices) to enhance its predictive capacity.

AUTHORS' CONTRIBUTION

All authors actively participated in this research and writing process. NH contributed to the formulation, methodology, and result analysis; ES and AH contributed to the concept and formulation; MM contributed to result interpretation; PS were responsible for reviewing, revisions, and editing.

REFERENCES

1. Indriyani N, Ishak H, Syamsuar, Ibrahim E, Syahribulan, Masni. Water Quality and Density of Aedes Sp Larvae: A Study from Indonesia. *Indian Journal of Entomology*. 2024;87(3):1-4. https://doi.org/10.55446/IJE.2024.2414
2. South Kalimantan Provincial Health Office. South Kalimantan Province Health Profile 2021. Banjarmasin: South Kalimantan Provincial Health Office; 2022. 1–100 p.
3. Amini M, Hanafi-Bojd AA, Aghapour AA, Chavshin AR. Larval Habitats and Species Diversity of Mosquitoes (Diptera: Culicidae) in West Azerbaijan Province, Northwestern Iran. *BMC Ecol*. 2020;20(1):1–11. https://doi.org/10.1186/s12898-020-00328-0
4. Wilson-Bahun TA, Kamgang B, Lenga A, Wondji CS. Larval Ecology and Infestation Indices of Two Major Arbovirus Vectors, *Aedes Aegypti* and Aedes Albopictus (Diptera: Culicidae), in Brazzaville, the Capital City of the Republic of the Congo. *Parasit Vectors*. 2020;13(1):1–18. https://doi.org/10.1186/s13071-020-04374-x
5. Udayanga L, Aryaprema S, Gunathilaka N, Iqbal MCM, Fernando T, Abeyewickreme W. Larval Indices of Vector Mosquitoes as Predictors of Dengue Epidemics: An Approach to Manage Dengue Outbreaks Based on Entomological Parameters in the Districts of Colombo and Kandy, Sri Lanka. *Biomed Res Int*. 2020;2020(5):1-11. https://doi.org/10.1155/2020/6386952
6. Ning L, Niu J, Bi X, Yang C, Liu Z, Wu Q, et al. The Impacts of Knowledge, Risk Perception, Emotion and Information on Citizens' Protective Behaviors During the Outbreak of COVID-19: A Cross-Sectional Study in China. *BMC Public Health*. 2020;20(1):1–12. https://doi.org/10.1186/s12889-020-09892-y
7. Hidayah N, Suhartono E, Hidayat A, Prastya SE. A Predictive Map of Larvae Presence Risk Based on Modeling Algorithm in Urban Settings of Endemic Area. *BIO Web of Conferences, The 5th ICOPH-TCD*. 2024;00034(133):1–11. https://doi.org/10.1051/bioconf/202413300034
8. Dalpadado R, Amarasinghe D, Gunathilaka N. Water Quality Characteristics of Breeding Habitats in Relation to the Density of *Aedes Aegypti* and Aedes Albopictus in Domestic Settings in Gampaha District of Sri Lanka. *Acta Trop*. 2022;229(106339). https://doi.org/10.1016/j.actatropica.2022.106339
9. Hery L, Guidez A, Durand AA, Delannay C, Normandeau-Guimond J, Reynaud Y, et al. Natural Variation in Physicochemical Profiles and Bacterial Communities Associated with *Aedes aegypti* Breeding Sites and Larvae on Guadeloupe and French Guiana. *Microb Ecol*. 2021;81(1):93–109. https://doi.org/10.1007/s00248-020-01544-3
10. Maharani Z, Saputra A, Info A, Fever DH, Chlorine R. Strategic Management of Public Health Risks: Correlation Between Water Quality and Aedes Sp. in South Jakarta. *APTISI Transactions on Management*. 2024;8(1):66–70. https://doi.org/10.33050/atm.v8i1.2205
11. Multini LC, Oliveira-Christe R, Medeiros-Sousa AR, Evangelista E, Barrio-Nuevo KM, Mucci LF, et al. The Influence of the Ph and Salinity of Water in Breeding Sites on the Occurrence and Community Composition of Immature Mosquitoes in the Green Belt of the City of São Paulo, Brazil. *Insects*. 2021;12(9):797. https://doi.org/10.3390/insects12090797
12. Herawati A, Ramadhan ARR, Hidayah N. Hubungan Salinitas, Suhu, Dissolved Oxygen, dan pH Air Tempat Perindukan dengan Keberadaan Jentik Vektor Demam Dengue. *An-Nadaa: Jurnal Kesehatan Masyarakat*. 2022;9(2):185-189. http://dx.doi.org/10.31602/ann.v9i2.8742
13. Sazali M, Soesilohadi RCH, Wijayanti N, Wibawa T. Oviposition Behavior of *Aedes aegypti* Difference Colored Water Container at Pagutan Subdistrict, Mataram City. *AIP Conf. Proc*. 2020;2260(1):1-6. https://doi.org/10.1063/5.0015677
14. Huzortey AA, Kudom AA, Mensah BA, Sefa-Ntiri B, Anderson B, Akyea A. Water Quality Assessment in Mosquito Breeding Habitats Based on Dissolved Organic Matter and Chlorophyll Measurements by Laser-Induced Fluorescence Spectroscopy. *PLoS One*. 2022;17(7):1-14. https://doi.org/10.1371/journal.pone.0252248
15. Saleh F, Kitau J, Konradsen F, Kampango A, Abassi R, Schiøler KL. Epidemic Risk of Arboviral Diseases: Determining the Habitats, Spatial-Temporal Distribution, and Abundance of Immature *Aedes Aegypti* in the Urban and Rural Areas of Zanzibar, Tanzania. *PLoS Negl Trop Dis*. 2020;14(12):1-20. https://doi.org/10.1371/journal.pntd.0008949

16. Ouédraogo WM, Toé KH, Sombié A, Viana M, Bougouma C, Sanon A, et al. Impact of Physicochemical Parameters of *Aedes Aegypti* Breeding Habitats on Mosquito Productivity and the Size of Emerged Adult Mosquitoes in Ouagadougou City, Burkina Faso. *Parasit Vectors*. 2022;15(1):1-13. https://doi.org/10.1186/s13071-022-05558-3
17. Alkhayat FA, Ahmad AH, Rahim J, Dieng H, Ismail BA, Imran M, et al. Characterization of Mosquito Larval Habitats in Qatar. *Saudi J Biol Sci*. 2020;27(9):2358–2365. https://doi.org/10.1016/j.sjbs.2020.07.006
18. Liu Z, Zhang Q, Li L, He J, Guo J, Wang Z, et al. The Effect of Temperature on Dengue Virus Transmission by Aedes Mosquitoes. *Front Cell Infect Microbiol*. 2023;13(1242173):1-10. https://doi.org/10.3389/fcimb.2023.1242173
19. Mamenun, Koesmaryono Y, Sopaheluwakan A, Hidayati R, Dasanto BD, Aryati R. Spatiotemporal Characterization of Dengue Incidence and Its Correlation to Climate Parameters in Indonesia. *Insects*. 2024;15(5):1-15. https://doi.org/10.3390/insects15050366
20. Nurdin N, Siregar YI, Mubarak M, Wijayantono W. Environmental Factors linked to the Presence of *Aedes aegypti* Larvae and the Prevalence of Dengue Hemorrhagic Fever. *Open Access Maced J Med Sci*. 2022;10(5):475–480. https://doi.org/10.3889/oamjms.2022.8533
21. Veronica A, Abas M, Hidayah N, Sabtohadi D, Marlina H, Mulyani W. *Metodologi Penelitian Kuantitatif 1st ed*. Padang: PT. Global Eksekutif Teknologi; 2022. 1–159 p. https://repository.umi.ac.id/1989/2/Metodologi%20Penelitian%20Kuantitatif.pdf
22. Aryaprema VS, Caride K, Kuppe C, Xue RD, Qualls WA. Salinity Effects on the Distribution of *Aedes aegypti* and Aedes albopictus in St. Johns County, Florida. *Journal of the Florida Mosquito Control Association*. 2024;71:50–58. https://doi.org/10.32473/jfmca.71.1.135293
23. Sugeno M, Kawazu EC, Kim H, Banouvong V, Pehlivan N, Gilfillan D, et al. Association Between Environmental Factors and Dengue Incidence in Lao People's Democratic Republic: A Nationwide Time-Series Study. *BMC Public Health*. 2023;23(1):1-10. https://doi.org/10.1186/s12889-023-17277-0
24. Kristiawan K, Widjaja A. Perbandingan Algoritma Machine Learning dalam Menilai Sebuah Lokasi Toko Ritel. *Jurnal Teknik Informatika dan Sistem Informasi*. 2021;7(1):35-46. https://doi.org/10.28932/jutisi.v7i1.3182
25. Njila H, Sani H, Ombugadu A, Tanko N. Evaluation of Coloured Containers as Attractants to Gravid Mosquitoes for Oviposition. *Trends Tech Sci Res*. 2023;6(1):1-8. https://doi.org/10.19080/TTSR.2023.06.555679
26. Andrioli DC, Busato MA, Lutinski JA. Characteristics of the Dengue Epidemic in Pinhalzinho, Santa Catarina, Brazil, 2015-2016. *Epidemiol Serv Saude*. 2020;29(4):1-7. https://doi.org/10.5123/s1679-49742020000400007
27. Parker AT, McGill K, Allan BF. Container Type Affects Mosquito (Diptera: Culicidae) Oviposition Choice. *J Med Entomol*. 2020;57(5):1459–1467. https://doi.org/10.1093/jme/tjaa045
28. Caragata EP, Otero LM, Tikhe C V., Barrera R, Dimopoulos G. Microbial Diversity of Adult *Aedes aegypti* and Water Collected from Different Mosquito Aquatic Habitats in Puerto Rico. *Microb Ecol*. 2022;83(1):182–201. https://doi.org/10.1007/s00248-021-01743-6
29. Mataba GR, Munishi L, Brendonck L, Vanschoenwinkel B. The Role of Anthropogenic Container Habitats as Mosquito Oviposition Habitats in Rural Settlements in Northern Tanzania. *Journal of Vector Ecology*. 2022;47(1):69–80. https://doi.org/10.52707/1081-1710-47.1.69
30. Macêdo SF, Silva KA, Vasconcelos RB, Sousa IV, Mesquita LPS, Barakat RDM, et al. Scaling Up of Eco-Bio-Social Strategy to Control *Aedes aegypti* in Highly Vulnerable Areas in Fortaleza, Brazil: A Cluster, Non-Randomized Controlled Trial Protocol. *Int J Environ Res Public Health*. 2021;18(3):1-23. https://doi.org/10.3390/ijerph18031278
31. Yared S, Gebressilasie A, Worku A, Mohammed A, Gunarathna I, Rajamanickam D, et al. Breeding Habitats, Bionomics and Phylogenetic Analysis of *Aedes Aegypti* and First Detection of Culiseta Longiareolata, and Ae. Hirsutus in Somali Region, Eastern Ethiopia. *PLoS One*. 2024;19(1):1-16. https://doi.org/10.1371/journal.pone.0296406
32. Mataba GR, Munishi L, Brendonck L, Vanschoenwinkel B. The Role of Anthropogenic Container Habitats as Mosquito Oviposition Habitats in Rural Settlements in Northern Tanzania. *Journal of Vector Ecology*. 2022;47(1):69–80. https://doi.org/10.52707/1081-1710-47.1.69
33. Mbanzulu KM, Wumba R, Mboera LEG, Kayembe JMN, Engbu D, Bojabwa MM, et al. Pattern of *Aedes aegypti* and Aedes albopictus Associated with Human Exposure to Dengue Virus in Kinshasa, the Democratic Republic of the Congo. *Trop Med Infect Dis*. 2022;7(11):1-16. https://doi.org/10.3390/tropicalmed7110392
34. Carrillo MA, Cardenas R, Yañez J, Petzold M, Kroeger A. Risk of Dengue, Zika, and Chikungunya Transmission in the Metropolitan Area of Cucuta, Colombia: Cross - Sectional Analysis, Baseline for A Cluster - Randomised Controlled Trial of A Novel Vector Tool for Water Containers. *BMC Public Health*. 2023;23(1000):1–15. https://doi.org/10.1186/s12889-023-15893-4
35. Prasad P, Gupta SK, Mahto KK, Kumar G, Rani A, Velan I, et al. Influence of Climatic Factors on the Life Stages of Aedes Mosquitoes and Vectorial Transmission: A Review. *J Vector Borne Dis*. 2024;61(2):158-166. https://doi.org/10.4103/JVBD.JVBD_42_24
36. Hug DOH, Gretener-Ziegler R, Stegmayer RI, Mathis A, Verhulst NO. Altered Thermal Preferences of Infected or Immune-Challenged *Aedes Aegypti* And Aedes Japonicus Mosquitoes. *Sci Rep*. 2024;14(1):1-9. https://doi.org/10.1038/s41598-024-63625-4

37. Piedra LA, Martinez Y, Camacho E, Garcia I, Rodriguez D, Vanlerberghe V, et al. Temephos Resistance Status of *Aedes aegypti* Populations from Havana, Cuba. *J Am Mosq Control Assoc*. 2024;40(2):117–120. https://doi.org/10.2987/23-7164
38. Bisset JA, Rodríguez MM, Piedra LA, Cruz M, Gutiérrez G, Ruiz A. Reversal of Resistance to the Larvicide Temephos in an *Aedes aegypti* (Diptera: Culicidae) Laboratory Strain from Cuba. *J Med Entomol*. 2020;57(3):801–806. https://doi.org/10.1093/jme/tjz206
39. Ratnasari A, Jabal AR, Syahribulan, Idris I, Rahma N, Rustam SNRN, et al. Salinity Tolerance of Larvae *Aedes Aegypti* Inland and Coastal Habitats in Pasangkayu, West Sulawesi, Indonesia. *Biodiversitas*. 2021;22(3):1203–1210. https://doi.org/10.13057/biodiv/d220316
40. Alvarez-Costa A, Leonardi MS, Giraud S, Schilman PE, Lazzari CR. Challenging Popular Belief, Mosquito Larvae Breathe Underwater. *Insects*. 2024;15(2):1-11.
https://doi.org/10.3390/insects15020099
41. Azam N, Salim M, Wah YB, Reeves C, Smith M, Fairos W, et al. Prediction of Dengue Outbreak in Selangor Malaysia Using Machine Learning Techniques. *Sci Rep*. 2021;11(939):1–9. https://doi.org/10.1038/s41598-020-79193-2
42. Mustaffa NA, Zahari SM, Farhana NA, Nasir N, Azil AH. Forecasting the Incidence of Dengue Fever in Malaysia: A Comparative Analysis of Seasonal ARIMA, Dynamic Harmonic Regression, and Neural Network Models. *International Journal of Advanced and Applied Sciences*. 2024;11(1):20–31. https://doi.org/10.21833/ijaas.2024.01.003
43. Nejad FY, Varathan KD. Identification of Significant Climatic Risk Factors and Machine Learning Models in Dengue Outbreak Prediction. *BMC Med Inform Decis Mak*. 2021;21(141):1–12. https://doi.org/10.1186/s12911-021-01493-y
44. Nasir M, Wulandhari SA, Tenrisau D, Ibrahim AH, Rahastri A, Kasim MF, et al. Machine Learning Approach to Predict the Dengue Cases Based on Climate Factors. *Window of Health: Jurnal Kesehatan*. 2024;7(2):203–214. https://doi.org/10.33096/woh.vi.1428
45. Tian N, Zheng JX, Li LH, Xue JB, Xia S, Lv S, et al. Precision Prediction for Dengue Fever in Singapore: A Machine Learning Approach Incorporating Meteorological Data. *Tropical Medicine and Infectious Disease*. 2024;9(4):72-80. https://doi.org/10.3390/tropicalmed9040072
46. Jesús CR, Rogers RE. Habitat Segregation Patterns of Container Breeding Mosquitos: the Role of Urban Heat Islands, Vegetation Cover, and Income Disparity in Cemeteries of New Orleans. *Int J Environ Res Public Health*. 2021;19(1):1-16. https://doi.org/10.3390/ijerph19010245
47. Chandrasegaran K, Lahondère C, Escobar LE, Vinauger C. Linking Mosquito Ecology, Traits, Behavior, and Disease Transmission. *Trends Parasitol*. 2020;36(4):393–403. https://doi.org/10.1016/j.pt.2020.02.001