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Fogging Effectiveness Based on Time and Location of DHF Cases (Study in Sleman Regency)

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Abstract

Dengue fever is a viral infection transmitted through the bite of the Aedes mosquito. Dengue fever is a public health problem worldwide, including in Indonesia. The increase in dengue cases is closely related to the presence of mosquito vectors. The prevention of dengue outbreaks is by fogging focus. Until now, there is no method to evaluate the effectiveness of focal fogging, yet many suspect that fogging focus is less effective because the incidence of DHF tends to increase over several decades. The study aims to find a method to evaluate the effectiveness of fogging with a spatial-temporal approach. It is an observational study using data on the incidence of DHF along with the date of illness, coordinates of DHF patients, and the date of fogging obtained from the District Health Office. Data processing is by ArcMap 10.5. Determination of the time limit and extent of protective fogging is based on the provision that if in the buffer area within a radius of 200 meters, there is more than one case of DHF on days 4-21 after the patient has a fever, then fogging is declared ineffective. There were 1,070 cases of DHF in 2008-2013 in Sleman Regency. 773 (72.24%) cases were fogged, while 290 were not. Of the 773 fogged cases, 59 (7.63%) were within the time and place of fogging protection. It means that the effectiveness of fogging in Sleman Regency reached 92.37%. Overall, there were 59 of 1,070 (5.5%) DHF cases came from ineffective fogging. By spatio-temporal approach, the fogging focus has been quite successful in suppressing the incidence of DHF in the Sleman Regency. In the future, it is necessary to consider fogging is focused other than in the patient's house and surroundings.

Introduction

One of the viral infectious diseases that is still a public health problem worldwide is dengue hemorrhagic fever (DHF). The geographic distribution of DHF was originally only in the tropics but has now spread to subtropical areas in America (Stephenson et al., 2022) and Europe (Ahmed et al., 2020; Gossner et al., 2022). The widespread of DHF occurs not only due to high population mobility in the era of globalization, but also due to global warming (Stephenson et al., 2022; Tran et al., 2020). The existence of global warming causes subtropical areas that were originally cold temperatures so that they are not suitable for mosquito life to change to become warmer so that the vector mosquito can live and transmit the virus.

There are 2 species known as vectors of DHF, namely Aedes aegypti as the general vector and Aedes albopictus as a secondary vector. Aedes aegypti are more in the house and its surroundings, while Ae albopictus is more common outside (Yuliani et al., 2021). Several reports indicate that Ae aegypti is more common as a DHF vector in urban areas with warmer temperatures, while Ae albopictus is more common as a vector in rural areas (Dev et al., 2014.) or urban and sub-urban areas in the

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subtropics (Stephenson et al., 2022). The Aedes mosquito has a very short flight range (50-100 m),(Verdonschot & Besse-Lototskaya, 2014) diurnally, which actively sucks blood during the day, although it can also be at night if the room is bright (Rund et al., 2020). The feeding behavior of Ae aegypti is anthropophilic (Rund et al., 2020), while Ae albopictus is a generalist (Supartha, 2008). In addition, Ae aegypti is also interrupted feeding, which is sucking blood many times before it is full of blood (Harrington et al., 2014). This behavior can result in the number of sufferers being more than one person at the same time in one house or one environment.

Based on the Regulation of MOH RI No. 50/2017, focus fogging is carried out provided that the results of the epidemiological investigation showed larva-free rates < 95% in a radius of 100 m around the patient's house and there is 1 DHF patient or 3 people experiencing a fever of unknown origin. Fogging is carried out at the patient's house and surroundings with a radius of 200 m, 2 times with a range of 7 days. The fogging focus must be on competent field workers from the Health Office.

Many suspects that fogging focus is less effective, indicated by the incidence of DHF tends to increase over several decades (Harapan et al., 2019). Many studies to evaluate the effectiveness of fogging with entomological parameters have shown inconsistent results (Archiarafa et al., 2016; Bowman et al., 2016; Ibrahim et al., 2016). There is no method to evaluate the effectiveness of focal fogging in DHF cases.

Based on knowledge of the incubation period and the range of fogging, this study aims to evaluate the effectiveness of fogging with a spatial-temporal approach. This method tried to answer problems related to measuring the effectiveness of fogging in preventing dengue hemorrhagic fever. It is hoped that the research results can provide information about the effectiveness of fogging to prevent dengue outbreaks.

Method

This research is an analytic observational, using a cross-sectional design. The data used is the incidence of DHF from 2008-2013 in Sleman Regency, which includes the date of illness, the date of the first and second fogging, and the home address. The next step in the research is illustrated in Figure 1.

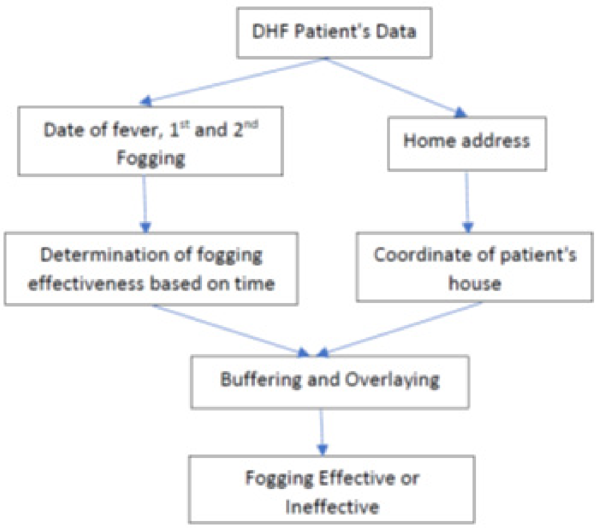

Figure 1. The Steps of the Research

The effectiveness of fogging was evaluated using GIS software (ArcMap 10.5), by creating a buffer area with a radius of 200 m from the center of the first patient's house. If there is more than one case of DHF in the buffer area on days 4-21 after the first patient has a fever, fogging is declared ineffective. The provision for a radius of 200 m is based on a fogging radius according to the provisions of the Sleman District Health Office. The provision of a protective period of 4-21 days is based on the estimated time required for the fever to appear after fogging is carried out. Data on the date of illness, the date of the first and second fogging as well as the home address of a DHF patient were obtained from the Sleman District Health Office. Based on the available home addresses, we look for the x and y coordinates by visiting the location, then determine the coordinates using the Global Positioning System (GPS).

The procedure for assessing the effectiveness of fogging with the Spatial-Temporal approach uses ArcMap 10.5. Data processing is done manually using the analysis buffer function. The steps for spatially processing data are as follows: 1). data preparation in the spreadsheet includes identity, date of illness, and information on fogging; 2). The unique coding of data per row in each sheet according to the year; 3). Choose the coordinates used, namely UTM; 4). Added sick time column (year, month, and date); 5). Giving information about fogging or not; 6). Added a time column when fogging was performed (year, month, and date); 7). Added fogging effect expiration time column; 8). Ensure that the date of the summation does not exceed the number of days in the month; 9). All data per year is stored in one sheet so that it can be recalled in the GIS; 10). Open the GIS, and add the .xls data that already has the unique code and UTM coordinates; 11). Perform data display and save as a point shapefile. The point shapefile contains information on the distribution of people with dengue fever, whether fogging or not; 12). Perform buffer analysis with a choice of a radius of 200 meters. The result of buffer analysis is polygon shapefile fogging; 13). Added the number of sick people column after fogging on the main spreadsheet; 14). Counting the number of people with dengue fever within a radius of 200 meters from the fogging point

Result and Discussion

The results of the evaluation of fogging using functions in GIS which were applied to data on the incidence of DHF in 2008-2013 in Sleman Regency are in Figures 1-3.

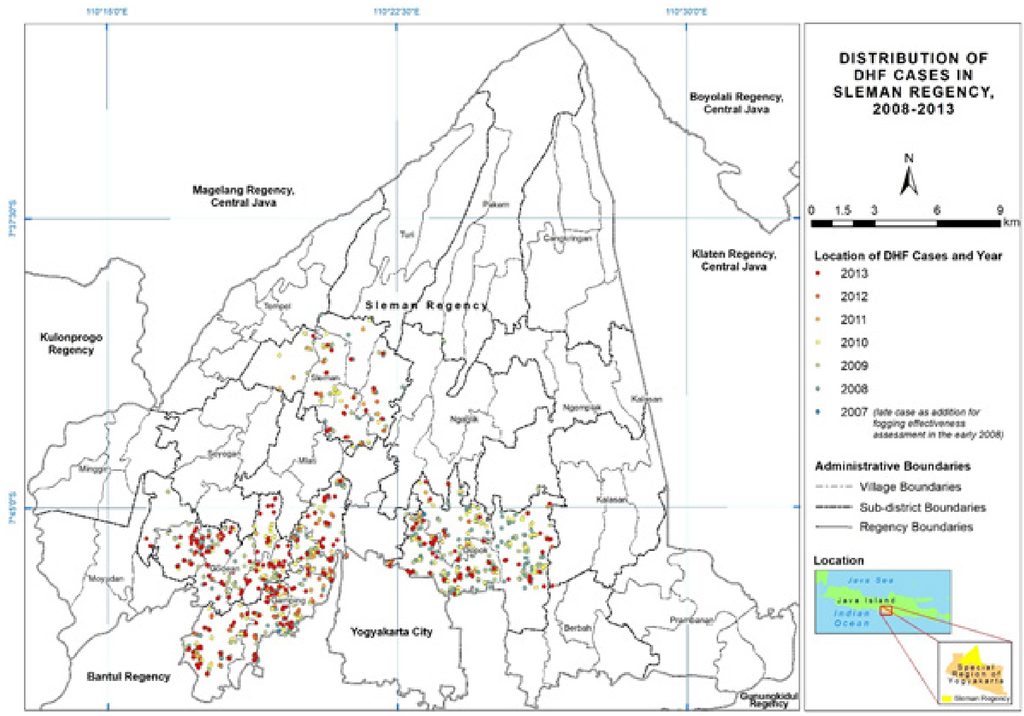

Figure 2. Geographical Distribution of DHF Cases in Sleman Regency in 2008-2013

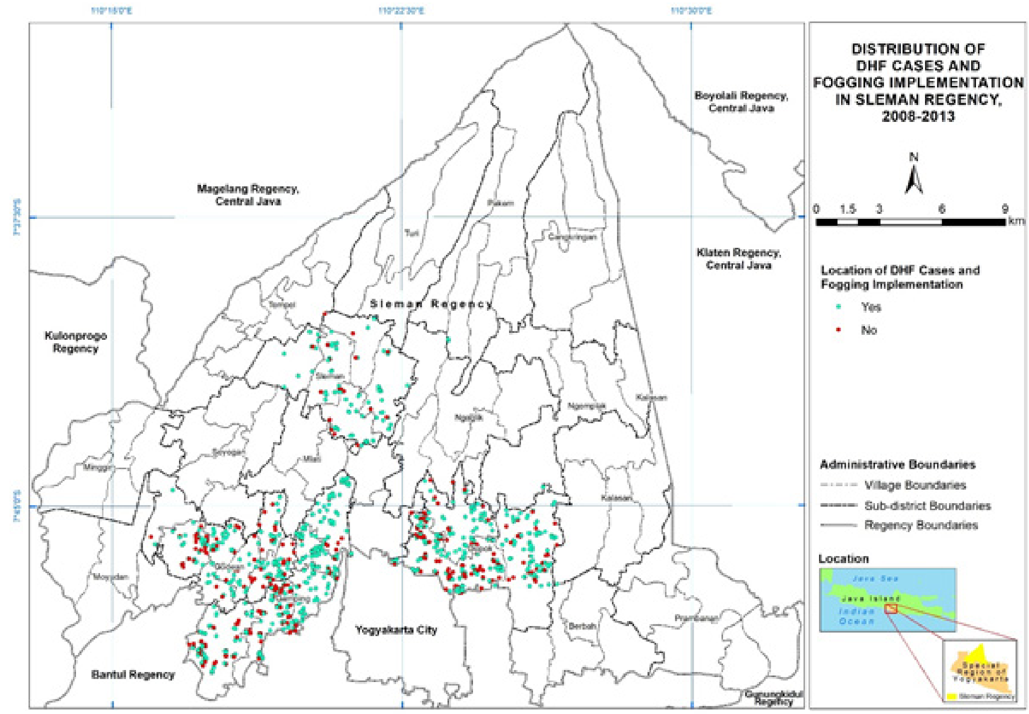

Figure 3. Geographical Distribution of DHF Cases with and without Fogging in Sleman Regency in 2008-2013

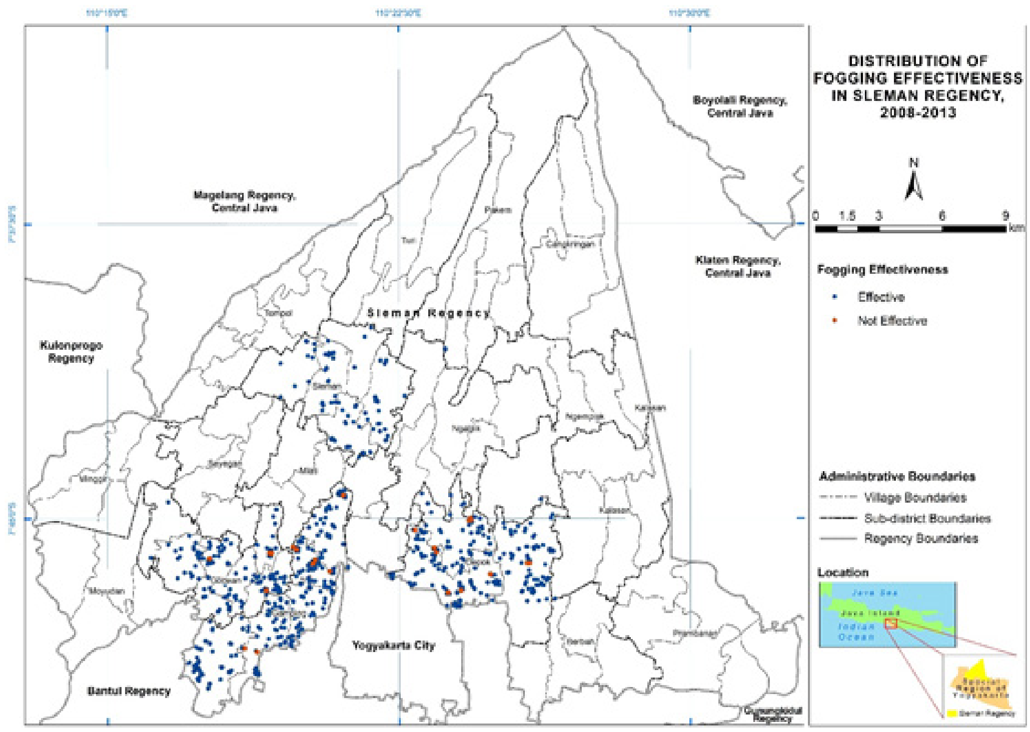

Figure 4. Geographical Distribution of Fogging Effectiveness

Figure 2 illustrates that the incidence of DHF in the Sleman Regency is more common in the southern part of the Sleman Regency. The area is bordered by the city of Yogyakarta and belongs to the agglomeration area of the city of Yogyakarta. Figure 3-4 describes the geographic distribution of DHF cases where fogging and effective fogging. It appears that effective fogging is more dominant than ineffective fogging.

There were 1,070 cases of DHF between 2008-2013 in the Sleman Regency. From those cases, 773 (72.24%) were fogged, while 290 were not. Of 773 fogging cases, 59 (7.63%) were caused by ineffective fogging (occurs within the time and place of fogging protection). Thus the effectiveness of fogging in Sleman Regency is 92.37%. Overall, there were 59 of 1,070 (5.5%) DHF cases came from ineffective fogging.

Fogging focus is a method to prevent outbreaks based on killing adult female mosquitoes (Usuga et al, 2019). Fogging is carried out after meeting particular requirements, namely after there are cases and the results of epidemiological investigations show the larva-free rate (LFR) is less than 95%, there are DHF patients or 3 people with symptoms of fever of unknown origin (Regulation MOH RI No. 50/2017). This restriction prevents Aedes mosquito resistance to insecticides due to uncontrolled use of insecticides.

Research on the effectiveness of fogging ever done, is with entomological parameters. These studies show inconsistent results. Fogging is effective in reducing mosquito density (LFR and House Index (HI) (Ibrahim et al., 2016) in Makassar, but does not reduce the HI and ovitrap index (OI) in Semarang City (Archiarafa et al., 2016), so its role in decreasing dengue cases is still debated. Research linking the frequency of fogging with the number of dengue incidents shows that the higher the frequency of fogging, the higher the number of dengue cases (Sipin et al, 2021), but this cannot be concluded that fogging fails to prevent dengue because fogging is done when the number of cases increases.

The results of the research that we have done show that 5.5% of cases of DHF in the Sleman Regency originate from ineffective fogging. Ineffective fogging may be caused by several things, including 1). The types and doses of insecticides used for fogging did not follow the rules (Nansen & Thomas, 2013); 2). The fogging technique did not comply with the procedure; (Nansen & Thomas, 2013) 3). The insecticide used was resistant to the target mosquito (Gan et al., 2021; Sudo et al., 2018).

The types of insecticides recommended for fogging focus in Indonesia include pyrethroids, carbamates, and organophosphates (Regulation of MOH RI No. 50/ 2017). Pyrethroids affect both target and nontarget central nervous systems. They interact with voltage-gated sodium channels in neurons as their principal mode of action (Riar, 2014). Meanwhile, Carbamate causes an increase in acetylcholine levels at parasympathetic and sympathetic nervous system ganglionic synapses, muscarinic receptors on parasympathetic nervous system target organs, the central nervous system, and nicotinic receptors in skeletal muscle tissue (Silberman & Taylor, 2022). Organophosphates can stably bind to AChE and stop ACh oxidation (Xu et al, 2018). Overstimulation of the muscarinic and nicotinic receptors results from the “liberation” of Ach causes the death of the insect (Adeyinka et al., 2022). Target site resistance and metabolic resistance are the two main types of resistance that exist in pests or insects. Target site resistance occurs when an insecticide’s specific binding site is altered (mutated) or removed, rendering the target site unsuitable for activation. Additionally, metabolic resistance causes an overproduction of the enzymes that detoxify and break down pesticides, leading to pest resistance (Khan et al., 2020; Mulyaningsih et al, 2018).

Several studies related to Ae aegypti resistance to insecticides show that Ae aegypti has been resistant to pyrethroid insecticides at high levels (in PNG) (Demok et al., 2019), indicating the emergence of pyrethroid resistance in Saudi Arabia (Dafalla et al, 2019), both of pyrethroids and organophosphate resistance in California (USA) (Yang et al., 2020), and most likely expanding into less populated areas, according to a study in Kalimantan, Indonesia (Hamid et al., 2018). Studies in Southeast Asia using data from 2000-2019 show that there is a trend of increasing resistance of Aedes mosquitoes to insecticides used for fogging in controlling dengue (Gan et al, 2021). Unlike in Assam, India, Aedes is still susceptible to Malathion (Yadav et al, 2015), a type of insecticide often used for fogging foci in the dengue control program. The results of this study also indicated that 95% of cases of DHF that occurred in Sleman Regency were probably caused by various things in the occurrence of DHF transmission other than the failure of fogging focus. Several risk factors for the occurrence of dengue cases may be due to mosquito bites at school (Ratanawong et al., 2016; Suarez and Cano, 2016), workplace (Perdomo et al., 2020; Zhang et al, 2022), or tourist attractions (Masyeni et al., 2018; Tan and Lee, 2022). Thus, fogging may also be carried out in a school environment/workplace/tourist location or other places that may be the site of dengue transmission other than the patient's house and surroundings

Conclusion

By the spatial-temporal method, 5.5% of the incidence of DHF in the Sleman Regency occurs because fogging is not effective, so the fogging focus has been quite successful in suppressing the incidence of DHF in the Sleman Regency. In the future, it is necessary to consider fogging focus other than the patient's house and surroundings.

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