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Larval survey of the dengue-endemic area in Samarinda: guide to determine risk containers

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ABSTRACT

Dengue has been reported in Indonesia since1968; the cases tend to increase and spread every year. From 2015-2019 almost all districts in Indonesia had dengue cases. This study aimed to determine the value of the entomological index and its relationship with the treatment of various types of containers and spatial epidemiology. A larval survey was conducted to determine the presence of larvae in water containers. Logistic regression and spatial data analysis were performed to see the distribution and make a buffer area map of *Aedes sp*. spreading risk. The types of containers observed in this study were water tubs, drums, buckets, refrigerator containers, dispenser containers, and other categories. There were 221 containers found containing *Aedes sp.* larvae. Container types affected the presence of larvae with adjusted ORs of 2.779 (95% CI: 1.441-5.360) on buckets, 9.812 (95% CI: 1.249-77.051) on refrigerator holders, and 0.301 (95% CI: 0.147-0.617) on dispenser holders, while the other variables were constant. The spatial analysis found that many houses are at risk of dengue transmission within a radius of 100 m. The discovery of containers as potential breeding sites for *Aedes sp.* provides a chance for an increase in dengue cases in Samarinda.

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1. INTRODUCTION

Dengue was first reported in Indonesia (Jakarta and Surabaya) in 1968. The cases tend to increase and spread every year. In 2015-2019 almost all Indonesian districts had dengue cases [1], [2]. Samarinda City is one of the dengue endemic cities in East Kalimantan, Indonesia which first reported cases of dengue in 1988. Data on dengue fever from the Samarinda City Health Office reported that in 2014 there were 1126 cases with an incidence rate (IR) of 2.38, in 2015 there were 1272 cases. with an IR of 2.6, in 2016 2,832 cases, IR 6.9, in 2017 as many as 2,814 thousand and with an IR of 2.1. Until now dengue still occurs every year in line with the development of increasingly widespread, dense, and heterogeneous settlements [3].

The incidence of dengue is influenced by several interacting factors which include disease agents (the dengue virus), the presence of vectors, and environmental conditions that support the development of mosquito vectors [4]. Mosquitos from genus *Aedes* (*Ae*) is responsible for carrying and transmitting the dengue virus which consists of various species. Of this genus, the main vector of the dengue virus is *Ae. aegypti* species. It is the main vector responsible for dengue fever transmission and dengue fever epidemics. Other mosquito species in the genus *Aedes* including *Ae. albopictus*, *Ae. polynesiensis*, and *Ae. scutellaris*; who have limited ability to act as vectors of dengue fever. The even distribution of dengue cases in almost all regions of Indonesia is due to the presence of vector mosquitoes (*Ae. aegypti* and *Ae. albopictus*) which are endemic in every region [1], [5]. These two mosquito species generally carry out their life cycles in environments close to human settlements. Usually, their breeding places can be found in containers containing clean water both inside and outside the home [6].

Currently, a vaccine advanced with an attenuated stay virus, the chimeric yellow fever 17D-tetravalent dengue vaccine (CYD-TDV), has been certified for scientific use in numerous countries, and plenty of vaccine applicants are nonetheless below studies and development [7]. Consequently, the disease control is more focused on the vector by reducing the density of mosquito populations around settlement areas through several ways: reduction or protection of potential breeding habitats[8], the use of natural predators such as larvae, fish, and copepods [9], or entomopathogenic bacteria (*Bacillus thuringiensis*) [10], and chemical control with insecticides for larvae and adult mosquitoes [11]. Sidodadi and Dadimulya villages are included in the working area of the Segiri Public Health Center, Samarinda Ulu District, Samarinda City. Control efforts that have been carried out include fogging focus, counseling and investigation when epidemiological cases are found dengue cases occur almost every year in the two urban villages, but there are no indicators for entomological data. Data from the Segiri Health Center stated that in 2016 there were 133 cases, in 2017 there were 18 cases, in 2018 there were 57 cases and in 2019 there were 47 cases. Entomological data is used as basic data to monitor and evaluate intervention efforts in an area. This study aims to determine the entomological index number and its relationship with various types of containers found in Sidodadi and Dadimulya.

2. RESEARCH METHOD

2.1. Design and subject

The observe changed into authorised through The Ethics Commission, National Institute of Health Research and Development, Indonesian Ministry of Health with moral clearence variety LB.02.01/2/KE.296/2018. All respondents have signed knowledgeable consent. The populace of the observe changed into the network in the location of Sidodadi and Dadimulya villages, Samarinda City, Indonesia. This changed into an observational analytical observe with a cross-sectional design.

2.2. Sampling and epidemiological data collection

The population in this study were households in Sidodadi and Dadimulya villages. The sample in this study was 300 households in Sidodadi and Dadi Mulya villages with the visual method of at least 100 samples in one village according to WHO criteria. The inclusion criteria included a house with at least one household, having adult household members, and being willing to be a respondent. The exclusion criteria were residential houses in the form of flats with monthly rent and houses being built. Containers found in and around human settlements are detailed according to WHO guidelines [12]. Global positioning system (GPS) device used for mapping purposes in larval surveys. The GPS used is a Garmin Monterra® and has been calibrated every time it is used. Excel sheet was created to record GPS number, latitude and longitude data on positive and negative larvae.

2.3. Statistical methods

Observations had been made at the class of packing containers that contained *Aedes sp.* larvae. The 'residence index' or HI is described because the variety of advantageous homes for *Aedes* larvae (HI=Number of homes advantageous for *Aedes sp.* larvae/Number of homes inspected x a hundred) and the 'field index' or CI is the percentage of packing containers advantageous for *Aedes sp.* larvae (CI=Number of advantageous packing containers/number of packing containers inspected x a hundred). Further, the variety of advantageous packing containers in step with a hundred homes in a selected region referred to as the 'Breteau index' (BI=Number of advantageous packing containers/number of homes inspected x a hundred) become calculated. BI facts is the unmarried maximum beneficial index for estimating populace density in a region. BI and HI are commonly used to outline threat regions for preventive action. Further, to determine the larva free (LF) which is to find out the larva free number indicator in an area for *Aedes sp.* larva (LF=number of negative houses/number of houses inspected x100) [12]. Another indicator that marks the main breeding container is the "breeding preference ratio" (BPR) which is also calculated based on the ratio between the proportion of *Aedes sp.* in each container and the proportion of breeding grounds for *Aedes sp.* [13].

For data analysis, logistic regression methods were used. This study wanted to see how much influence several variables had on the presence of larvae in containers in the household. These variables include type, location, and container cover; the presence of fish in containers; container material and color; whether the container is given temephos; and whether the container was drained in the last one week.

Open street map (OSM) images of the two villages are used as the base maps to map all GPS points. The software analysis and manipulation functions are used in quantum geographic information system

(QGIS). This geographic reference system is free and open source software of spatial analysis. Spatial data analysis used to determine the pattern of mosquito flight distances.

3. RESULTS AND DISCUSSION

The number and types of containers based on the presence of lids, location, presence of fish, draining in the last one week, use of temephos, as well as the material and color of the containers are presented in Table 1. The types of containers found in this study were water tubs, drums, buckets, refrigerator containers, dispenser containers, and other categories. The most dominant types of containers were buckets, followed by drums and water tubs. Most of the containers were open or uncovered and located indoors. In addition, most of the containers were not sown with temephos or did not raise any fish. Meanwhile, for the drained container in the last 1 week, about more than 50% container known was drained. The material of the containers was dominated by plastic, while over half of them had dark colour.

Table 1. Container type and category

Container type	Cover		Location		Raise fish		Drained the last 1 week		Given temephos (last 2 weeks)		Material		Color		Amount
	Uncovered	Covered	Indoors	Outdoors	Yes	No	Yes	No	Yes	No	Non plastic	Plastic	Light	Dark	
Water tub	3	247	243	7	6	244	166	84	41	209	232	18	124	126	250
Drum	207	154	273	88	3	358	180	181	12	349	75	286	112	249	361
Bucket	64	362	322	104	4	422	286	140	6	420	21	405	195	231	426
Refrigerator holder	3	37	40	0	1	39	7	33	0	40	1	39	16	24	40
Dispenser holder	3	64	67	0	1	66	20	47	1	66	4	63	35	32	67
Others	36	162	87	111	33	165	65	133	0	198	56	142	138	60	198
Total	316	1,026	1,032	310	48	1,294	724	618	60	1,282	389	953	620	722	1,342

Table 2 shows that the most positive container larvae are drum as much as 31.74% of the total containers found and followed by water tub. The highest BPR value is in dispenser holder. This means that the dispenser holder has the greatest potential among other types of containers as a breeding ground for mosquito larvae.

Table 2. *Aedes aegypti* entomological surveillance index on various containers

Container type	Positive container (Y)	%	Total containers (X)	%	BPR (Y/X) percentage
Water tub	56	25.34	250	18.63	1.36
Drum	86	38.91	361	26.90	1.45
Bucket	22	9.95	426	31.74	0.31
Refrigerator holder	1	0.45	40	2.98	0.15
Dispenser holder	27	12.22	67	4.99	2.45
Others	29	13.12	198	14.75	0.89
Total	221	100.00	1342	100.00	1.00

Out of all the inspected containers, 221 of them were containing *Aedes* larvae. Table 3 reveals that based on each urban village (Dadimulya and Sidodadi), the House Index (HI) scores were obtained: 44.67 and 48.66; Container Index (CI): 14.72 and 18.29; breteau index (BI): 67.33 and 80; and the values of larva free (ABJ): 55.33 and 51.33. Relationship analysis between the presence of larvae with the type of container, presence the container lid, location, presence of fish, drained in the last one week, use of temephos, as well as the container material and color are presented in Table 4.

Table 3. Entomological surveillance index by urban village

Urban village	Number of houses	Number of positive houses	Total containers	Positive container	HI	CI	BI	LF
Dadimulya	150	67	686	101	44.67	14.72	67.33	55.33
Sidodadi	150	73	656	120	48.66	18.29	80	51.33
Total	300	140	1342	221				

Table 4. Bivariate test results

Variables	p-value	OR	95% CI
Water tubs	0.000	1	-
Drum	0.682	1.083	0.738-1.590
Buckets	0.000	0.189	0.112-0.318
Refrigerator holder	0.018	0.089	0.012-0.661
Dispenser holder	0.004	2.338	1.320-4.414
Others	0.039	0.595	0.363-0.974
Location of container	0.225	1.227	0.881-1.708
Container lid	0.875	1.032	0.733-1.453
The presence of fish	0.033	4.686	1.129-19.446
Drained	0.000	3.512	2.565-4.808
Temephos	0.032	0.532	0.290-0.946
Color of container	0.001	1.638	1.216-2.207
Container materials	0.000	0.411	0.305-0.553

Results from bivariate analysis are presented in Table 4. There was a significant correlation ($p<0.0001$) between the presence of larvae and buckets with ORs of 0.189 (95% CI: 0.112-0.318), refrigerator holder showed a significant correlation ($p<0.018$) with ORs of 0.089 (95% CI: 0.012-0.661), dispenser holder showed a significant correlation ($p<0.004$) with ORs of 2.338 (95% CI: 1.320-4.414), others type of canitainers showed a significant correlation ($p<0.039$) with ORs of 0.595 (95% CI: 0.363-0.974). Other factors that had a significant correlation with presence of larvae were the presence of fish (OR: 4.686; 95% CI: 1.129-19.446), drained containers in the last one week (OR 3.512; 95% CI: 2.565-4.808), temephos (OR 0.532; 95% CI: 0.290-0.946), material of container (OR 0.411; 95% CI: 0.305-0.553), and color of container (OR: 1.638; 95% CI: 1.216-2.207). At the same time, the other variables that were not significantly correlated with the presence of larvae were the location of the container and the presence of the container lid.

In several studies it was also known that buckets, refrigerator water containers, dispenser containers as potential places for mosquito larvae with a positive correlation [14], but the presence of fish [15] and draining once a week [16] and the provision of temefos negatively correlated [17]. Some fish that are known to eat larvae include: *Poecilia reticulata*, *Rasbora daniconius*, *Aplocheilus dayi*, *Oriochromis mossambicus*, *O. Niloticus* and *Puntius bimaculatus* [18]. The variables included in the multivariate analysis were those with a significance value of<0.25; which are the type of container, presence of fish, drained in the last one week, temephos and material, and color of the container as shown in Table 5.

Table 5. Multivariate logistic regression on the risk of presence of larvae

Variables	Coefficient	p-value	OR	95% CI
Water tubs		0.000	1	-
Drum	-0.338	0.196	0.713	0.428-1.190
Buckets	1.022	0.002	2.779	1.441-5.360
Refrigerator holder	2.284	0.030	9.812	1.249-77.051
Dispenser holder	-1.199	0.001	0.301	0.147-0.617
Others	0.170	0.580	1.185	0.649-2.116
The presence of fish	-2.280	0.002	0.102	0.024-0.444
Drained	-1.264	0.000	0.282	0.201-0.397
Color of container	-0.360	0.035	0.697	0.499-0.974
Container materials	0.855	0.000	2.352	1.525-3.627

The final model of the multivariate analysis revealed that container type affected the presence of larvae with adjusted ORs of 2.779 (95% CI: 1.441-5.360) on buckets, 9.812 (95% CI: 1.249-77.051) on refrigerator holder, and 0.301 (95% CI: 0.147-0.617) on dispenser holder, while the other variables were constant conditions. In addition, others variable were also associated with the presence of larvae. They are the presence of fish in the container (ORadj: 0.102; 95% CI: 0.024-0.444), drained (ORadj: 0.282; 95% CI: 0.201-0.397), color of container (ORadj: 0.697; 95% CI: 0.499-0.974), and container materials (ORadj: 2.352; 95% CI: 1.525-3.627).

Most residents, especially during the dry season, usually have many buckets that are used as temporary water reservoirs. These buckets are often used to collect air and often leave as little air as possible for mosquitoes to lay eggs in the bucket. This type of bucket water reservoir is rarely cleaned by residents. Residents usually just pour out the air in the coals without it, so it is possible that mosquito eggs are still residents of *Ae. aegypti* exists because mosquito eggs are usually *Ae. aegypti* clinging to the wall of the bucket [19]. The same thing also happened to the back of the refrigerator and dispenser which were rarely cleaned, so the place was used as a breeding ground for mosquitoes [20]. Water in a container that makes mosquitoes lay eggs repeatedly will indicate the place is safe to lay eggs because of the chemical compounds (pheromones) that are released [21].

In Figure 1 we can see a map showing areas with the potential for dengue transmission in Sidodadi and Dadimulya villages. The figure shows houses with *Aedes sp.* larvae (red points) as the initial measurement along a radius of 100 m to the surrounding area. It is based on an average mosquito flight distance of 100 m. It is also seen that many houses are located within the 100 m radius, so the possibility of transmission is very high. Positive houses are thought to contribute to the spread and increase in the mosquito population as a vector for dengue fever.

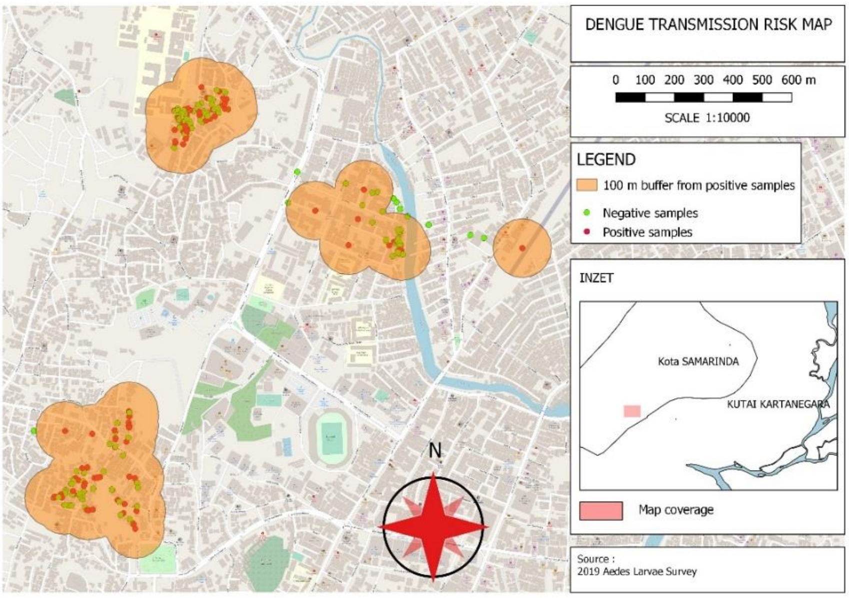

Figure 1. The specimens of Sidodadi and Dadimulya villages show positive larva houses within a 100 m buffer

In this study, an entomological survey was carried out to see the magnitude of the entomological index based on WHO criteria on various containers and their treatments. The number of containers inspected was 1,342. Samarinda Ulu District is the central area of the city with high housing density. Generally, Dadimulya Village is close to a river, while Sidodadi Village is located on a highland.

The results showed that the type of container is generally in open condition. This condition increases the risk of mosquitoes to lay their eggs so that the chance for mosquito abundance is also higher [22]. Container placement is observed out of doors the house, that is supposed as a keeping box if at any time at some stage in the dry season or watering the vegetation and most effective in part tired in one week (46.6%) ensuing withinside the box being an appropriate breeding floor for larvae to come to be younger and mosquitoes. Several research have mentioned that particularly large open water boxes (along with indoor and outside drums) are maximum effective in phrases of larva development. For example, observations made at Columbia observed that open boxes offer a positive putting for mosquitoes [23]. An entomological survey after the 2,000-dengue fever outbreak in Dhaka, additionally diagnosed open boxes as a capacity webweb page for *Ae. aegypti* [24]. In three coastal areas of Mexico, it become additionally diagnosed that concrete tanks and open barrels have been the maximum effective boxes in phrases of developing *Ae. aegypti* [25]. The use of temephos in the last two weeks as an effort to control chemicals can be done in an open container with the recommended dose [26]. The use of temephos in this study was only 4.47% because the Public health center no longer distributed temephos to avoid resistance to *Aedes aegypti* larvae. The results of research in Samarinda City indicate that temephos is not effective in killing *Aedes aegypti* in 24 hours of observation with LC50 of 1.88-2.24 ppm and LC90 of 2.07-3.59 ppm [27].

Based on the types of containers found in the study, drums and water tanks (inside and outside) gave a greater proportion of the presence of larvae. Several studies also gave the same results, for example, research in Kupang City, Indonesia found that drums and water tanks contributed 35.8% and 60.6% [28]. Another study in the City of Bengaluru, India also stated that drums (29.7%) and water tanks (6.2%) contributed dominantly to the presence of *Aedes* aegypti larvae and pupae in the two research areas, namely K.P.Agrahara and Guttahalli, India [29]. Other conditions in the dispenser container (12.22%) provide a higher breeding preference ratio (BPR) (2.45) when compared to drums (1.45) and water tanks (1.36). This thing happen because the dispenser container is rarely checked and in open condition. Drums and water tanks are usually often used for daily needs and have a large amount of water which are also used to hold water in case of a water crisis, and are rarely closed. These conditions provide an opportunity for mosquitoes to lay eggs and accommodate large numbers [24]. Drums and tanks that are rarely drained will accommodate *Lachnospiraceae, Synechococcaceae, Alcaligenaceae* and *Cryomorphaceae* bacteria which can attract mosquitoes to lay eggs [30].

Both villages still have a high house index, 44.67% and 48.66% for Dadimulya and Sidodadi. Entomological surveillance of *Ae. aegypti* density is important to determine dengue transmission factors, in order to prioritize areas and seasons for vector control [22], [23]. The selection of the appropriate surveillance strategy is based on results and objectives, taking into account time, resources, and level of endemicity [31]-[33]. The success of reducing the incidence of community-based dengue fever has been carried out in the Lansaka district, Nakhon Si Thammarat province, Thailand. They call it the "Lansaka Model", that is, this model was designed in partnership with all stakeholders from 44 villages in five sub-districts. The surveillance system consists of seven steps at the household level based on the primary care surveillance center (PCSC), as well as four components at the district level based on the district surveillance center (DSC) [34]. The development of community surveillance was also carried out in Cambodia by providing guppy fish in 14 villages and about 1,000 in the community which gave significant results in reducing dengue cases within one year [15].

The results of this study showed that the role of container type, fish, drainage frequency, color, and container contributed significantly to the presence of larvae. This condition requires action and prevention at the household level, for example using fish and the frequency of draining once a week. then at the monitoring and evaluation stage by the local health authority, it is necessary to carry out consistent and periodic surveillance and can involve the community. Therefore, it is important to ensure continuous dengue vector surveillance and vector control during the pandemic with better methods [35]. Especially, health workers in the field need to be properly trained [33] and equipped with personal protective equipment (PPE) during the COVID-19 pandemic to ensure safety. Besides that efforts can also be made to predict the epidemic and minimize the transmission of dengue fever [36].

4. CONCLUSION

Spatial analysis found that many houses are at risk of dengue transmission within a radius of 100 m. The discovery of potential containers as breeding for *Aedes sp.* habitat provides an opportunity for an increase in dengue cases in Samarinda City. In addition, the discovery of potential containers in the form of refrigerator containers and buckets as a breeding for *Aedes sp.* habitat with the highest OR value provides an opportunity to increase dengue cases in Samarinda City. Many houses are at risk of contracting dengue fever within a radius of 100 m. The discovery of potential containers in the form of refrigerator containers and buckets as a captive for *Aedes sp.* habitat give a chance for an increase in dengue cases.

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