ORIGINAL ARTICLE

Relationship Between Frequency of Fogging and Dengue Cases in Sandakan, Sabah in 2011 to 2018

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ABSTRACT

Introduction: Typical response to dengue fever cases is the fogging activity to target the adult mosquito population. This process must be performed at a time period coinciding with the mosquito life cycle. However, there is no evidence to confirm the efficacy of fogging in preventing mosquito bites, and this study would examine the connection between the incidence of fogging in Sandakan and the number of dengue cases recorded. **Materials and Methods:** Dengue surveillance data were derived from the e-Dengue database system (version 2.0). This analysis looked at the fogging level of every locality in 15 zones and at the incidences of dengue in Sandakan. We collected the data from Sandakan Health District Office. The operation data has been combined with each location. The level of fogging was dependent on the amount of region affected and the year, which was then converted to monthly results. Data was obtained using a regression analysis, and analyzed. **Results:** Results indicate that the frequency of fogging increases with dengue cases. A statistical result shows that more fogging activities resulted in greater numbers of dengue cases. A correlation coefficient of 0.75 suggests the frequency of fogging and the incidence of dengue fever are positively correlated. **Conclusion:** Overall, there is a linear pattern of positive data association. This result shows that the higher the fogging frequency, the higher the incidence of dengue fever.

Keywords: Dengue fever, Fogging frequency, No of dengue cases, Sabah

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INTRODUCTION

Dengue virus, a single-stranded RNA virus of the family Flaviviridae, is currently the most prevalent human arboviral infection in the world. It was estimated that from the 50-100 million cases reported annually, approximately 500,000 cases progress to Dengue Haemorrhagic Fever (DHF) (1-3). Mobilisation of humans, rapid development and climate change are the main factors for the geographic expansion of both mosquitoes (4-5). Dengue virus is classified from the flavivirus genus and has four main type of serotypes which is DEN 1, DEN 2, DEN 3 and DEN 4 (6). This leads to severe febrile disease and sometimes to deadly haemorrhagic complications (7).

Since dengue vaccine is not available, transmission prevention of this disease relies solely on vectorontrol program (8-9). Vector control programs include mechanical, chemical and biological control (10). Mechanical control is performed when the public health official visits households and remove any potential container for the mosquitoes to lay eggs. This method is easy but time consuming and requires large mobilisation of human. Chemical vector control by using insecticides was the main strategy (10) and applied by the most countries to reduce the burden of transmission (11-12), however over the years the development of insecticide resistance has been recorded (3). This resulted in failure of the mosquito control programs to achieve their target therefore increasing the risk of transmission. Recently, Wolbachia mosquitoes were developing using the Sterile Insect technique (SIT) as a biological control (10). Recently it has been suggested that that the most effective vector control was to target the production of breeding sites instead of water-holding containers as it was cost effective and can be easily performed by individuals. However this method needs the awareness of the community to clean up any possible breeding site. In urban area it is difficult to mobilize the community because of the lack of understanding of dengue risk and

and the impact of the action of the residents in preventing dengue by eliminating the potential breeding sites.

MATERIALS AND METHODS

This study was conducted by compiling the data from 2011 to 2018 from the Sandakan Health District on fogging and dengue. This study involved three phases; I identification of fogging frequency from 2011 to 2018 in 15 zones in Sandakan; (ii) identification of dengue incidence in each locality; and (iii) determination of the relationship between fogging frequency and dengue incidence. Ethical approval for this study has been obtained from the National Medical Research Registry (NMRR). Ethical approval reference number of the Medical Research & Ethics Committee (MREC): NMRR-17-3503-38568. Secondary data from public domains that do not contain information on human subjects was also collected from the Vector Borne Disease Division of the Sandakan District Health Department and permission to access the data was obtained.

The association between the number of dengue cases and the frequency of fogging was investigated with a cross-sectional analysis. Data was gathered from the Sandakan Health District Vector Unit. The data was obtained by passive surveillance and involved two key data: (1) the frequency of fogging in each locality of every region in Sandakan over the past 8 years, and (2) the number of dengue cases over the past 8 years. The data collection includes a baseline of mosquito data in order to construct a potential monitoring system for infection. The findings of the analysis were determined as having a causal relationship with the existing vector control programme.

Study Population

This study was located in the area of Sandakan. Sandakan is located in Northern Borneo with an area of 2,266 km2. There are 15 localities in this district and 620 of them are covered by this district. Sandakan has experienced a high rate of urbanisation and a high prevalence of dengue. The population of Sandakan is 518,200 of people, 326,800 of which are local residents, and 191,400 of those are non-local residents. The location is an area with high-rise buildings, terrace houses, and traditional village houses. Due to the high number of non-local villagers, many squatters have illegally developed within the city which causes the high number of dengue cases.

Data Source, Integration and Management

Dengue surveillance data were derived from the e-Dengue database system (version 2.0). The purpose of this study was to determine the frequency of fogging and the dengue cases in Sandakan throughout the past eight years. Both data were obtained from the Sandakan District Health Office. The dengue data did not include the patient data. Fogging frequency was measured by area and year. The characteristics for each locality were identified to establish patterns and identify the locality with the highest prevalence of fog throughout the year. The incidence of dengue was calculated for every location and over time. The numbers of dengue cases, combined together, were used to determine the rate of incidence. Data is shown in a box and whisker plot, which shows the frequency of food poisoning and dengue cases. An analytical observational study was conducted that included cross sectional analysis. Data was collected and analysed using analysis of variance. The relationship between the frequency of dengue cases and the incidence rate was assessed with a simple linear regression model. It is presented in the form of such a scattered plot and the value added over eight years is also shown.

RESULTS

Identify the Frequency of Fogging and Dengue Cases Based on the Locality in Sandakan, Sabah.

(i) Frequency of fogging: Data were collected between 2011 and 2018 to see the frequency of fogging distributions in each area. The box plot graph was presented for a deeper understanding of trend (Figure 1). The fogging frequency only centred on areas with single cases or in a dengue epidemic areas. The average frequency of fogging was determined per year on the basis of position. In general, in each area, the pattern increased the amount of fogging. In 2012 the lowest fogging frequency occurred. This was because of the smaller number of dengue events. oIn 2014, the fogging frequency increased rapidly as well as the number outbreak localities also increased.

The minimum number of fogging frequency in each area was 1 and the maximum frequency is 15 times per location each year (Figure 1A). This suggests that the fogging was replicated nearly every month. Space treatment is normally performed 2-3 days for 10 days where rapid reduction is required, particularly in hotspot areas where outbreaks last longer than 30 days. Further application is rendered once or twice a week to effectively eliminate adult mosquitoes. It was specifically

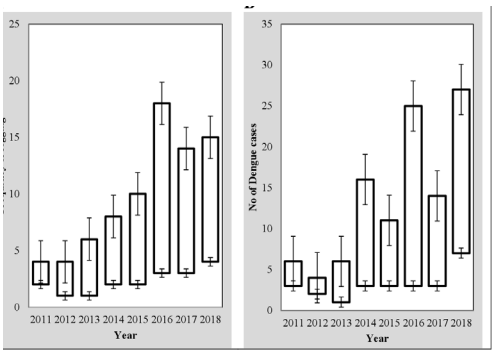

Figure 1: Pattern of frequency of fogging (A) and number of dengue cases (B) in average in Sandakan, Sabah from 2011 to 2018

noticed that there was a large level of fogging in 2016 due to the high number of outbreaks and confirmed cases.

(ii) Numbers of dengue cases: The frequency of dengue cases has been related to the distribution of cases in each locality. The incidence was estimated by area and year from 2011 to 2018 and displayed in the form of a box plot. This indicates the distribution and trend of cases during the year. The box plot analysis (Figure 1B) indicates that the frequency of dengue cases was equally distributed with the number of sites. The largest number of cases was in 2016, preceded by 2015. The lowest number of cases came in 2012. This indicates that in recent years, Sandakan has a high incidence of dengue cases among the community, which may indicate the lack of specific care and vaccination for dengue fever (18). Many control mechanisms have been placed in place to minimize the burden of dengue transmission; however, the number of cases is still growing. A total of 2068 cases of dengue fever were registered between 2011 and 2018. (8 years). From 2012 onwards, reports of dengue fever rose exponentially. However, there was a small decline in recorded cases in 2012 and the maximum registered cases in 2016, with 509 cases reported.

Figure 1(B) indicates that the minimum number of cases reported per location per year was 1 case and the maximum number of cases was 22 cases. There is a persistent trend in the distribution of cases per year. Dengue fever is very widespread in all areas of Sandakan. This indicates that dengue fever has expanded to more areas, resulting in more dengue cases reported. The distribution of cases can be related to the patient's mobility during the viremia phase. Usually, the viremia phase begins 2-3 days before the start of symptoms and lasts for 4-5 days through acute illness. People that are in the viremic stage can bite the mosquito and this is named person to transfer of mosquitoes. This process would result in the spread of dengue fever as the host, *Ae. aegypti* and *Ae. albopictus* acts as a vector for the transmission of the virus from human biting (22). The biggest issue here is the potential of fogging activity to eliminate the adult mosquito population.

The Relationship Between Frequency of Fogging and number of Dengue Cases

A Pearson correlation analysis was conducted to establish the relationship between fogging incidence and overall dengue fever cases in Sandakan from 2011-2018. The study of the scatter plot in Figure 2 reveals that the level of fogging increases with dengue cases. A significant value of <0.05 demonstrated a significant association between the level of fogging and the occurrence of dengue fever. The correlation coefficient of 0.75 suggests a clear positive correlation between fogging frequency and dengue fever frequency. Overall, 78.40 percent of the fogging incidence can be clarified by dengue cases for 8 years of evidence. There is a linear sequence of positive data correlation. Visually, there have been no significant outliers for all the years. This

		Frequency of fogging	No of dengue cases
Correlation coeeficient	Frequency of fogging	1.000	0.784
	No of dengue cases	0.784	1.000
Sig (2 tailed)	Frequency of fogging		0.000
	No of dengue cases	0.000	
N	Frequency of fogging	96	96
	No of dengue cases	96	96

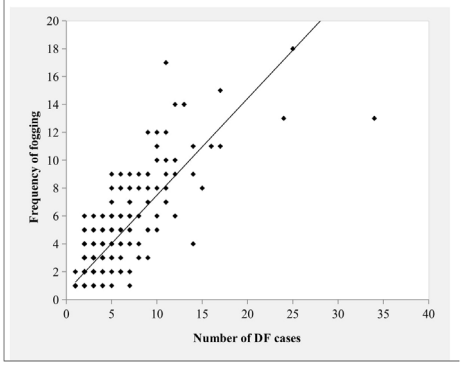

Figure 2: Correlation coeeficient and Scatter plot analysis between frequency of fogging and the number of dengue cases in Sandakan Sabah from 2011 to 2018.

result indicates that the higher the dengue reports, the higher the fogging frequencies.

DISCUSSION

Based on the data and findings, the highest occurrence of fogging and the number of recorded cases was reported in 2016 and increased last year. While the fogging operation was highly anticipated to eliminate adult mosquitoes, it is still lacking in several aspects. Over the years, dengue preventive and control strategies in Sandakan have struggled to decrease the amount of dengue incidents, perhaps due to lack of community involvement and sufficient funding. Recent studies have found that fogging has had no effect on eliminating adult mosquitoes (18). Around the same period, though, space spraying often greatly decreases the amount of adult mosquitoes and reduces larval intensity (14). An study performed by Bowman in 2016 (14) assess the efficacy of residual outdoor spray was recorded by adult Ae. albopictus decreased by 13.90% (95 percent CI – 21.86,-5.94) in the intervention community. Prevention and control intervention: health education and fogging also lowered the larvae index. A research in South Sulawesi also found that fogging is successful in controlling dengue cases (15). While this control programmed would decrease adult mosquitoes quickly when it is sprayed directly into the infected area when opposed to other methods, mosquitoes that arise after initial insecticide treatment may still be infective. It may be inferred that the range of the insecticide is not far enough or that the adult mosquito can pass through the smoke of the space treatment.

Gubler's (2011) study also claimed that the use of insecticide spraying using ULV technology, which was initiated in the early 1970s, has totally collapsed as the world has become endemic to dengue cases (13). In addition, the effect of fogging operation was dependent on other variables such as wind speed, precipitation, temperature, environment, methodology and, most notably, the form of insecticide used. Fogging operations involved high costs, including diesel, insecticide rates and repair of the fogging system. In addition, the repeated use of insecticide contributes to health problems, especially for staff. Insecticidal tolerance to adult mosquitoes must also be considered. Space spraying depends on the use of insecticides, especially pyrethroid spraying, although high levels of pyrethroid resistance have already been observed (14). DDT and other insecticides have already been detected around the world and are expected to continue to develop resistance, which may impact the efficacy of space spraying (15).

Consequently, a different strategy and alternative strategies can be adapted to the understanding that the existing 'failed' system of minimizing the spread of dengue fever. However, due to the weakness and lack of specific care, the current control mosquito vector control is still effective. Besides, there is no reliable evidence that confirms either of the available control strategies, including space spraying. Given the frequency of fogging that did not adequately regulate the epidemic, this technique was found to be effective for rapid reduction of transmission. It is advised where the reduction of the source has not reduced the number of adult mosquitoes. The research in Gowa City, South Sulawesi Indonesia by Muhammad Taslim also confirms that fogging is successful in controlling the transmission of dengue fever (16). Nevertheless, the population would not support indoor fogging due to the odor of the insecticide and the concern about interaction with the insecticide and the equipment inside the house. Many residents refuse fogging inside the house due to insecticide residues. That's why there is little coverage of fogging operation in certain places, particularly in terrace houses, high-rise buildings and condominiums. The success of fogging is often connected to the deployment technique, the necessary fogging equipment and the appropriate operator-training programme. Strong scheduling and management of fogging is also needed to improve the efficacy of this process. Planning and management consists of a well-trained team in the preparation of fogging machines, in particular in the treatment and preparation of insecticide mixtures, as the dosage of mixture between insecticide and diesel is necessary to ensure the coverage of 200 metres of radius in one locality. As part of an integrated vector management approach, fogging operation is best applied with some other tool that is complemented by Ultra Low Volume (ULV) because there is no data to indicate fogging behaviour as a single monitoring action. Furthermore, this operation is only carried out in a specifically defined region for a short period of time where there are cases registered, such as preventive efforts in hotspot areas or when the outcome of entomological surveillance such as the Ovitrap Index (OI) is more than 10%.

A research in Chiang Mai showed that space spraying has a greater knockdown and killing of mosquitoes when applied inside, rather than outside, the building (17). This is attributed to the lethal concentration of insecticides that dilute with groundwater, which decreases the exposure period of outdoor mosquitoes. If room spraying is practised according to spraying requirements, i.e. both windows and doors are closed for 15 minutes, the concentration of insecticides is right and even fogging delivery has increased efficiency in minimising the mortality of adult mosquitoes. The effectiveness of space spraying is often connected to the skill and temperament of spray men, the accessibility of private premises, including accommodation, the environmental quality, the fair and appropriate coverage of the sprayed field and the acceptability of the populations. Many of the sprayed premises are only in the outside areas and around the houses; men have little entry to the assets owing to the doors being closed. This is because the door of the entrance has been closed, or nobody is at home, and often people do not encourage spraying inside their building. Most shot mosquitoes would not be subjected to lethal amounts of insecticides owing to space spray distance and would only be exposed to sublethal doses of insecticides. This can be presumed as to why fogging activity is not successful in controlling dengue cases in Sandakan.

CONCLUSION

There was a clear positive correlation between the frequency of fogging and the number of dengue cases. This implies that the greater the occurrence of dengue incidents, the higher the frequency of fogging in one area each year. It can be inferred that fogging was not very successful for a variety of reasons. The main reason to concern is the dependence on fogging practises, lack of community participation and susceptibility to mosquitoes. In order to reduce the burden of transmission of dengue cases in Sandakan, more research should be carried out to evaluate the vector control programme that has already been introduced. This includes the insecticidal resistance of the mosquito, the application technique of the fogging machine and the dispersion of the chemical in the surroundings.

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REFERENCES

1. Ocampo CB, Julieth N, Carabalн M, Alexander N, Osorio L. Reduction in dengue cases observed during mass control of Aedes (Stegomyia) in street catch basins in an endemic urban area in Colombia. Acta Tropica. 2014; 132: 15-22.
2. Mendonca BAA, de Sousa ACB, de Souza AP, Scarpassa VM. Temporal genetic structure of major dengue vector *Aedes aegypti* from Manaus, Amazonas, Brazil. Acta Tropica. 2014: 134, 80-88.
3. Liu-helmersson J, Quam M, Wilder-smith A, Stenlund H, Ebi K. Climate Change and Aedes Vectors : 21st Century Projections for Dengue Transmission in Europe. EBioMedicine. 2016; 7: 267–277.
4. Bharati M, Saha, D. Acta Tropica Assessment of insecticide resistance in primary dengue vector , *Aedes aegypti* (Linn .) from Northern Districts of West Bengal , India. Acta Tropica. 2018; 187(July): 78–86.
5. Murhekar M, Joshua V, Kanagasabai K, Shete V, Ravi M, et al. International Journal of Infectious Diseases Epidemiology of dengue fever in India , based on laboratory surveillance data , 2014 – 2017. International Journal of Infectious Diseases.2018; 2014–2017.
6. Xiaoliang M, Hansen A, Hanson-easey S, Xiang J, Cameron S, et al. Perceptions of capacity for infectious disease control and prevention to meet the challenges of dengue fever in the face of climate change : A survey among CDC staff in Guangdong Province , China. Environmental Research. 2016; 148: 295–302.
7. Asam M, Chandor-proust A, Dauphin-villemant C, Poupardin R, Jones CM, et al. Molecular mechanisms associated with increased tolerance to the neonicotinoid insecticide imidacloprid in the dengue vector Aedes aegypti. Aquatic Toxicology. 2013; 126: 326–337.
8. Christofferson RC, Mores CN. A role for vector control in dengue vaccine programs. Vaccine. 2015; 33(50), 7069-7074.
9. Dias WO, Wanner EF, Cardoso RTN. Mathematical Biosciences A multiobjective optimization approach for combating *Aedes aegypti* using chemical and biological alternated step-size control. Mathematical Biosciences. 2015; 269: 37–47.
10. Dieng H, Satho T, Farrahana N, Suradi B, Abang F, et al. Presence of a predator image in potential breeding sites and oviposition responses of a dengue vector, Acta Tropica. 2017; 176(August): 446–454.
11. Deming R, Manrique-Saide P, Barreiro AM, Cardena EUK, Che-Mendoza A, Jones B, Lenhart A. Spatial variation of insecticide resistance in the dengue vector Aedes aegypti presents unique vector control challenges. Parasites & vectors. 2016; 9(1), 67-75.
12. Gubler DJ. Prevention and Controlof *Aedes aegypti* Borne Disease: Lesson Learned from Past Successes and Failures. Asia Pasific Journal Molecular Boiology and Biotechonolgy.2011; 111-4
13. Kudom AA. Entomological surveillance to assess potential outbreak of *Aedes*-borne arboviruses and insecticide resistance status of Aedes aegypti from Cape. Acta Tropica. 2020; 202(November 2019), 105257.
14. Bowman LR, Donegan S, McCall PJ. Is dengue vector control deficient in effectiveness or evidence?: Systematic review and meta-analysis. PLoS Neglected Tropical Diseases. 2016; 10(3), e0004551.
15. Muhammad Taslim A, Arsunan Arsin, Hasanyddin Ishak, Sudirman Nasir. Effect of Health Education, Abate and Fogging to Larvae Index in Endemis Area at Gowa District, South Sulawesi Indonesia, International Journal of Science: Basic and Applied Research (IJSBAR). 2017; Volume 33, No 2: pp 10 -14.
16. Carzoli AB, Of M, Health P. Utilizing Historical Mosquito Surveillance Data To Investigate The Efficacy Of Municipal Fogging In by Presented to the Faculty of the Graduate School of The University of Texas at El Paso of the Requirements, (August). 2017.
17. Plernsub S, Saingamsook J, Yanola J, Lumjuan N, Tippawangkosol P, Walton C, Somboon P. Temporal frequency of knockdown resistance mutations, F1534C and V1016G, in *Aedes aegypti* in Chiang Mai city, Thailand and the impact of the mutations on the efficiency of thermal fogging spray with pyrethroids. Acta Tropica. 2016; 162, 125-132.