

## ORIGINAL ARTICLE

# Influence of Meteorological, Entomological and Environmental Parameters with Dengue Incidence in Kota Kinabalu, Sabah

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## ABSTRACT

**Introduction:** Dengue fever represents a significant challenge to public health, affecting 3.9 billion individuals residing in 129 dengue endemic countries. Local dengue incidence is influenced by environmental factors, including rainfall, temperature, humidity, and wind speed. This study aimed to determine the relationship between meteorological, entomological, and environmental parameters and dengue cases in Kota Kinabalu, Sabah. **Materials and methods:** An ecological study was conducted from 2016 to 2021 using the dengue database and meteorological data. Pearson's correlation coefficient was used to examine the correlation between the predictor variables and number of dengue cases in Kota Kinabalu. **Results:** A significant negative linear correlation ( $r=-0.28$ ,  $p < 0.01$ ) was observed between the weekly maximum temperature and weekly number of dengue cases. There was a significant negative linear correlation ( $r=-0.22$ ,  $p < 0.01$ ) between the weekly minimum temperature and weekly number of dengue cases. A strong positive correlation was observed between the weekly number of *Aedes albopictus* ( $r=0.65$ ,  $p < 0.01$ ) and the *Aedes* index ( $r=0.64$ ,  $p < 0.01$ ) and the weekly number of dengue cases. A significant positive linear correlation was found ( $r=0.39$ ,  $p < 0.01$ ) between the weekly number of vacant lots and weekly number of dengue cases. **Conclusion:** This clearly shows that temperature, entomological factors, and the presence of vacant lots play crucial roles in dengue occurrence in Kota Kinabalu, Sabah. Comprehensive dengue control strategies that consider environmental management, efficient vector control, and community engagement should not be overlooked. *Malaysian Journal of Medicine and Health Sciences* (2025) 21(4): 90-97. doi:10.47836/mjmhs.21.4.12

**Keywords:** Dengue cases, Environmental parameters, Entomological parameters, Meteorological parameters, Correlation

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## INTRODUCTION

Dengue fever (DF), a viral infection transmitted by mosquitoes, is a major global public health issue. In recent decades, there has been a significant increase in the incidence of this phenomenon, as indicated by the sharp increase in the reported cases. The World Health Organization (WHO) has observed a significant increase in global dengue cases, with reported instances increasing from 505,430 cases in previous years to higher numbers in recent times. The surge in cases demonstrates the disease's growing geographic reach and escalating threat to global health (1).

Dengue fever poses a significant challenge in the

Western Pacific region. The region's diverse climatic and environmental conditions create favourable breeding grounds for primary vectors of dengue and *Aedes* mosquitoes. The WHO Western Pacific Office recognises the substantial impact of dengue fever as a health concern within its jurisdiction (2). Malaysia, which is in the Western Pacific, is also affected by dengue epidemics. The presence of *Aedes* mosquitoes is facilitated by the nation's tropical climate and urbanisation patterns, which in turn contributes to dengue transmission.

Malaysia has experienced recurrent dengue outbreaks with varying severity and frequency. In epidemiological week 6 of 2024, there were 22,058 reported dengue cases, representing a 68.5% rise from the 13,094 cases reported during the same period in 2023. There were 10 dengue-related deaths reported by week 6 of 2024, an increase from 9 deaths during the same period in 2023 (2). Kota Kinabalu experienced a notably higher

prevalence of dengue cases compared to other districts in Sabah, accounting for 18.4% of the total cases, with 7,001 reported in 2023. Additionally, there was a significant rise in dengue cases in 2023, with a 17.3% increase compared to the previous year (3)

There is a relationship between rainfall, temperature, humidity, wind speed, and the incidence of dengue in the local area(5). Environmental factors was observed example elevation in temperature (Relative Risk (RR) :1.39; 95% Confident Interval (CI): 1.25-1.55), relative humidity (RR: 1.59; 95% CI: 1.51-1.67 per 5% increment), and precipitation (RR: 1.13; 95% CI: 1.21-1.74) were all positively correlated with an increased risk of dengue (6). Environmental factors such as vacant lots and construction sites are correlated with dengue incidence. As construction sites are dynamic environments, different construction phases may make them suitable for *Aedes* mosquitoes reproduction if potential breeding habitats are constantly created or not eliminated. For instance, water puddles on a variety of surfaces, such as concrete floors in unfinished buildings, are common and have been demonstrated to be attractive breeding habitats for *Aedes aegypti* (7).

The infection rate (36.7%) and transmission rate (83.3%) observed in *Ae.albopictus* were higher than those recorded for the *Ae. aegypti* control colony, which showed rates of 32.8% and 60%, respectively. The virus was detected in 48.5% of fourth instar larvae and 39.1% of female offspring from experimentally infected *Ae.albopictus* (8). In 34 Brazilian municipalities, the House Index values for *Ae.albopictus* were higher than *Ae.aegypti* (9).

This study highlights gaps by using environmental, entomological, and meteorological parameters to develop reliable predictive models for outbreak alerts in Kota Kinabalu, Sabah. While correlations between factors like temperature, vacant lots, and *Ae.albopictus* mosquito populations and dengue cases are established, there is insufficient understanding of why *Ae.albopictus* shows a stronger association with dengue than *Aedes aegypti* and how specific urban structures, like construction sites, influence breeding patterns. Additionally, data limitations due to the Covid-19 pandemic and the need for longer-term studies underscore the challenge of creating a comprehensive model. Complex interactions among climate factors also require further study to improve surveillance and targeted control strategies.

Hence, this study to identify the influence of the dengue surveillance data and meteorological factors with dengue incidence and to determine whether these factors can be used to build a model to predict dengue outbreaks for timely outbreak notification and resource management in Kota Kinabalu.

## MATERIALS AND METHODS

This study used an ecological design involving eDengue data, including vacant lots, construction sites, *Aedes* species, *Aedes* indices, dengue case data, and meteorological parameters, collected from 2016 to 2021. Kota Kinabalu, located in Sabah, was selected as the research site because of the relatively high number of dengue fever cases in Kota Kinabalu in comparison to those in the other districts in Sabah.

Secondary data were obtained from the Sabah State Health Department's dengue system database. Data on confirmed dengue cases were obtained from the Vector Borne Disease Control Programme and meteorological parameters were obtained from the Sabah Meteorological Office. Observations were chosen as they were presented at health facilities with dengue fever and registered with eDengue during the study period from January 2016 to 25 December 2021.

The dependent variable in this study was the number of weekly dengue cases from 2016 to December 2021. The independent variables for this study were entomological data, the weekly number of *Aedes* indices, and the weekly number of *Aedes* species. Environmental parameters were classified as the weekly number of vacant lots and weekly number of construction sites. Meteorological parameters included weekly maximum temperature, weekly minimum temperature, weekly maximum relative humidity, weekly minimum relative humidity, weekly maximum wind speed, weekly minimum wind speed, weekly maximum rainfall, and weekly minimum rainfall.

Microsoft Excel was used for the initial data collection. Dengue surveillance data from eDengue and meteorological parameters were inputted into Microsoft Excel. The analysis was conducted by aggregating daily data into weeks based on epidemiological weeks (with an epidemiological week beginning on Sundays)(10). Data preprocessing for dengue cases, meteorological data, and dengue surveillance data includes checking for missing, duplicate, abnormal, or outlier values. The dengue cases, meteorological data, and surveillance data were valid and complete and were free from missing or duplicate data.

The completed data were analysed using the Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics for the meteorological data, entomological data, environmental data, and dengue cases from 3 January 2016 to 25 December 2021 are described. A correlation test was used for inferential statistics to determine whether there was a link between environmental, entomological, and meteorological parameters in dengue cases. The Pearson correlation coefficient was calculated for data with a normal

distribution, whereas the Spearman rank-order correlation coefficient ( $\rho$ ) was used for data without a normal distribution.

Five assumptions were made to test the dataset using Pearson's Correlation Test. Pearson's Correlation Test is based on the first premise that the two variables being analysed should be assessed on a continuous scale, either at the interval or ratio level. The second hypothesis states that two continuous variables are correlated with one another. The third assumption was that there must be a linear relationship between the two variables to generate a scatter plot. The fourth hypothesis stated that there should be no significant outliers. For Pearson's correlation coefficient test to be valid, the variables had a bivariate normal distribution. This is the fifth assumption: If assumptions three, four, and five were not satisfied, the rank-order correlation coefficient developed by Spearman ( $\rho$ ) was utilised (11). The correlation coefficient quantifies the strength and direction of the association between the two variables. The strength of the association increases when transitioning from 0 to +1 and from 0 to -1. The strength of the association was classified as fair when it fell within the range of  $\pm 0.1$  to  $\pm 0.3$ . A moderate association was observed when the range was  $\pm 0.3$  to  $\pm 0.5$ , whereas a strong association was observed when the range is  $\pm 0.5$  to  $\pm 1.0$  (12).

The correlation coefficient ranges from -1 to +1, with the lower bound representing a negative correlation and the upper bound representing a positive correlation. A correlation coefficient of +1 signifies a positive correlation, indicating that as one variable increases, the other variable exhibits a linear increase. A correlation coefficient of -1 signifies a completely negative correlation, implying that, as one variable experience an increase, the other undergoes a linear decrease. A correlation coefficient of zero signifies the absence of a linear relationship or correlation between the variables

(13).

**Ethical Clearance**

The study was approved by the Ethics Committee of University Malaysia Sabah with approval code JKEtika 1/23 (30) and National Malaysian Research Registry (NMRR ID -23-00058- LZV(IIR)).

**RESULTS**

**Descriptive analysis of the meteorological parameters, entomological parameters, and environmental parameters**

Meteorological parameters were categorised into four groups based on weekly measurements: temperature, wind speed, relative humidity, and rainfall (Table I). The mean weekly maximum temperature recorded was 33.6°C, while the mean weekly minimum temperature was 23.5°C. The mean weekly maximum relative humidity was 85.1% and the mean weekly minimum relative humidity was 76.3%. The mean weekly maximum wind speed was recorded at 10.3 knots, whereas the mean weekly minimum wind speed was measured at 4.9 knots. Mean weekly minimum rainfall was recorded at a rate of 0.1 mm per hour.

The entomological parameters (Table I) were categorised as the weekly number of *Aedes* species, including the weekly number of *Ae.aegypti*, the weekly number of *Ae. albopictus*, and the weekly number of mixed species, including *Ae.aegypti* and *Ae. Albopictus*. The mean weekly number of *Ae.aegypti* was 1.46, whereas that of *Ae. Albopictus* was 9.50. The mean number of mixed species per week was 0.34. The mean weekly *Aedes* indices was 11.3. The environmental parameters were categorised based on the weekly number of vacant lots and the weekly number of construction sites. The mean number of vacant lots per week was 7.07, whereas the mean number of construction sites per week was 1.86.

**Table I: The Descriptive Analysis of the Weekly Meteorological Parameters, Entomological Parameters and Environmental Parameters**

Variables	Category	Mean	SD	Median	IQR	Skewness	Kurtosis	
Weekly Meteorological Parameters	<b>Temperature (°C)</b>							
		Maximum Temperature	33.57	1.03			0.088	0.241
		Minimum Temperature	23.50	0.875			-0.577	2.202
	<b>Relative Humidity (%)</b>							
		Maximum Relative Humidity	85.12	4.837			-0.852	2.469
		Minimum Relative Humidity	76.29	4.87			-0.613	1.466
	<b>Wind Speed (knots)</b>							
		Maximum Wind Speed	10.26	3.48			0.230	0.560
		Minimum Wind Speed	4.93	1.21			-0.089	2.655
	<b>Rainfall (mm/h)</b>							
	Maximum Rainfall			19.10	37.90	1.961	4.670	
	Minimum Rainfall	0.05	0.30			8.424	78.449	
Weekly Entomological Parameters	<b>Aedes Species</b>							
		Albopictus Species	9.50	11.40			2.267	6.478
		Aegypti Species	1.46	2.77			3.645	19.789
		Mix species	0.34	0.76			2.439	5.529

CONTINUE

**Table I: The Descriptive Analysis of the Weekly Meteorological Parameters, Entomological Parameters and Environmental Parameters. (CONT.)**

Variables	Category	Mean	SD	Median	IQR	Skewness	Kurtosis
Weekly Entomological Parameters	<b>Aedes Index</b>						
	Aedes Index	11.30	13.64			2.433	8.149
Weekly Environmental Parameters	<b>Vacant Lot</b>						
	Vacant lot	7.07	6.45			1.190	1.363
	<b>Construction Site</b>						
	Construction site	1.86	6.74			6.828	62.402

**The Correlation Between Meteorological Parameters and Dengue Cases**

Correlation analyses were used to determine independent variables that were significantly correlated with the dependent variable (Table II). Spearman’s correlation was used for weekly maximum rainfall because of the violation of the Pearson’s correlation. For

the meteorological parameters, there was a statistically significant, fair, and negative linear correlation between the weekly maximum temperature and weekly dengue cases ( $r = p < 0.01$ ). Weekly dengue cases and weekly minimum temperature had a statistically significant, fair, and negative linear correlation ( $r = -0.217, p < 0.01$ ).

**Table II: The Correlation Between Weekly Meteorological Parameters, Entomological Parameters, and Environmental Parameters Weekly Dengue Cases**

Variables	Category	Correlation Coefficient	P-value
Weekly Meteorological Parameters	<b>Temperature (°C)</b>		
	Maximum Temperature	-0.283	<0.001
	Minimum Temperature	-0.217	<0.001
	<b>Relative Humidity (%)</b>		
	Maximum Relative Humidity	0.040	0.476
	Minimum Relative Humidity	0.014	0.801
	<b>Wind Speed (knots)</b>		
	Maximum Wind Speed	-0.090	0.114
	Minimum Wind Speed	-0.068	0.228
	<b>Rainfall (mm/h)</b>		
Maximum Rainfall	-0.045*	0.427	
Minimum Rainfall	-0.033	0.565	
Weekly Number of Entomological Parameters	<b>Aedes Species</b>		
	Albopictus Species	0.65	<0.001
	Aegypti Species	0.38	<0.001
	Mix species	0.33	<0.001
	<b>Aedes Index</b>		
Aedes Indices	0.64	<0.001	
Weekly Number of Environmental Parameters	<b>Vacant lot</b>		
	Vacant lot	0.39	<0.001
	<b>Construction site</b>		
	Construction site	0.05	0.338

\*Analyse by Spearman’s Rank Correlation

The correlation between weekly dengue cases and weekly maximal and minimal relative humidity was not statistically significant ( $r = 0.044, p = 0.48$  and  $r = 0.014, p = 0.80$ , respectively). The correlation between weekly dengue cases and the weekly maximum and minimum wind speeds was not found to be statistically significant ( $r = -0.090, p = 0.11$ , and  $r = -0.068, p = 0.23$ ). The weekly dengue cases and weekly maximal and minimal rainfall were not statistically significant ( $r = -0.045, p = 0.43$  and  $r = -0.033, p = 0.57$ , respectively) as in Fig.2.

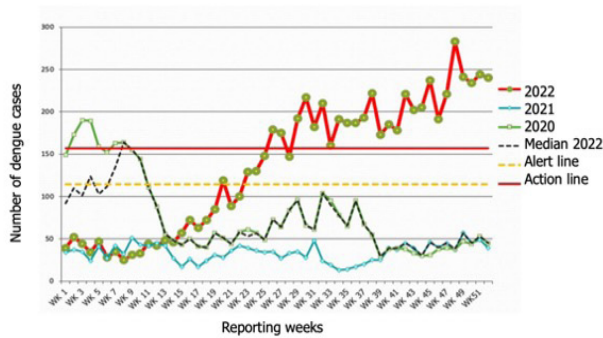
**The Correlation Between Entomological Parameters and Dengue Cases**

The entomological parameters focused on the *Aedes* Species and *Aedes* Indices. The *Aedes* Species were classified into weekly *Aedes albopictus*, weekly *Aedes aegypti*, and weekly mix species, as shown in the table below. A noteworthy and strong positive linear correlation was observed between the weekly count of *Aedes albopictus*, with a correlation coefficient of 0.65 and a p-value of less than 0.01. Table II presents

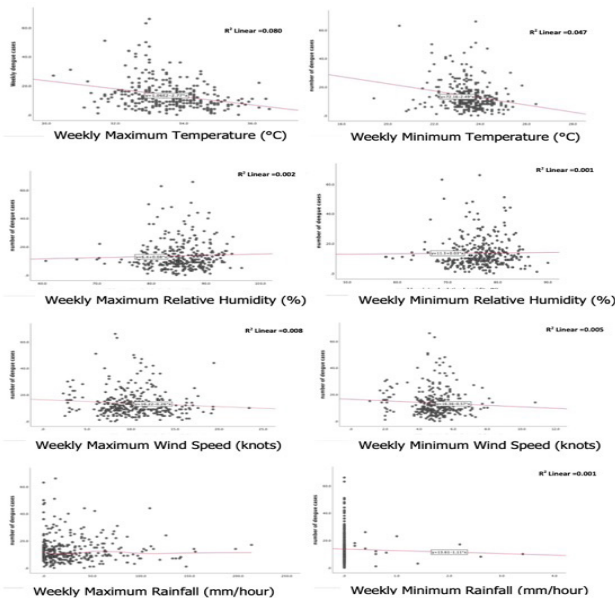
significant findings showing a moderate positive linear correlation between the weekly number of *Aedes aegypti* and the weekly count of mixed species with the weekly incidence of dengue cases ( $r = 0.38, p < 0.01, r = 0.33, p < 0.01$ ). There was a statistically significant linear correlation between the weekly *Aedes* index percentage and weekly dengue cases, with a correlation coefficient of 0.64 and a p-value of less than 0.01 as in Fig.3.

**The Correlation Between Environmental Parameters and Dengue Cases**

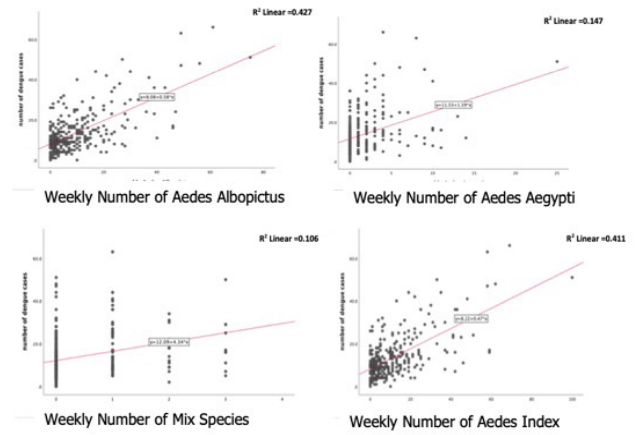
The environmental parameters were classified based on the weekly number of vacant lots and weekly number of construction sites. Table II demonstrates a statistically significant moderate positive linear correlation ( $r = 0.39, p < 0.01$ ) between the weekly number of vacant lots and the weekly incidence of dengue cases. The correlation between the weekly number of construction sites and weekly incidence of dengue cases was not statistically significant ( $r = 0.05, p = 0.34$ ) as in Fig.4.



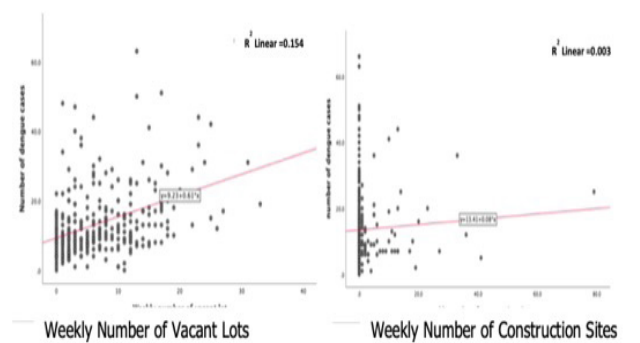
**Fig. 1 : Dengue cases reported weekly from 2020, 2021, 2022, and median 2017-2021 in Kota Kinabalu**



**Fig. 2 : Correlation between meteorological parameters with weekly number of dengue cases, 2016 to 2021, Kota Kinabalu Sabah**



**Fig. 3 : Correlation between entomological parameters with weekly number of dengue cases, 2016 to 2021, Kota Kinabalu Sabah**



**Fig. 4 : Correlation between environmental parameters with weekly number of dengue cases, 2016 to 2021, Kota Kinabalu Sabah**

**DISCUSSION**

**The Correlation Between Meteorological Parameters and Dengue Cases**

The optimal mean temperature range favourable for the development of mosquitoes was lower than 27.5°C (13) while in this study, the mean temperature was 24 °C to 35 °C and exhibited an inverse correlation with dengue incidence. Excessively high impact can result in adverse consequences for mosquito populations or viral replication, which may lead to a decrease in dengue transmission. The extrinsic incubation period was seven days when exposed to temperatures ranging from 32 -35°C (16). Higher temperatures in warm areas could potentially have detrimental effects on the transmission range of viruses, owing to reduced vector survival, reproduction, and immature habitats (15).

Mosquitoes have limited lifespans when exposed to humidity levels below 60%. This is due to insufficient time for completion of the parasitic developmental cycle within the mosquito's body (14). The mean minimal relative humidity was 76% in this study; however, there should be an interaction between humidity, temperature, and availability of water sources to facilitate the creation of suitable breeding conditions (16).

There was no correlation between the maximum and minimum wind speeds and the dengue incidence. The lack of correlation between wind speed and dengue cases can be attributed to dengue transmission, which usually occurs in certain areas, such as neighbourhoods or communities, where the mosquito population is concentrated (18). The influence of wind speed on dengue transmission in confined areas may not be substantial, as mosquitoes can locate appropriate breeding grounds and human hosts, even in the presence of moderate wind speeds (19), particularly in urban areas such as Kota Kinabalu. *Aedes* populations exhibit a proclivity to remain within a 200-meter radius of their respective breeding sites and demonstrate a limited flight range despite exhibiting a propensity for displacement, which can be attributed to various modes of transportation, including buses and cars (14).

The occurrence of drier conditions, as in the result where the average weekly precipitation is 0.05 mm/hour, may potentially facilitate the enhancement of egg resistance to desiccation (20). However, no significant correlation was observed between the incidence of dengue and rainfall. Additional variables such as temperature, humidity, vegetation coverage, and urbanisation trends also exert a significant influence (15). The interactions between these factors can be complex and may overshadow the direct correlation between rainfall and dengue.

### **The Correlation Between Entomological Parameters and Dengue Cases**

There was a positive correlation between *Aedes* mosquitoes and dengue incidence in Kota Kinabalu, because *Aedes* mosquitoes are highly adaptable to urban settings. They find abundant breeding sites, such as those with poor sanitation, inadequate water management, and urbanisation processes that create artificial containers or standing water, thereby increasing the abundance of *Aedes* mosquitoes (21).

*Aedes aegypti* is the primary vector of dengue transmission and has adapted to urban settings (22, 23). However, the outcome revealed that the correlation for *Aedes albopictus* was stronger than for *Aedes aegypti*. This was attributed to a certain factor, such as *Aedes albopictus*, which is known to be more adaptable to different climatic conditions and can survive in a wider range of environments than *Aedes aegypti* (24). *Aedes aegypti* exhibits endophilic behaviour, whereas *Aedes albopictus* is predominantly exophilic and is found in outdoor vegetation (25). The health inspector found it easier to collect larvae outside the premises than indoors, where permission was required to conduct an inspection within the house. These effects may have an impact on larval collection. A high *Aedes* index indicates an increased availability of breeding sites for *Aedes* mosquitoes, thereby facilitating their reproduction and growth. Consequently, this leads to an

increase in the density of mosquitoes that can transmit the dengue virus to humans. An elevated *Aedes* index is typically correlated with an increased probability of dengue occurrence. The same finding was found in Sri Lanka, where (26) the Vietnam (6) *Aedes* Index showed a significant and strong relationship with dengue cases.

### **The Correlation Between Environmental Parameters and Dengue Cases**

There is a positive correlation between vacant lots and dengue incidence, because vacant lots are frequently left unattended or inadequately maintained, resulting in the potential for stagnant water sources to persist for prolonged periods. These regions provide a suitable environment for mosquito growth, in the absence of routine maintenance and adequate drainage (27). The perception of resident actions regarding efforts to eliminate breeding sites in vacant lots affects the dengue transmission (28). The optimal microenvironment for the growth of *Aedes aegypti* can be identified by minimising exposure to sunlight, increasing proximity to vegetation, and shaded and vegetated surroundings, which are frequently found in abandoned areas (29).

Construction sites were not correlated with dengue incidence, even at sites suitable for *Aedes* reproduction, if potential breeding habitats were constantly created or eliminated. For instance, water puddles on a variety of surfaces, such as concrete floors in unfinished buildings, are common and have been demonstrated to be attractive breeding habitats for *Aedes aegypti* (7). However, mosquito prevention methods have been used at numerous construction sites. Construction workers and site managers usually destroy or control mosquito breeding sites. Regular inspections, appropriate drainage, covering or removing stagnant water sources, and larvicidal treatment. These measures limit mosquito density and risk of dengue (30).

Construction sites may attract transient populations of workers; hence, the overall impact on dengue transmission is influenced by factors, such as population density, movement of people within communities, and proximity to other dengue-prone areas (31). Construction sites may provide transient and limited habitats compared to residential areas; therefore, their impact on the number of mosquitoes and dengue transmission may remain minimal (7).

### **Limitation**

Multiple challenges were encountered during the study. Throughout the duration of this investigation, the Covid-19 pandemic transpired, presenting a multitude of obstacles, including the imposition of movement control orders (MCO) throughout the entirety of 2020. These factors may affect individuals seeking medical treatment at hospitals or clinics and have the potential to influence the quality of received samples, particularly in relation to dengue notifications within the eDengue

system. In addition, the data based on surveillance systems may have been underestimated. Second, the dataset involving dengue cases was limited to the period between 2016 and 2021, as instances of dengue cases were not documented in the eDengue system before 2016. Retrieving dengue case data before 2016 is time consuming and requires manual effort.

## CONCLUSION

This study highlights the important connections between meteorological, environmental, and entomological factors and the prevalence of dengue. Correlation with optimal temperature can increase mosquito breeding and viral transmission. There is a clear correlation between entomological parameters such as mosquito density, breeding habits, and the occurrence of dengue. This study revealed that empty lots with increased mosquito populations are more susceptible to dengue outbreaks, potentially owing to inadequate vector control measures or favourable breeding conditions. Hence, it is necessary for governmental authorities, non-governmental organizations, and policymakers to implement nationwide initiatives in conjunction with current policies to address the impending challenges arising from the prevalence of dengue. Therefore, community education campaigns must be conducted to enhance public awareness.

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