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Digital Mapping of Dengue Mosquito Movement towards Weather Factors, Mosquito Density, and Cultural Factors in Jember Regency

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Abstract

This study aims to map a digital movement of the Aedes aegypti mosquito in high-risk areas for dengue fever outbreaks, taking into account the public's knowledge of dengue fever, attitude towards their environment, action towards the environment, environment conditions of the community, weather and climate factors, and mosquito density assessed through the House Index(HI). This study is a quantitative observational analytic research with a cross-sectional design. The result of the linear regression test on the cultural variable of knowledge, attitudes, and family support showed an value of α >0,05, indicating the knowledge, attitude, and family support are not important internal factors in aeradicating dengue fever. Mainwhile, the action and community leader support variable showed value α <0,05, which are important internal and external factors in reducing dengue fever levels. Then, HI value for these sub-districts is 6-7, meaning thet the mosquito density is high. The Aedes aegypti mosquito buffer zone has a flying distance 200 meters according to the CDC, so ares within that reach can be affected. This is clarified by using a digital map of the risk area of the Aedes aegypti mosquito causing dengue fever. In conclution, the digital map that includes cultural data, aera characteristics starting from weather, climate, population density, altitude, temperatue, humadity, and characteristics of mosquitoes inhabiting an area, whether they are clustered os spread, can cause the movement of dengue fever mosquitoes or Aedes aegypti to become more aggressive in their activities. So, the internal and external factors in the habitat of the Aedes aegypti mosquito can cause its movement to become more dunamic in spreading the dengue virus.

Keywords: Aedes aegypti Mosquito, Culture, Dengue Fever, GIS (Geographic Information System)

INTRODUCTION

Diseases are widespread nowadays, starting from non-communicable diseases to communicable diseases that certainly pose a threat to public health (Diseases & Branch, n.d.; Gómez Gómez et al., 2022). One of the communicable diseases is dengue fever, which can affect people of all ages, as the mosquito that carries the dengue virus, particularly the female Aedes aegypti mosquito, still depends on human blood for reproduction (Abualamah et al., 2021; Lai, 2018). The geographical distribution and seasonal variations of dengue vector abundance and epidemic transmission have completely been controlled by the socio-cultural and the environmental variables. The dengue is spatially associated with socio-cultural and environmental determinants and the context varies according to different geographical areas (M.Palaniyandi, 2019).

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The dengue virus is released by the Aedes aegypti mosquito to prevent the blood sucked by the female mosquito from coagulating, and it is this blood that also becomes infected with the dengue virus (Sintayehu et al., 2020). The dengue virus attacks APCs (antigen presenting cells), which are generally macrophages originating from the liver. Viremia, which occurs before clinical symptoms appear, can be seen up to 5-7 days later (Roy & Bhattacharjee, 2021). The high-risk group for the occurrence of Dengue Fever (DF) in humans is in the age range of 5-9 years, and in Asia, it more dominantly attacks those under 15 years of age, while in the Americas, DF cases more commonly attack those over 15 years of age (Al-Tawfiq & Memish, 2018; M.Palaniyandi, 2019). The Aedes aegypti mosquito can live very close to humans. Dense residential environments are one of the important factors for the aggressiveness of Aedes aegypti mosquitoes. The daily flight range of Aedes aegypti mosquitoes is short, around 30-50 meters per day (Riskesdas, 2018) However, the farthest flight range of Aedes aegypti mosquitoes is 200 meters. This distance is based on the Aedes aegypti mosquito's need to survive and reproduce. Because Aedes aegypti mosquitoes need an ideal place to breed, they can fly up to 200 meters (Diseases & Branch, n.d.).

This mosquito usually rests inside houses and buildings, such as on hanging clothes, curtains, walls, and other dark places. Its larvae are often found in bathtub drains, used tires, and other types of water containers in residential areas. This mosquito is active during the day, especially in the morning and late afternoon (Corbel et al., 2023; M.Palaniyandi, 2019).The lifespan of Aedes aegypti mosquito is 3 weeks. Before 3 weeks, adult mosquitoes will look for an ideal environment to lay their eggs, which is in clean water puddles. These eggs take 1-2 days to become larvae, then the larvae take 4-9 days to become pupae, and the pupae take 2-3 days to become adult mosquitoes. Therefore, it can be concluded that from egg to adult mosquito, Aedes aegypti mosquitoes require around 15 days to live (Fátima et al., 2019; Fernandes et al., 2021; Roy & Bhattacharjee, 2021).

According to the data on dengue fever incidence from the Jember District Health Office, from 2018 to 2020, Jember District had the highest incidence rate of dengue fever in 2019, with 988 cases. The highest incidence rates were found in Kaliwates Sub-district, Sumbersari Sub-district, and Patrang Sub-district. Kaliwates Sub-district had 98 cases, Sumbersari Sub-district had 120 cases, and Patrang Sub-district had 102 cases (Dinas Kesehatan Kabupaten Jember, 2019). The role of GIS (Geographic Information System) in visualizing map information is to serve as a means of communication for various people to visually see an informative map. (Chan et al., 2022; Esri, 2019; Lü et al., 2019). Within GIS, it is possible to digitize maps to describe a dengue fever occurrence in a certain area and also

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predict the flight distance of Aedes aegypti mosquitoes according to their environment or habitat using Buffer Zone technique. This Buffer Zone operation is necessary for spatial analysis to determine the extent of the potential spread and location of dengue fever occurrences (Esri, 2019; Singh, 2021).

Furthermore, the House Index (HI) value is also an indicator commonly used to assess the density of Aedes aegypti mosquitoes in a specific area. The HI value indicates the number of houses that are positive for mosquito larvae in a particular area. Demographic characteristics of a region such as weather and climate can also affect the characteristics of an area that can become a habitat for Aedes aegypti mosquitoes. For example, these mosquitoes prefer temperatures between 25°C to 30°C (Jové et al., 2020; Zhao et al., 2021). In addition to temperature, weather and climate factors include humidity, altitude, rainfall, and the condition of the home environment. To support the demographic characteristics of a region, researchers also add social factors such as population density and the social and cultural environment of a region (Fernandes et al., 2021).

Knowledge, attitudes, practices, family support, and community leader support are social factors that can influence the high or low levels of dengue fever in an area. Social and cultural factors refer to an individual's response or reaction that is closed or open to a particular stimulus or object (Notoatmodjo, 2020). Therefore, the objective of this research is to create a digital map with social and cultural attributes including knowledge, attitude, behavior, environmental conditions, family support, and community leader support, as well as geographic factors such as weather and climate, HI values, and spatial buffering techniques on the map to observe the movement of Aedes aegypti mosquitoes based on these five major attributes, to achieve better environmental health.

METHODS

This study is a quantitative research with an analytical observational approach and a cross-sectional study design. The research combines the theory of Hendrik L. Blum and the theory of Lawrence Green, where in all data collection or retrieval processes, questionnaires and interviews were used simultaneously to collect primary data. The population and sample in this study were 177 respondents, and the demographic data of the area were obtained from secondary data of BPS (Central Statistics Agency) Jember in 2020 and other secondary data, such as the administrative map of Jember Regency in 2020, which were obtained from the Department of Public Works and Water Management of Jember Regency. Digital maps for the

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Buffer Zone technique and for all research variables were synchronized with the updated Google maps on Quantum GIS version 3.28. Culture data were obtained through direct interviews with respondents using questionnaires and interviews in 3 areas with high levels of dengue fever in Jember Regency. Simple regression tests were conducted to determine the influence of culture on mosquito density in these 3 areas. HI data (House Index) were obtained by direct environmental observation in 3 areas with high levels of dengue fever in Jember Regency. This primary data research was conducted for 6 months from October 2021 to April 2022, and the research was conducted in 3 locations in Jember Regency, namely Kaliwates District, Sumbersari District, and Patrang District, because these three districts had the highest levels of dengue fever in Jember Regency in 2019.

RESULTS

a. Predisposing factors of the community to dengue hemorrhagic fever in areas with high DBD cases.

Table 1. Classification of age of respondents in 3 districts with high DBD rates in Jember Regency

Responden	Districts Sumbersari		Districts Patrang		Districts Kaliwates		Total	
	n	%	n	%	n	%	n	%
Age 15 - 23 Years	20	33,4	25	41,6	23	40,3	68	58,8
Age 24 - 35 Years	30	50	20	33,4	17	29,8	67	40,2
Age 36 - 45 Years	10	16,6	15	25	17	29,8	42	25,2

Table 2. Results of linear regression analysis on the level of public knowledge about DBD in 3 districts with high DBD cases in Jember District.

Variabel	Districts Sumbersari		*P-Value*	Districts Patrang		*P-Value*	Districts Kaliwates		*P-Value*
	n	%		n	%		n	%	
Knowledge									
insufficient	13	19.4		4	7.3		7	12.9	
adequate	30	44.8	0,123	23	42.9	0,123	25	45.4	0,123
good	24	35.9		27	49.8		21	41.7	

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Table 2 shows the linear regression test of the knowledge variable on mosquito density. The results indicate a non-significant value of the knowledge variable on mosquito density in the three districts with high dengue fever intensity in Jember Regency.

Figure 1. Digital map of community knowledge level regarding Dengue Hemorrhagic Fever in Patrang, Sumbersari, and Kaliwates districts.

It can be seen from the map that the community's good knowledge about Dengue Hemorrhagic Fever in their area is in Patrang District, depicted in dark blue, while the other two districts, Kaliwates and Sumbersari, have light blue shades indicating that knowledge in these two districts is categorized as sufficient.

Table 3. Linear regression results on the level of community attitudes towards Dengue Hemorrhagic Fever in 3 districts with high cases of DBD in Jember Regency

Variabel	Districts Sumbersari		*P-Value*	Districts Patrang		*P-Value*	Districts Kaliwates		*P-Value*
	n	%		n	%		n	%	
attitude									
less caring attitude	9	13.4		1	1.8		5	9.1	
moderately caring attitude	15	22.4	0,286	7	12.7	0,286	12	21.9	0,286
very caring attitude	43	64.2		47	85.5		38	69.1	

Table 3 shows the linear regression test of the attitude variable on mosquito density. The results indicate a non-significant value of theattitude variable on mosquito density in the three districts with high dengue fever intensity in Jember Regency.

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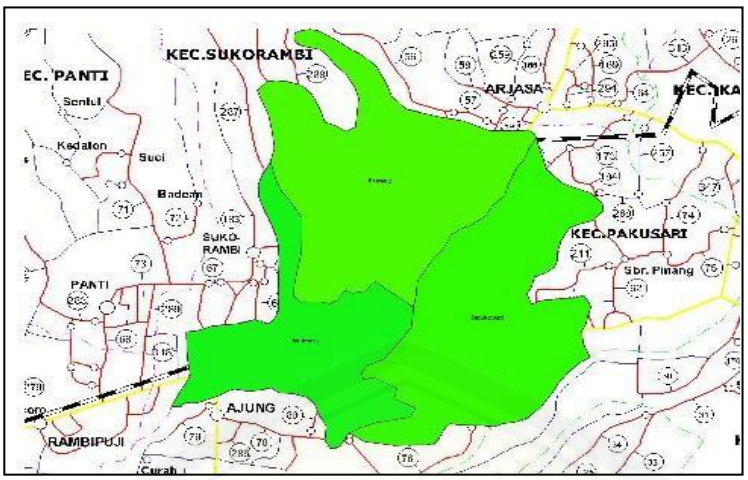

Figure 2. Digital map of Community Attitudes towards Dengue Hemorrhagic Fever in Patrang, Sumbersari, and Kaliwates districts..

The above Figure 2 shows the digital map of the Community Attitude towards Dengue Hemorrhagic Fever (DHF) in Patrang Subdistrict, Sumbersari Subdistrict, and Kaliwates Subdistrict. The map reflects that the community attitude towards the level of DHF in their surrounding area in these three sub-districts falls under the "very concerned" category. The researcher used light green color to represent these sub-districts in this digital map.

Table 4 Linear regression results of community action factors on DBD in 3 districts with high DBD rates in Jember Regency.

Variabel	Districts Sumbersari		*P-Value*	Districts Patrang		*P-Value*	Districts Kaliwates		*P-Value*
	n	%		n	%		n	%	
actions									
not doing	31	46.3	0,036*	6	10.9	0,032*	4	7.3	0,046*
doing	36	53.7		49	89.1		51	92.7	

Table 4 shows the linear regression test of the action variable on mosquito density. The results indicate a significant value of the action variable on mosquito density in the three districts with high dengue fever intensity in Jember Regency.

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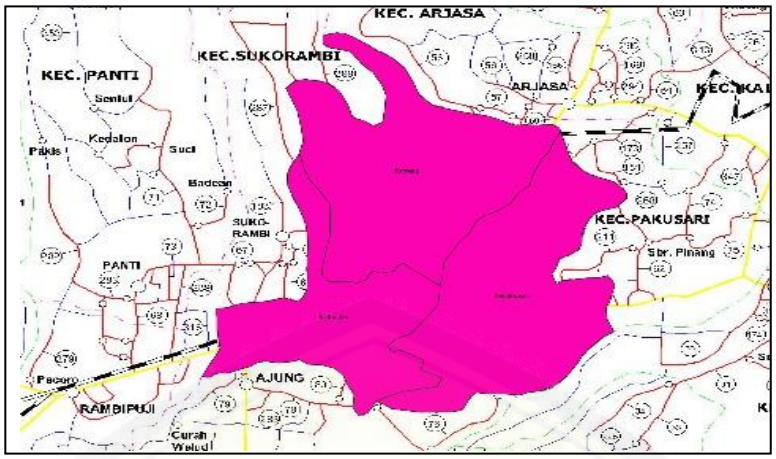

Figure 3. Digital map of Community Actions against Dengue Hemorrhagic Fever in Patrang, Sumbersari, and Kaliwates Districts.

In figure 3 above, it can be seen that the three districts are depicted with a light pink color. According to the research results, the community's actions in these three districts towards their environment are already very good, starting from always draining bath tubs, always checking for stagnant water and disposing of it, regularly disposing of trash in its place, and always cleaning the drainage channels around their homes independently or collectively every week.

b. Enabling factors of the community towards dengue hemorrhagic fever in areas with high DBD cases

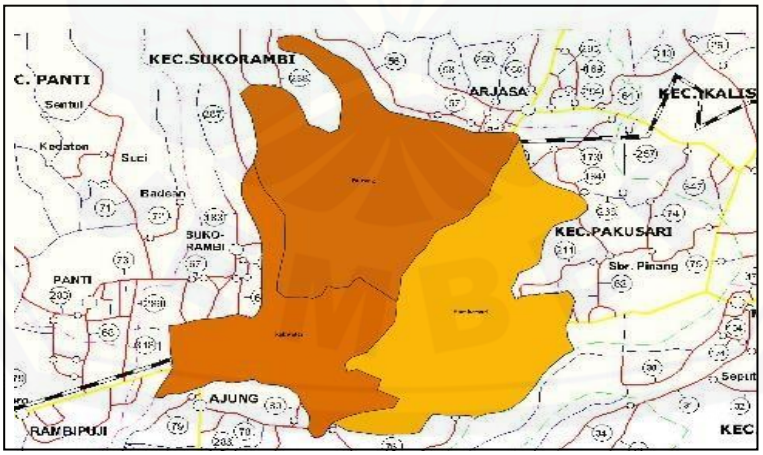

Figure 5. Digital map of community environmental characteristics related to dengue fever in Kec.Patrang, Kec.Sumbersari, and Kec. Kaliwates.

It can be seen from the map that the environmental conditions of the two districts, Kaliwates and Patrang, fall into the unhealthy category, depicted by the researcher in dark orange color. Meanwhile, Sumbersari district is categorized as less healthy because it has an

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equal number of healthy and unhealthy houses, 25 each, depicted by the researcher in yellow color.

c. Reinforcing factors of the community towards dengue hemorrhagic fever in areas with high DBD cases

Table 5 Linear regression test results on the factor of family support for respondents against dengue fever in 3 sub-districts in Jember Regency with high dengue fever rates.

Variabel	Districts Sumbersari		*P-Value*	Districts Patrang		*P-Value*	Districts Kaliwates		*P-Value*
	n	%		n	%		n	%	
Family support									
less supportive	23	34,3		7	12,7		9	16,4	
supportive	25	37,3	0,073	28	50,9	0,666	29	52,7	0,776
very supportive	19	28,4		20	36,4		17	30,9	

From this linear regression result, it was found that family support did not have any significant influence on the occurrence and management of dengue fever, which could be due to many people still disregarding regulations or policies issued within the family, as there is still a lack of trust among family members.

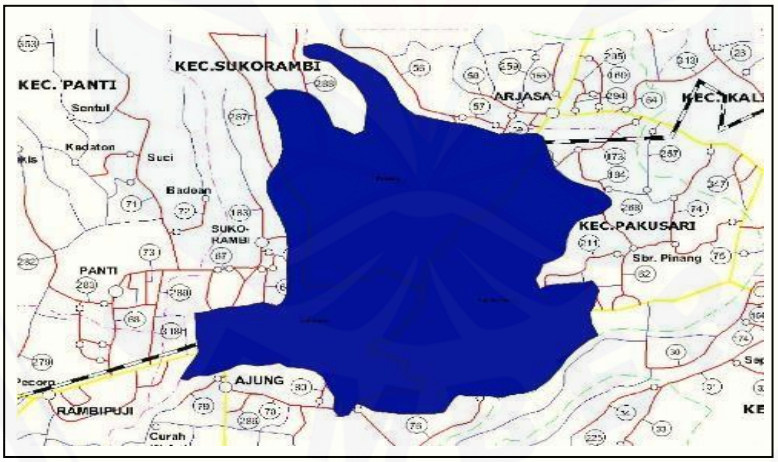

Figure 6. Digital map of family support for dengue fever rates in Patrang Sub-district, Sumbersari Sub-district, and Kaliwates Sub-district.

The map shows that family support in the community in the three sub-districts falls under the supporting category, which is depicted by the researcher using a dark blue color. This category includes family support in keeping their home environment clean, taking care of the surrounding environment, and preventing mosquitoes from entering the house.

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Table 6. Linear regression test results of community leader support factors of respondents towards DBD in 3 districts in Jember Regency that have high levels of DBD.

Variabel	Districts Sumbersari		*P-Value*	Districts Patrang		*P-Value*	Districts Kaliwates		*P-Value*
	n	%		n	%		n	%	
Support from community leaders									
less implementation	38	56,7	0,041*	13	23,6	0,047*	10	18,2	0,040*
implementing	29	43,3		42	76,4		45	81,8	

The linear regression analysis shows that the support of community leaders has an influence on the occurrence and prevention of Dengue Fever (DBD) in the high-risk areas in Kabupaten Jember. This support is a behavior influenced by community leaders in the neighborhood, such as the head of RT, head of RW, or village head.

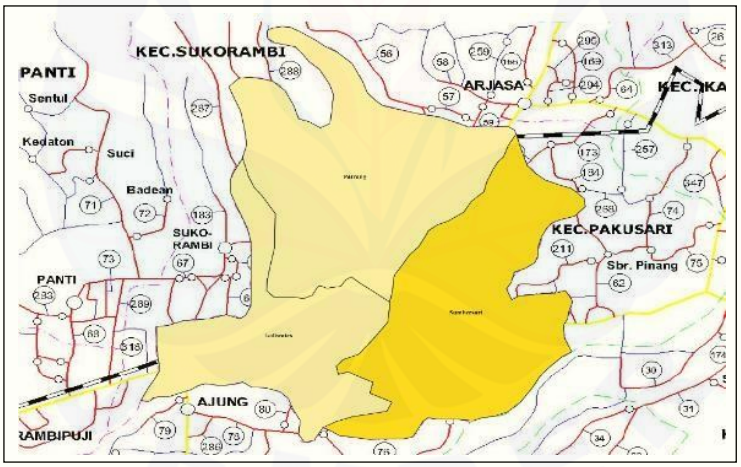

Figure 7. Digital map of community leader support for the level of dengue fever in Patrang, Sumbersari, and Kaliwates districts.

From the map, it can be seen that the support of community leaders in two districts falls into the category of "implemented," while Sumbersari district falls into the category of "less implemented." The researcher represented this with a light yellow color for the "implemented" category and a darker yellow color for the "less implemented" category.

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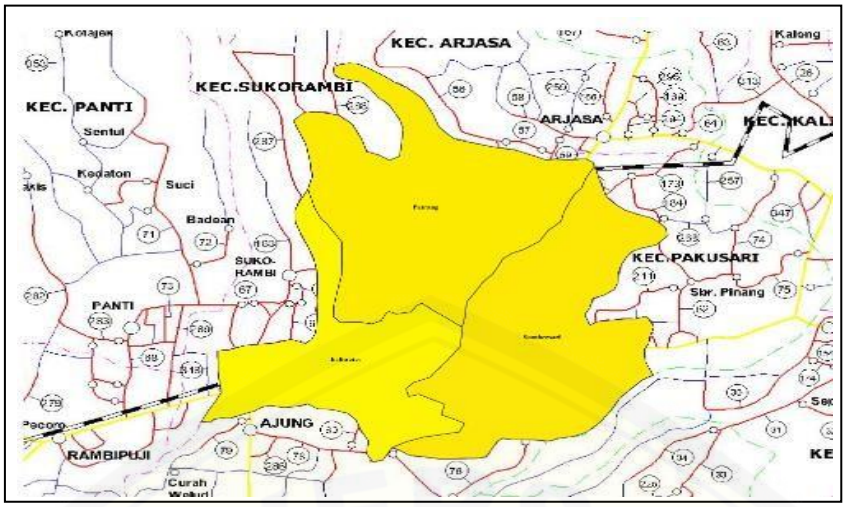

Figure 8 shows a digital map of mosquito density based on HI (House Index) values in three sub-districts.

It can be seen that the above digital map depicts strong yellow color in the areas of Kec. Patrang, Kec. Sumbersari, and Kec. Kaliwates. These three sub-districts are areas where the density of mosquitoes based on the House Index value has a Density Figure (DF) in the high category as determined by the WHO.

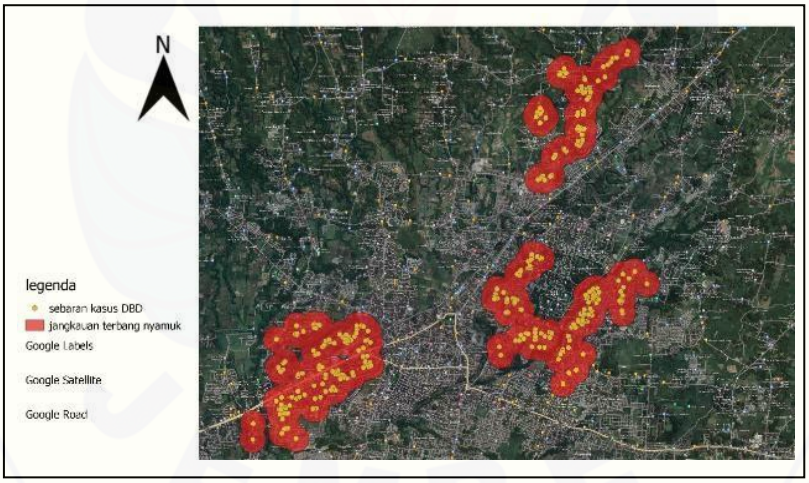

Figure 9. Digital map of the coverage area or buffer zone of Aedes aegypti mosquitoes based on the distribution points of dengue fever cases.

The digital map above depicts the range of Aedes aegypti mosquitoes based on the cases of dengue fever in three sub-districts, namely Patrang, Kaliwates, and Sumbersari. The researcher used a buffer zone of 200 meters from the dengue fever cases, where the yellow dots represent the cases and the red area represents the range of mosquitoes found around those dots, extending 200 meters. This is consistent with data released by the CDC, which states that Aedes aegypti mosquitoes can fly up to 200 meters. The digital map is also directly updated

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from Google maps, so the location of an area is more up-to-date and its coordinates are more precise.

DISCUSION

a. Predisposing factors of the community to dengue hemorrhagic fever in areas with high DBD cases.

Knowledge is something that can affect the formation of each individual's behavior (overt behavior). When these behaviors are accompanied by adequate knowledge, they can last long, but without adequate knowledge, the behavior may change and not be in line with the knowledge (Notoatmodjo, 2020). So, based on Figure 1, we can analyze that the highest level of knowledge, which is in the good category, is found in Patrang District because Patrang District has respondents with an average age of 15-23 years. Actually, Sumbersari District is almost similar to Patrang District, but Sumbersari District, with its quantity of respondents with an average age of 15-23 years, loses to Patrang District. In this study, respondents with an age range of 0-14 years were not examined because they were not old enough to be surveyed on their knowledge of dengue fever. From the results of the research in the three districts, it can be described that knowledge is not one of the factors that increases the density of Aedes Aegypti mosquitoes. Although knowledge is one of our senses, especially the most dominant one (around 75% to 87%) perceived by our eyes, while 13-25% of human knowledge is obtained or conveyed through other senses, so the more senses are used, the clearer the knowledge gained (Jové et al., 2020).

Attitude is an organization that has a settled nature from an emotional process, so this emotional state needs to be formed massively and takes a long time. This is what causes the attitude to not be able to affect the high or low level of mosquito larvae which can result in Dengue Fever (Arfan et al., 2022). So this attitude does not have an influence because the influence of a culture or habit that originates from previous generations will be stronger than a newly formed attitude in a few months or years. Therefore, attitude is directly related to culture, and culture is formed due to the routine of a series of activities, such as how long the activity is carried out until it becomes a routine activity, so attitudes can change when the culture of a certain area also changes (Gabiane et al., 2022; Gan et al., 2021)For these reasons, attitudes cannot have a massive impact in reducing the incidence of DBD in a particular area. Because once again, attitudes take a long time to be accepted by a community in an area with a high level of cultural adherence.

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Although there are still some communities in these three districts that have a less good category of actions towards the level of DBD, which is indicated by the lack of awareness and laziness of the people in the area to clean up their environment, poor drainage channels around their homes, and the overcrowding of settlements in the area.

An individual's actions will be influenced by various factors, such as the availability of tools, inhibiting conditions, prevailing norms, and cultural systems in a given environment. Thus, tools, norms, and culture are one unit of an individual in taking action. When tools are not available and norms are abandoned, then a culture of neglect towards something that should be acted upon will be formed (Lai, 2018; Zuharah et al., 2021).

b. Enabling factors of the community towards dengue hemorrhagic fever in areas with high DBD cases

Theoretically, it is stated that Aedes aegypti mosquitoes breed well in clean water that does not come into contact with soil. This is a good biotic environment for Aedes aegypti mosquitoes because clean water has a good pH. This is what refers to the researchers that many puddles can affect the level of DBD in a region. According to researchers, rainwater collected in containers is a good biotic environment for Aedes aegypti mosquitoes to breed. Aedes aegypti mosquitoes have a preference for clean water as a place to lay eggs and for their breeding ground. Some factors that influence female mosquitoes to choose places to lay eggs are temperature, pH, ammonia, nitrate, sulfate levels, as well as humidity, and mosquitoes usually prefer places that are not directly exposed to sunlight (Ferede et al., 2018; Mercier et al., 2022).

The House Index value is one of the indicators commonly used for vector surveillance of dengue fever. The House Index value indicates the number of houses with positive larvae in a particular area. Therefore, efforts are needed to reduce the House Index value in a given area. Factors that can influence the high House Index value are community behavior and participation, which are still lacking in mosquito breeding site eradication (PSN). The PSN 3M plus program based on the Indonesian Ministry of Health is draining, closing, and utilizing/recycling used goods, conducting larviciding, biological control by maintaining larvivorous fish, and using personal protective equipment such as mosquito nets, anti-mosquito lotion, etc. Extreme to moderately high rainfall is associated with 8 infectious diseases during the 2004-2008 period, one of which is dengue fever (Zhang et al., 2019). Temperature can affect the level of development and survival of Aedes aegypti vector. The factors of food availability, larval density, and temperature have a significant effect on the development and survival of Aedes aegypti larvae (Lai, 2018). The ideal air humidity for the development of

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Aedes aegypti mosquito larvae in nature ranges between 60% to 80%. If this humidity range occurs in an area, the development and growth of Aedes aegypti mosquitoes will be very rapid (M.Palaniyandi, 2019).

Every day, Aedes aegypti mosquitoes can fly up to 50 meters to be active. Therefore, it can be concluded that the denser a settlement is in an area, the higher the risk of dengue fever cases in that area. Also, the denser the area, the higher the potential for mosquito range to infect humans with the dengue virus (Corbel et al., 2023; Fernandes et al., 2021). Climate change in a place greatly affects the bionomics of Aedes aegypti mosquitoes, which are carriers of the dengue virus. Seasonal factors contribute to the increase in Aedes aegypti mosquitoes and potential outbreaks in an area. Different environmental conditions in each location can determine the number of Aedes aegypti mosquitoes found. These mosquitoes usually lay their eggs and larvae in discarded tires that become breeding sites for stagnant water. Thus, areas with many discarded tires filled with stagnant water are more likely to have a higher population of Aedes aegypti mosquitoes (Corbel et al., 2023).

c. Reinforcing factors of the community towards dengue hemorrhagic fever in areas with high DBD cases

This family support can be a factor that changes a person's old habits into new and better ones or simply remain as support with no change in habits. From these results, it can be said that the respondents are very enthusiastic about dengue fever prevention and control both in their own environment and the surrounding environment, which is influenced and encouraged by their families. Some family support actions in the community in the three sub- districts include using mosquito nets, mosquito repellent coils, and mosquito repellent devices to repel and prevent mosquitoes from entering their homes. This occurs because family support comes from the internal family or community. Family support is an attitude of action and acceptance of family members that is always supportive and ready to provide help and assistance when needed. A family is the smallest unit of society, consisting of a head of household and several people who live together and depend on each other (Ware-Gilmore et al., 2023; Zuharah et al., 2021).

Support from community leaders is a support obtained from interpersonal relationships that refer to pleasure, peace, and beneficial assistance, which comes in the form of verbal information that is certainly accepted by individuals or communities from community leaders who bring behavioral effects. Community leaders' positions are obtained by individuals because of their knowledge, wisdom, and success in living in the community. This wisdom and knowledge possessed by community leaders usually become role models for people in their

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respective fields. Because of their activities, skills, and characteristics, community leaders are respected and esteemed (de Macêdo et al., 2021; Parker et al., 2019).

CONCLUSIONS

The factor of public knowledge shows that knowledge alone is not enough to increase or decrease the density of Aedes aegypti mosquitoes in Jember Regency, as it is insufficient to change people's habits in combating the mosquitoes. The factor of public attitude also shows that attitude alone cannot have a massive influence on the high or low density of mosquitoes that cause Dengue Fever. This is because a person's attitude cannot be changed quickly to take action in Jember Regency. In the factor of action, it is the most influential factor in determining the high or low density of mosquito larvae that cause Dengue Fever. This is because actions can change the human environment and have an impact on their lives in Jember Regency. The condition of the home environment, including its cleanliness, sanitation, and the amount of stagnant water, can be the key to increasing the number of Aedes aegypti larvae that can breed in a certain environment. Family support is still not massive enough to be used to reduce the number of Dengue Fever cases in Jember Regency, as it can only be a supporting factor and cannot necessarily change a person's long-standing habits. Compared to the support of community leaders, it may have a different effect, as people tend to follow the policies or regulations set by them rather than those set by their own family. From the digital map presented, the areas with a high incidence of Dengue Fever in Jember Regency are located in three districts, namely Patrang, Kaliwates, and Sumbersari, which have higher temperatures, higher humidity, lower altitude, and the highest population density compared to the surrounding areas. Therefore, Aedes aegypti mosquitoes have an ideal habitat in these three districts, and their efficient flying range makes it easier for them to infect humans.

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