ORIGINAL ARTICLE

Sociodemographic and Entomological Factors Associated With Dengue Outbreaks in Sabah

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ABSTRACT

Introduction: Dengue fever has reached an endemic status in approximately 128 countries worldwide, with a significant rise in the frequency of outbreaks. In recent years, Sabah has witnessed a surge in dengue cases, accompanied by a corresponding increase in dengue mortality. The reported deaths rose from 8 in 2017 to 29 in 2018, marking a significant 362% increase within a year. This study aimed to investigate factors associated with dengue outbreaks in Sabah. **Methods:** A cross-sectional study was conducted using the surveillance data from 2017 to 2020 available in e-Dengue, the Malaysian National Dengue Registry. A simple and multivariate logistic regression was performed to determine the association between factors and the dengue outbreak. **Results:** Aged 21–59 have 66 % lower risk odds than 0–12 years old in contributing to dengue outbreaks (95% CI: 0.272–0.406). There are 1.729 times increased risk in students than in unemployed personnel of contributing to dengue outbreaks (95 % CI: 1.565–1.910), with employed personnel having 20.7% lower odds than unemployed personnel of contributing to dengue outbreaks (95 % CI: 0.623–0.767). Urban localities have 44.9% higher odds of developing dengue outbreaks than rural localities (OR: 1.449, 95 % CI: 1.334–1.574). AI ≥ 1% has 78.2% higher odds than AI <1% with a dengue outbreak (95 %: CI: 1.642–1.933). **Conclusion:** Future dengue prevention and control initiatives in Sabah may benefit greatly from this study's sociodemographic and entomological findings.

Keywords: Dengue outbreak; Sociodemographic; Entomological; Sabah

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INTRODUCTION

Dengue fever has reached an endemic status in approximately 128 countries worldwide, with a significant rise in the frequency of outbreaks (1). The most affected regions by dengue outbreaks are America, Southeast Asia, and the Western Pacific, with Asia accounting for about 70% of all dengue cases worldwide (2). Dengue is a notifiable disease in Malaysia and is an epidemic in the country. Malaysia has been continuously battling this deadly mosquito-borne viral disease for many years. The country experienced a series of dengue outbreaks in 1973, with 1,487 cases and 54 deaths, and since then has recorded the highest number of dengue cases in the past four years, with 130,101 cases and 182 deaths (3,4). The vector responsible is Aedes aegypti, and another species is the secondary vector, Aedes albopictus. In Malaysia, all four serotypes of the dengue virus (DENV1, DENV2, DENV3, and DENV4) are known to exist and potentially cause disease transmission (5, 6). In 2019, the country recorded the highest number of dengue cases in the past four years, with 130,101 cases, rising to 61% with 182 deaths, bringing the incidence rate to 390.4 cases per 100,000 population (3). The states that contributed the most significant number of dengue cases in 2018 and 2019 are Selangor, Wilayah Persekutuan Kuala Lumpur, Johor, Penang, and Sabah (7). Sabah, the state in the northern part of Borneo Island, has been included in the fight against dengue fever outbreaks. Dengue cases have been on the rise in Sabah in recent years, and so has dengue mortality, with 29 deaths reported in 2018 compared to only eight deaths in 2017, a 362% increase in a year (8).

Due to the absence of a specific treatment or vaccine for dengue, vector control and prevention measures continue to be the primary means of combating the disease. Vector surveillance is primarily used to determine breeding places and vector density so control and preventive methods can be implemented based on the findings (9). Many factors led to a surge in dengue cases or an outbreak, including increased mosquito breeding grounds, rapid development, a lack of awareness raising, inadequate environmental management, and ineffective control measures (10–13). Despite the measures taken to prevent the spread of dengue fever in Sabah, recent years have seen an alarming rise in fatalities and morbidity. The escalating number of dengue cases poses significant public health implications. Dengue fever not only causes a substantial burden on healthcare systems but also impacts individuals, families, and communities. The increased morbidity and mortality associated with dengue outbreaks necessitate effective and efficient public health responses to mitigate the disease's impact. Therefore, in this study, we aimed to determine the sociodemographic and entomological factors associated with dengue outbreaks in Sabah to assist districts in developing effective planning, vector control programs, and health promotion activities to reduce disease morbidity and mortality.

MATERIALS AND METHODS

This cross-sectional study was conducted in Sabah, Malaysia, in the northern part of Borneo Island. All dengue cases with confirmed seropositive status registered under the Malaysian National Dengue Registry (e-Dengue) between 2017 and 2020 in Sabah, search and destroy activity for an outbreak, and a single case from 2017–2020 was included in this study. The data extracted from e-Dengue has incomplete or duplicate information that was excluded from this study. The outbreak is the reception of the second case registered from the index case within 14 days in the same locality. MOH classifies outbreaks into three categories: controlled outbreaks (first 14 days), uncontrolled outbreaks (more than 14 days), and hotspots (more than 30 days) (14). In this study, all types of outbreaks were included as dengue outbreaks. The names and identifiers of the patients in the registry were anonymized and kept confidential.

Descriptive and inferential statistics were used to present the data in this study. Dengue cases were merged with vector control activities to analyze associated factors through descriptive and inferential analysis. Duplicates were removed, and 13,157 samples were used for analysis. In e-Dengue, dengue cases are classified into sporadic and outbreak; thus, coding for this study is dengue outbreak cases "1" and sporadic cases "0" for both descriptive and inferential analysis. A simple univariable logistic regression analysis was done for the variables, and those with a p-value less than 0.001 were included in the multivariable logistic regression analysis. The assumption was checked, and the once-fulfilled test was performed accordingly. Multivariate analysis was done using the backward logistic regression method. A significant p-value of factors was considered to be associated with the dengue outbreak. Data were transferred into Microsoft Excel for the study database between commencement and completion, and the data analysis was done using Statistical Package for Social Sciences (SPSS) V26.

Ethical Consideration

This study used secondary data removed from personal information and patient identification. The study was conducted following approval by the Medical Review & Ethics Committee (MREC), the Ministry of Health, National Research Medical Registry (NMRR-21-396-58572 (IIR) and Universiti Malaysia Sabah (UMS) (JKEtika 1/21 (14)).

RESULTS

Descriptive Findings of Dengue Cases and Outbreaks in Sabah 2017 to 2020

Table I presents the distribution of dengue cases in Sabah from 2017 to 2020 by type (single cases or outbreaks) among the state's 25 districts. In the last four years, there were 10,190 single cases of dengue fever (65.6 %) and 5,349 outbreaks (34.4%). With 2,433 cases, Kota Kinabalu had the highest number of sporadic cases (74.7%), while Sandakan had the highest number of outbreak cases (56.5%), with 1,400 cases. The other districts with a high rate of outbreaks are Kunak (45.8%), Semporna (41.1 %), Lahad Datu (41.0 %), and Tawau (41.0%), which are all located on the state's east coast. Other districts with similar dengue outbreak trends on the west coast are Putatan (36.1%), Tuaran (28.5%), Papar (23.6%), and Penampang (23.4%). Tongod district has no outbreaks, and all 52 cases are sporadic.

Figure 1 presents the epidemiological week-by-week trend of dengue cases from 2017 to 2020. Every year, the trend is the same: cases are high at the beginning of the month, beginning with week 1 in January, decreasing around week 13, and increasing again from week 29 until the end of the year. However, in 2019, there was a sharp increase in cases from week seven onwards, reporting nearly 200 more cases than in previous years, and towards the end of week 49, reporting 150 more cases. This trend was expected to continue in 2020, with nearly 200 cases reported from week two onward. However, in 2020, cases

Table I : Distribution of Dengue Cases in Sabah 2017 to 2020

Variables	Frequency, n (%)	Type of Case	
		Sporadic, n (%)	Outbreak, n (%)
Kota Kinabalu	3258 (21.2)	2433 (74.7)	825 (25.3)
Tawau	2540 (16.3)	1525 (60.0)	1015 (40.0)
Sandakan	2477 (15.9)	1077 (43.5)	1400 (56.5)
Lahad Datu	1628 (10.5)	961 (59.0)	667 (41.0)
Semporna	1280 (8.2)	754 (58.9)	526 (41.1)
Penampang	453 (2.9)	347 (76.6)	106 (23.4)
Putatan	438 (2.8)	280 (63.9)	158 (36.1)
Kunak	404 (2.6)	219 (54.2)	185 (45.8)
Kudat	354 (2.3)	279 (78.8)	75 (21.2)
Tuaran	340 (2.2)	243 (71.5)	97 (28.5)
Kota Marudu	297 (1.9)	287 (96.6)	10 (3.4)
Keningau	272 (1.8)	245 (90.1)	27 (9.9)
Papar	246 (1.6)	188 (76.4)	58 (23.6)
Beluran	196 (1.3)	159 (81.1)	37 (18.9)
Ranau	176 (1.1)	172 (97.7)	4 (2.3)
Kinabatangan	173 (1.1)	144 (83.2)	29 (16.8)
Tenom	172 (1.1)	131 (76.2)	41 (23.8)
Pitas	172 (1.1)	144 (83.7)	28 (16.3)
Kota Belud	138 (0.9)	133 (96.4)	5 (3.6)
Beaufort	118 (0.8)	108 (91.5)	10 (8.5)
Sipitang	118 (0.8)	107 (90.)	11(9.3)
Nabawan	98 (0.6)	94 (95.9)	4 (28.6)
Kuala Penyu	91 (0.6)	65 (71.4)	26 (28.6)
Tongod	52 (0.3)	52 (100)	0 (0.0)
Tambunan	48 (0.3)	43 (89.6)	5 (10.4)
Total	15,339 (100)	10190 (65.6)	5349 (34.4)

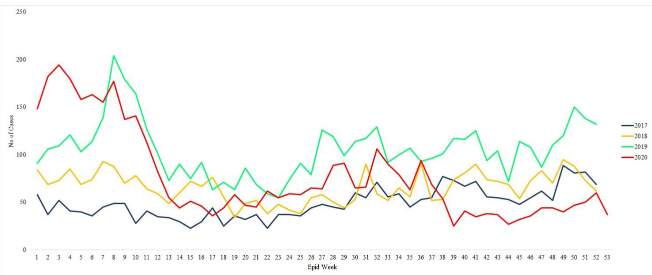

Figure 1 : The trend of dengue cases from 2017 to 2020 by epidemiology week.

remained below 50 from week 13 and gradually increased in week 28, followed by a downtrend pattern with cases below 50 until the end of the year.

Sociodemographic Factors Associated with Dengue Outbreak

The sociodemographic factors associated with the dengue outbreak in Sabah are shown, in Table II. The most cases in the outbreak were recorded among the adolescent age group of 13 to 20 (30.5%), followed by the younger children aged 0 to 12 years old (30.3%), the working age group of 21 to 59 years old (17.7%), and 4.3% senior citizens with the age group of more than 60 years old. Age category showed a significant difference with a p-value <0.001, with 66.6 % of 21–59-year-olds having lower risk odds than 0–4-year-olds contributing to dengue outbreaks (OR: 0.332, 95 % CI: 0.272–0.406). About 50.5 % of the age group > 60 years old also has lower

Table II : Analysis of sociodemographic factors and their association with the dengue outbreak

Variables	Frequency, n (%)	Type of Case					
		Sporadic, n (%)	Outbreak, n (%)	COR (95% CI)	p-value	AOR (95% CI)	p-value
Age (years old)							
0-12	2893 (22.0)	2016 (69.7)	877 (30.3)	1.00	ref	1.00	ref
13-20	3014 (22.9)	2095 (69.5)	919 (30.5)	1.008 (0.903- 1.127)	0.883	0.952 (0.846- 1.071)	0.683
21-59	6228 (47.3)	5125 (82.3)	1103 (17.7)	0.332 (0.272- 0.406)	0.001*	0.692 (0.601- 0.797)	0.001*
> 60	1021 (7.8)	892 (87.4)	129 (12.6)	0.495 (0.447-0.548)	0.001*	0. 393 (0.329- 0.469)	0.001*
Gender							
Male	7517 (57.1)	5956 (79.2)	1561 (20.8)	1.00	ref	1.00	ref
Female	5639 (42.9)	4172 (74.0)	1467 (26.0)	0.745 (0.687-0.809)	0.001*	0.791 (0.725- 0.862)	0.001*
Nationality							
Malaysian	12334 (93.8)	9489 (76.9)	2845 (23.1)	1.00	ref	-	-
Non-Malaysian	822 (6.2)	639 (77.7)	183 (22.3)	0.955 (0.806-1132)	0.596	-	-
Occupational Status							
Unemployed	4104 (31.2)	3197 (77.9)	907 (22.1)	1.00	ref	1.00	ref
Employed	5193 (39.5)	4342 (83.6)	2121 (16.4)	0.691 (0.623-0.767)	0.001*	0.834 (0.736-0.945)	0.004*
Student	3859 (29.3)	2589 (67.1)	1270 (32.9)	1.729 (1.565-1.910)	0.001*	1.353 (1.220- 1.527)	0.001*
Locality Status							
Rural	7136 (54.3)	5279 (74.0)	1857 (26.0)	1.00	ref	1.00	ref
Urban	5995 (45.7)	4824 (80.5)	1171 (19.5)	1.449 (1.334-1.574)	0.001*	1.563 (1.434- 1.703)	0.001*

Abbreviation: COR, crude odds ratio, AOR, adjusted odds ratio, designation of locality status (urban or rural) was according to the Malaysian Department of Statistics definitions of the urban and rural, total of 13,157 samples analysed.

odds of risk (OR: 0.495, 95 % CI: 0.447–0.548) than 0 to 12 years old in contributing to dengue outbreaks.

26.0% of females contributed to the dengue outbreak, while sporadic cases were 74.0%, with an overall total of 5,539 female cases. Males have 25.5% lower odds than females of contributing to dengue outbreaks (OR: 0.745, 95 % CI: 0.687–0.809). There are 1.729 times more risks in students than unemployed personnel in contributing to dengue outbreaks (95% CI: 1.565–1.910). However, employed personnel have 30.9% lower odds than unemployed personnel of contributing to the dengue outbreak (OR: 0.691, 95 % CI: 0.623–0.767). Urban localities have 44.9% higher odds of developing dengue outbreaks than rural localities (OR: 1.449, 95 % CI: 1.334–1.574). Nationality did not show any association with the dengue outbreak. The findings remained the same in univariable and multivariable analyses.

Entomological Factors Associated with Dengue Outbreak

The overall number of recorded AI ≥1% was 43.4 %, with AI≥1 in outbreak areas (28.9%), compared to 71.1% of AI ≥1% in sporadic cases. The pattern is almost similar in the Breteau Index, whereby overall BI ≥5% (22.5 %) with recorded BI ≥ 5% in the outbreak area (28.9%) and 71.1 % of BI ≥5% in sporadic cases. Nevertheless, the overall CI ≥10 % was only 2.0 %, with CI >10 % (18.4 %) and 23.1 % of CI ≥ 10 % recorded in sporadic cases. Entomological factors that show significant differences using simple logistic regression are the Aedes index and Breteau index, AI ≥ 1 has 78.2% higher odds than AI <1 with a dengue outbreak (OR: 1.782, 95% CI: 1.642–1.933), followed by BI ≥ 5 is also found to be 1.501 times more likely with a dengue outbreak than BI< 5 (95% CI: 1.369–1.647). Aedes albopictus is the most abundant species, with 634 (61.5 %), followed by Aedes aegypti (23.2%) and 15.5 % of the mixture of Aedes albopictus and Aedes aegypti. The univariable analysis did not show the significance for Aedes breeds. The findings remained the same in univariable and multivariable analyses (Table III).

DISCUSSION

MOH's national dengue statistics show that Sabah, a Malaysian state on Borneo Island, is also seeing an increase in dengue incidence and a rise in dengue-related mortality (15, 16). The reported cases per week follow a seasonal pattern every year except for 2020,

Table III : Analysis of entomological factors and their association with the dengue outbreak

Variables	Frequency, n (%)	Type of Case					
		Sporadic n (%)	Outbreak n (%)	COR (95% CI)	p-value	AOR (95% CI)	p-value
Aedes Index							
AI< 1%	7452 (56.6)	6070 (81.5)	1382 (18.5)	1.00	ref	1.00	ref
AI≥ 1%	5704 (43.4%)	4058 (71.1)	1646 (28.9)	1.782 (1.642-1.933)	0.001*	1.815 (1.649-1.998)	0.001*
Breteau Index							
BI< 5%	10198 (77.5)	8025 (78.7)	2173 (21.3)	1.00	ref	1.00	0.009*
BI≥ 5%	2958 (22.5)	2103 (71.1)	855 (28.9)	1.501 (1.369-1.647)	0.001*	1.157 (1.038-1.289)	-
Container Index							
CI< 10%	12889 (98.0)	9910 (76.9)	2979 (23.1)	1.00	ref	-	-
CI≥ 10%	267 (2.0)	218 (81.6)	49 (18.4)	0.748 (0.547-1.022)	0.068	-	-
Aedes Species							
Aedes albopictus	634 (61.5)	488 (77.0)	146 (21.3)	1.00	ref	-	-
Aedes aegypti	239 (23.2)	188 (78.7)	51 (21.3)	1.292(0.806-2.070)	0.287	-	-
Aedes albopictus & aegypti	158 (15.3)	117 (74.1)	41 (25.9)	1.103 (0.769-1.582)	0.594	-	-

Abbreviation: COR, crude odds ratio, AOR, adjusted odds ratio

when dengue incidence in Sabah began to decline after week 13. This pattern is not only for Sabah but also for Peninsular Malaysia. Movement restrictions were imposed on Malaysia during this period due to the COVID-19 pandemic. Less movement of people, schools and parks being closed, public gatherings being prohibited, and curfews being enforced are contributing factors to the decrease in the incidence of the disease. People stayed home during this period, and many became creative by gardening or cleaning their homes daily, which could have contributed to the decrease in cases (17). Similar trends were discovered in Penang, with the possible cause identified as the presence of Aedes albopictus in the environment during the lockdown period, which may have caused the active biting of Aedes upon mobilisation of people to resume as usual. It was also discovered that no Aedes aegypti breeding was identified at home during the lockdown period (18).

Other than that, Sabah has two seasons, dry and wet seasons, whereby Northeast Monsoon and Southeast Monsoon. Between November and March, the Northeast Monsoon brings cooler temperatures and less rainfall, whereas the Southwest Monsoon brings warmer temperatures and more significant rainfall between May and September. Some studies say that Aedes mosquitoes hatch faster in higher temperatures, and the egg lasts about eight months during the colder season (19–22). Age is a common factor studied in dengue incidence and outbreak. The age group of 21 to 59 years showed lower odds of dengue outbreaks compared to the age group of 0- 12 years old. Children are among the vulnerable group with dengue infection; previous studies in Sabah showed that severe dengue is high among those under 19 years old (15). Similar results were found in an Indian study of children under ten exposed to dengue at least once while living in a dengue epidemic area (23).

Students were found to have a high risk of being associated with a dengue outbreak. This finding contrasts with studies that found that working adults, especially outdoors probably the cause of dengue outbreaks to occur (24,25). Nevertheless, research on dengue knowledge, attitude, and practice among school and college students found that these groups had a greater risk of developing a dengue outbreak (26,27). An outbreak is more likely to occur when mosquitoes are abundant and in a favourable environment. Apart from that, another possible explanation is the time difference between students travelling to school in Sabah between 6 a.m. and 6.30 a.m. during the mosquito-biting period. They could contract infection while waiting for the school bus on their way to school. (28). Thus, it is critical to pay more attention to these findings so that the disease burden can be effectively reduced among these individuals.

The study findings also indicated that males have a protective association with dengue outbreaks, suggesting they are less likely to contract the disease than females. Previous studies in Sabah's Keningau and Kota Kinabalu districts have found females more susceptible to dengue outbreaks (28,29). Females, particularly those at home, are likely to like gardening plants in flowerpots, and they may be more creative in using unusual materials like tyres and plastic containers. However, a lack of awareness of vector breeding sites may result in mosquitoes laying eggs in gardening items such as flowerpot holders, flowerpots, and plant watering cans (30,31). As a result, individuals risk becoming infected with dengue infection because of their gardening activities, which could lead to an outbreak.

In both univariate and multivariate logistic regression, urban areas were identified as having a higher likelihood of contributing to dengue outbreaks than rural areas. However, a previous study done in Sabah based on dengue cases from 2010 to 2016 suggested that dengue epidemics are becoming more common in Sabah, both in urban and rural areas (32) and keeping in mind that Sabah has rapidly undergone urbanization, especially in the major cities such as Kota Kinabalu, Sandakan, Tawau, and Lahad Datu. Some studies reported an upsurge in dengue transmission due to increased urbanization (33–35). The fact that Aedes, the vector, can coexist with humans inside or outside the house has increased the likelihood of dengue infection spreading in densely populated urban areas. Studies have shown that viraemic individuals may easily travel from urban to rural areas and vice versa (35).

While the Aedes index shows the Aedes positivity rate of houses, the Breteau index shows the number of positive containers among the houses inspected. Aedes Index ≥1 % and Breteau Index≥5 % are strongly associated with dengue outbreak cases in Sabah. The findings are comparable to a study conducted in North Sumatra, Medan, in which the Aedes index was also found to have a strong relationship with dengue infection (36). This is similar to a study in Sri Lanka, where the Breteau index showed a significant association in predicting dengue outbreaks (37). Adult Aedes indices were not a good predictor of a dengue outbreak in a study conducted in the United States, as the indices did not have a strong association with developing outbreaks (38). However, this study's findings of a high Aedes index coincide with an increase in dengue outbreaks in Sabah during the last four years.

Lack of responsibility in keeping the home mosquito-free is crucial in preventing dengue outbreaks. Despite excellent community awareness and knowledge of dengue, inadequate preventive practices do not reduce incidences (39–41). It is indeed essential that every household be empowered to play their role in dengue prevention by cleaning up their houses once a week, both indoors and outside. Container indexes were not associated with dengue outbreaks in this study. The findings are consistent with infection sources outside the home that were probably addressed by community action (38). Thus, targeted public health educational interventions can significantly reduce larval indicators, preventing dengue transmission (42).

There are limitations to this study. As this is secondary data extracted from the MOH e-dengue registry, data availability is highly dependent on manual passive notification from data providers and active case findings. Even though this study was unable to conduct further analysis on the association of Aedes species with their breeding locations due to a lack of sample size and the education status of the community, the findings of the trends in dengue cases and other associated factors may aid in dengue prevention and control. However, more research should be done to address this limitation.

CONCLUSION

In conclusion, understanding and preventing dengue transmission are crucial for reducing the disease burden in Sabah. This study identified important factors associated with dengue outbreaks, including females, children under 12 years old, and students. The findings have significant implications for community-based dengue prevention efforts. Urban areas were found to have a higher risk of outbreaks, and the Aedes index and Breteau Index proved effective in assessing dengue risk.

To enhance dengue prevention, it is recommended to implement health education and promotion programs that actively engage and empower women. By enhancing their knowledge, awareness, and practices, women can play a vital role in preventing dengue. Additionally, close collaboration with the state education and health departments is essential to ensure Aedes-free educational institutions and provide a secure learning environment. This requires sustained efforts and commitment from organizations and authorities working together to achieve optimal outcomes in dengue prevention.

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