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Determination of Outbreak Prone Area by Density Figure as Basic Prevention of Dengue Hemorrhagic Fever on Endemic Area

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***Abstract*—Dengue disease transmission and death continues to occur in various regions in Indonesia. The higher the vector density, the higher the possibility of dengue outbreaks. The aim of the study was to determine Density Figure in endemic villages at Rural, Urban and Coastal Cities in Semarang and Mapping the Status of Dangerous Area of DHF in Endemic Sub-Districts in Rural, Urban and Coastal Areas in Semarang. The population was all water reservoirs in Semarang. Samples were water reservoirs inside houses in dengue-endemic villages in Semarang, which was taken by purposive sampling in the coastal areas, urban and coastal cities of Semarang. This is a cross-sectional survey research which utilized larval density to determine transmission risk status of DHF-prone areas. Data collection was done by visual inspection of larvae in each puddle/reservoir. The tools and materials used are flashlights, recording forms for larvae and note takers. The research instruments were: observation checklist, interview guide and questionnaire. Data analysis was univariable. The results showed that areas vulnerable to dengue hemorrhagic fever were located in densely populated areas and lacked environmental sanitation management, with number of density ranging from 4-6.6. Overall risk of transmission by dengue larvae density was moderate and caution is needed.**

***Keywords*— larva density, density figure, transmission level**

I. Introduction

Dengue Hemorrhagic Fever (DHF) remains one of the main vector-related disease in Indonesia. Other vector-related diseases in Indonesia are malaria, filariasis, chikungunya, Japanese encephalitis, pes, leptospirosis, and diarrhea. These diseases have outbreak potential which causes mortality or significant health impact on those infected, resulting in detrimental effect to the country (Aruncachalam et al., 2010).

Recent global climate change causes change in mosquito life cycle. Raising ambient temperature accelerates mosquito life cycle into 1 week from egg phase to adult phase. Indonesia government efforts on vector control in last six decades remain fruitless as DHF cases keeps increasing. Such efforts include detection of mosquitos and other bug vectors with disease potential, as well as vector surveillance system to monitor their growth and dissemination in the community (WHO, 2011).

Data from Semarang public health office stated that the number of DHF cases increased from 2015 to 2017. In 2015, there were 1,729 cases with 20 deaths; IR and CFR were 92.1% and 1.7% respectively. In addition, IR and CFR in Semarang city failed to meet the national target, which was 51 in every 100.000 person for IR and <1% for CFR (Dinkes Provinsi Jateng, 2015).

Semarang, as the capital city of Central Java Province, is endemic for DHF and has a high risk for dengue. Data from the Central Java Provincial Health Office in 2015 showed an increasing trend for IR from 2012 to 2015. Gunungpati is a sub-district with a high incidence of dengue. Sekaran Village Public Health Center area have high potential for DHF growth due to its geographic condition; DHF cases were found every year. Sekaran, Patemon, Kalisegoro and the surrounding areas are dengue-endemic villages located around campuses. Gunungpati Subdistrict is a rapidly developing area with high mobility population, insufficient mosquito nests eradicating (PSN) behavior and frequently vacant rented rooms, which contributed to the increase in DHF transmission

Success in DHF control involves the government and related sectors, supported by community in form of PSN, cadres and health workers [1]. Programs such as 3M plus can only be sustained with high commitment from health policy stakeholders and the community. It consists of: 1) Draining and brushing the walls of water reservoir at least once a week, 2) Sealing every water reservoir, 3) Recycling items that can collect rainwater [2]. It is known that the larva free count (ABJ) in Semarang was still below 95%, which means that DHF transmission through vectors is highly probable.

Government has been monitoring the distribution and vector density of DHF vectors as of late [3]. Larvae density is of high importance in DHF. High larval density in a community means higher dengue transmission potential; the reverse low is true where the lower the vector density, the lower is DHF transmission rate [4]. High vector density also means higher probability of DHF outbreaks (Nagpal et al., 2016).

Housing is a potential area for DHF vector growth because due to its characteristics that are suitable for mosquito breeding such as water reservoirs (bath tubs), water containers, flower vases, or water-filled containers that are protected from soil and sunlight [5]. Therefore, to determine larvae density in endemic areas in Semarang, we need to measure HI (House Index), CI (Container Index), and BI (Breteau Index) to determine Density Figure which could be used to determine DHF transmission potential that will be important for outbreak management.

Determination of DHF outbreak-prone areas could be conducted by looking at Aedes aegypti mosquito larvae density. Larval density can be used to assess DHF transmission rate in an area. Comprehensively, larval density can be assessed using Density Figure; this indicator will help the government to formulate a policy for DHF outbreak management in DHF-potential areas. Therefore, the purpose of this study was to determine Density Figure through HI, CI and BI in endemic Sub-Districts in Rural, Urban and Coastal areas of Semarang City and Mapping of DHF outbreak in those areas.

II. Materials and Methods

This was a cross-sectional research based on survey of larval density in DHF-endemic areas with one-time larval observation. The study was conducted at three types of DHF-endemic areas namely, rural, urban and coastal areas in Semarang City. The locations were selected based on district endemicity status. The population were all water reservoirs in Semarang that had the potential to become *Aedes aegypti* breeding nests. The samples were water reservoirs inside houses taken by purposive sampling in the endemic DHF villages in rural, urban, and coastal areas of Semarang City that met the criteria. The urban villages chosen were Sekaran and Pakintelan urban villages for rural criteria, Pedurungan village for urban criteria and Genuk urban village for coastal criteria.

Data was collected through visual method. Survey was conducted by visually inspecting the presence of larvae in every water reservoirs without sampling the larvae. The tools and materials used were flashlights, larvae recording forms and ballpoint.

Each subject was observed once with 2 persons, by observing a) every container or reservoir that have potential as breeding ground of *Aedes aegypti,* b) every large water reservoir (TPA) such as bath tub, jars, drums, and other water tanks. If larvae was not found during the first inspection, observation was continued for 0.5-1 minute to ensure the absence of larvae, c) all small containers such as vase or water plant container, or bottles containing turbid water that are turbid usually necessitate a transfer of its content into another container for observation, d) flashlight was used to inspect containers located in a dark place or turbid water.

The study was started by submiting ethical clearance proposal No. 053/KEPK/EC/2019, requesting for location permit, determining research samples, measuring data to determine House Index (HI), Container Index (CI), Breteau Index (BI), and Larvae Free Index (ABJ), descriptive quantitative data analysis to calculate HI, CI, BI, and DF, and establish Density Figure of each area, and mapping areas vulnerable to DHF outbreaks.

House Index (HI) is total of houses positive for larvae compared to total of all observed houses.

$$HI = \frac{\text{Total of houses positive for larvae}}{\text{Total of houses observed}} \times 100\,\%$$

Container Index (CI) is total of containers with positive larvae, compared to total of all containers observed.

$$CI = \frac{\text{Total of containers with positive larvae}}{\text{Total of containers observed}} \times 100\,\%$$

Breteau Index (BI) is the total of container with larva in 100 houses

$$BI = \frac{\text{Total of containers with larvae}}{\text{100 of houses observed}} \times 100\,\%$$

House index is generally used to measure dissemination of mosquito in a community. It is also the simplest and fastest way to observe the presence of larvae. House index can also be utilized to swiftly indicate *Aedes aegypti* distribution in an area. Container index generates more detailed indication of mosquito population in water reservoirs. Meanwhile, Breteau index correlate indicate a relationship between housing and larvae-positive reservoir and is considered as the most informative index; however, it does not account for reservoir productivity.

Based on HI, CI, and BI, larvae density was categorized as in Table 1. Density figure (DF) is the density of *Aedes aegypti* larvae which is a combination of HI, CI, and BI and is presented in a scale from 1 to 9 as WHO stated in 1972 [6]:

TABLE I. Larva Index

Density figure (DF)	**House Index (HI)**	**Container Index (CI)**	**Breteau Index (BI)**
1	1 – 3	1 – 2	1 - 4
2	4 – 7	3 – 5	5 – 9
3	8 – 17	6 – 9	10 – 19
4	18 – 28	10 -14	20 – 34
5	29 – 37	15 – 20	35 -49
6	38 – 49	21 - 27	50 – 74
7	50 -59	28 - 31	75 – 99
8	60 – 76	32 – 40	100 – 199
9	**>77**	>41	>200

a. Source: WHO (1972)
Table annotation:
b. DF = 1 = low density
c. DF = 2-5 = middle density
DF = 6-9 = high density.

Based on the larvae survey, we determined Density Figure after calculating HI, CI, and BI, and then compared it to Larvae Index table. DF number interpretation is shown in Table 2.

TABLE II. DENSITY FIGURE INTERPRETATION TABLE

No	Density	Interpretation
1	1-3	Green area, no or low transmission risk by larvae
2	4-5	Yellow area, middle transmission risk by larvae, take caution.
3	>5	Red area, high transmission risk by larvae, immediate larvae control

III. RESULTS AND DISCUSSIONS

The number of DHF cases fell to 103 cases at 2018 from 299 cases in the previous year. 2018 was also the year with the lowest number of cases since 1994. Incidence Rate also decreased significantly from the previous year (2017), which was 18.14, to 6.17 in 2018. CFR also decreased from 2.7 in 2017 to 0.97 (1 death) in 2018.

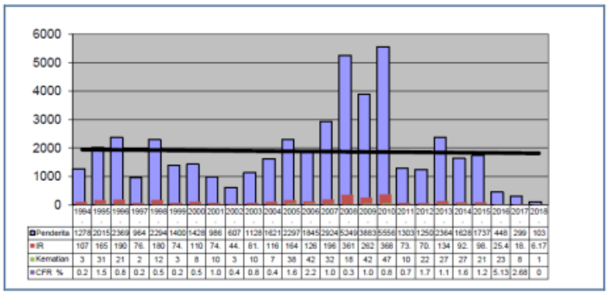

Figure 1. Progress Chart of IR-CFR DHF years 1994-2018

Based on age group, DHF case was the among 5-9 years and 10-14 years groups (26 cases) while the lowest is among 50-54 years age group, with 1 case or 1%. The highest proportion was found among toddlers and school-age children (0-14 years), reaching 69%. This proportion repeats every turn. Further stufy is needed to investigate the cause of DHF incidence dominance among toddlers and school-age group compared to other age groups.

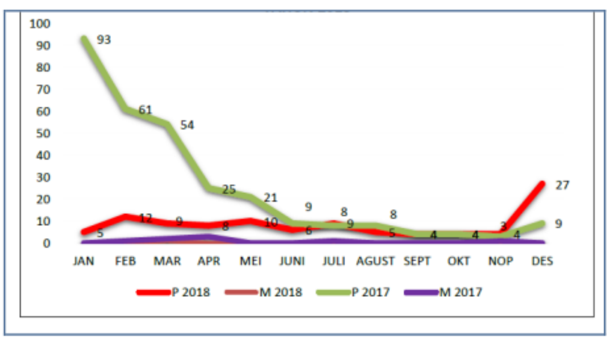

Figure 2. Monthly Chart of DHF Cases in 2018

Figure 2 shows that from January to November 2018, DHF cases in 2018 is lower compared in 2017 except during December. The highest incidence in 2018 occurred in December (27 cases) while it was January (93 cases) in 2017. According to Regional Regulation (Perda) of Semarang, December 2018 was classified as outbreak. The lowest incidence in 2018 occurred during September – November with 4 cases while in 2017 it was during November with 3 cases. DHF cases average in 2018 was 9 cases/month, while in 2017 it was 25 cases/month.

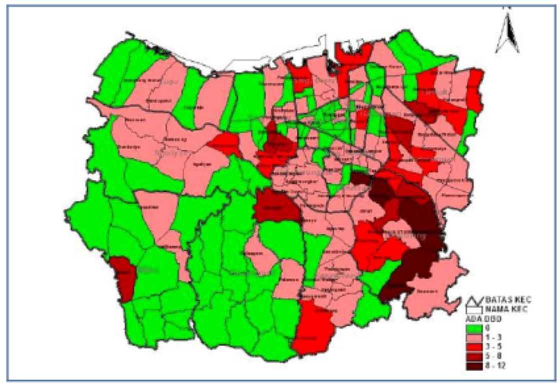

Figure 3. Map of Urban Villages with DHF Cases in Semarang (2018)

In 2017, 103 sub-districts (58.2%) experienced DHF cases, contrary to 74 villages (41.8%) in Semarang that experience 0 case throughout year. Thirty-seven or 20.9% urban villages in Semarang had DHF outbreak in 2017.

Data obtained in April-May 2019 is in line according to the previous Larvae Index data. Container is every place or reservoir that can store water which does not stream to other places. They can be used by mosquitoes as breeding sites, Aedes aegypti prefer clean water that are away from soil and sunlight, and stored in dark/humid area (Dinkes DKI Jakarta, 2003).

DKI Jakarta Health Office (2003) stated that the breeding place of Aedes aegypti is divided into 3 grousps, namely 1) water reservoir (TPA), a container for daily usage of water such as bath tub, buckets, etc, 2) not TPA, such as animal drink containers, used goods (e.g. tire, cans, bottles, glass fragments), flower vase, etc, 3) natural water container, such as coconut shells, holes in trees, leaf midribs, stone holes, bamboo pieces, shells etc.

Starting from January 2019 to March, Semarang Health Office recorded 140 cases of dengue fever with five deaths. The highest number of dengue fever cases was in Tembalang District, 34 cases [7]. Data showed that the number of cases was 2,364 in 2013, 2, 1,628 cases in 2014, 1,737 cases in 2015, 448 cases in 2016, 299 cases in 2017, and 50 cases in 2018.

2018 Health Office data reported that the percentage of larva-free house was 91.70%, which was significantly different compared to the result of actual survey where the percentage of larva free houses was 76.2% in Sekaran urban village, 90% in Sendangmulyo urban village and 41.7% in Genuk urban village. This could happen because larva monitoring is always announced beforehand, hence the residents already cleaned their water reservoirs before data collection by puskesmas cadres or jumantik cadres (larva monitors) by dasa wisma (Dawis).

TABLE III. TYPE AND TOTAL CONTAINERS WITH POSITIVE LARVAE AT EACH ENDEMIC URBAN VILLAGES IN SEMARANG, 2019

Container Type	Sekaran		Sendangmulyo		Genuk	
	Container observed	Larva (+) Container	Container observed	Larva (+) Container	Container observed	Larva (+) Container
Bath tub	35	1 (2.9%)	50	5 (10.0%)	24	6 (25.0%)
Other water container (e.g. bucket)	31	6 (19.4%)	20	1 (5.0%)	24	7 (29.2%)
Spilled dispenser	15	0 (0.0%)	35	3 (8.6%)	24	2 (8.3%)
Spilled refrigerator water	24	3 (12.5%)	30	3 (10.0%)	24	4 (26.7%)
Flower vase	9	1 (11.1%)	15	2 (13.0%)	24	3 (12.5%)
Bird drink container	11	1 (9.1%)	10	2 (20.0%)	24	4 (16.7%)
Used cans	14	2 (12.3%)	8	2 (25.0%)	24	5 (20.8%)
Total	139	14 (10.1%)	168	18 (10.7%)	168	31 (18.5%)

TABLE IV. LARVAE DENSITY IN SEKARAN, SENDANGMULYO AND GENUK URBAN VILLAGES IN SEMARANG, APRIL-JUNE 2019

Villages	House		Container		Larvae index			
	N	Larvae (+)	n	Larvae (+)	ABJ (%)	HI (%)	CI (%)	BI (%)
Sekaran	42	10	139	14	76.2	23.8	10.1	33.33
Sendang mulyo	50	5	168	18	90	10	10.7	36.00
Genuk	24	14	168	31	41.7	58.3	18.5	129.16

n= number of samples

Based on Table 4, we can conclude that the village with the highest HI, CI, and BI was Genuk, while the lowest was Sendangmulyo. ABJ in all location was less than 95%. Density figure was determined by matching HI, CI, and BI on to Table 1. Larvae Index.

TABLE V. DENSITY FIGURE IN SEKARAN, SENDANGMULYO, AND GENUK VILLAGES IN 2019

No	Villages	Stratification	HI	BI	CI	DF
1	Sekaran	Endemic	4	4	4	4
2	Sendangmulyo	Endemic	3	4	5	4
3	Genuk	Endemic	7	5	8	6.67

Table 5 shows that the village with highest larvae density was Genuk with DF 6.67 (high-risk), while others were around DF 4 (middle-risk).

Genuk is a region located in coastal area with very mobile population and plenty water puddles away from soil, which can be a mosquito breedingnest. In addition, larvae surveillance was heavily reliant on the enthusiasm of cadres and puskesmas officers because this region is already very urban and there was little interaction between neighbors. Meanwhile, Sendangmulyo is a housing complex where civil servants resided; larvae monitoring activity were held routinely due to their relatively higher education level. In Sekaran, most of the houses are rented out to college students from nearby campus, hence surveillance was poorly executed, but the residents routinely cleaned the house and its surrounding environment, resulting in medium-risk larvae density.

Rodrigues et al., (2015) stated that Aedes aegypti establish themselves in urban area and isolation frequency was higher inside the house. Female larvae density is in line with total residents in the house. Data shows that human population density is correlated to the number of female Aedes aegypti inside the house. Meteorological variable also affected mosquito population. Data showed that higher human-vector contact increased the probability of DEN virus transmission [8].

The larval density of Aedes sp. in endemic areas is lower than DHF sporadic areas. Larval density is not correlated with DHF endemic area stratification. Endemic areas do not necessarily have high larvae densities, hence the number of cases was not affected by larvae density but can be influenced by other factors such as population mobility [9].

The results of study on May-June 2017 at several areas in Semarang, namely Tugu District, Ngaliyan District, North Semarang District, Mijen District, West Semarang District and Pedurungan District with the population of all 54 houses around DHF patients from three hospitals. (Dr. Kariadi General Hospital, Dr. Adhyatma, MPH Hospital and KRMT Wongsonegoro Hospital). The larval survey shows that house index (HI) was 44.44% which is categorized at the density figure (DF) of 6. This means more rapid Aedes aegypti dissemination [10].

Arifudin, et al., (2016) stated that Aedes aegypti was more prevalent compared to Aedes albopictus (97.74%), with house index of 52.50%, container index of 34.72%, breteau index of 66.50% and density figure of 7. This implies that Aedes aegypti is easier to find inside of the house compared to Aedes albopictus that is easier to find outside of the house. Cement bathtub is the most commonly found container of Aedes larvae compared to other containers [11].

In the previous study, the house index of Aedes larvae in the Salemba Campus at Indonesia University was 4.7%. HI found was lower than the normal national HI, 5%; CI and BI values were 8.3% and 12.7% respectively. According to WHO density figures, the University of Indonesia Salemba campus is classified on a scale of 2-3, meaning that they have low risk of DHF transmission [12]. The risk of DHF transmission in the Salemba campus was also supported by the number of potential breeding containers for Aedes aegypti mosquitoes such as bath tubs, buckets, used cans, dispensers, flower pots and other artificial water storage that are located throughout buildings. These water reservoirs are environmental risk factors for DHF transmission when they are left unattended..

IV. Conclusions and Suggestions

Breakthrough based on evidence is urgently needed to prevent outbreak, therefore determination of outbreak-prone areas with Density Figure is crucial in DHF outbreak prevention. Larval density is one of the indicators to assess the vulnerability of a community to dengue. The higher the vector density, the higher the possibility of dengue outbreaks.

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