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Identification of Dengue Hemorrhagic Fever Risk Zone in Daerah Istimewa Yogyakarta Province 2021

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Abstrak

Daerah Istimewa Yogyakarta (DIY) merupakan salah satu wilayah endemik Demam Berdarah Dengue (DBD) di Indonesia. Pada 2021, *Incidence Rate* (IR) DIY mencapai 32/100.000 populasi dengan *Case Fatality Rate* (CFR) mencapai 1,01%. Untuk mengurangi jumlah kasus DBD diperlukan suatu tindakan pencegahan. Manajemen penyakit berbasis wilayah dapat menjadi solusi mengurangi kasus DBD, seperti pemetaan risiko penyakit. Penelitian ini bertujuan untuk mengetahui tingkat risiko penularan DBD di Provinsi DIY tahun 2021. Penelitian ini merupakan studi *cross-sectional* dengan pendekatan pemetaan dan ekologis. Variabel faktor risiko yang berkorelasi dengan insiden DBD akan di skoring, kemudian hasilnya dijabarkan menggunakan peta risiko DBD. Penelitian dilaksanakan pada bulan September-Oktober tahun 2022. Berdasarkan analisis bivariat, faktor iklim memiliki hubungan dengan kejadian DBD. Pada Bulan Januari, wilayah Kota Yogyakarta dan Kulon Progo berada dalam risiko tinggi. Pada bulan November, wilayah Gunungkidul berada dalam risiko tinggi. Pada bulan Desember daerah dengan kategori tinggi antara lain Bantul dan Gunungkidul. Distribusi risiko DBD di DIY meningkat selama musim hujan. Pembuat kebijakan diharapkan dapat memprioritaskan daerah berisiko tinggi dalam menciptakan kebijakan.

Abstract

Daerah Istimewa Yogyakarta (DIY) is one of dengue endemic regions in Indonesia. In 2021, Dengue Hemorrhagic Fever (DHF) Incidence Rate (IR) in DIY was 32/100,000 population with Case Fatality Rate (CFR) reaching 1.01%. Reducing DHF cases is necessary to take preventive actions. Area-based disease management can be a solution to reduce DHF cases, such as mapping analysis of disease risk map. This research aims to determine the DHF transmission risk level in DIY Province during 2021. It is a cross-sectional study with mapping and ecological approach. Risk factors that correlate with DHF incidence will be scored, then the results will described as risk map. This research was conducted in September-October 2022. Based on bivariate analysis, climatic factors have a correlation with DHF. In January, Yogyakarta City and Kulon Progo were in high risk. Gunungkidul was highly vulnerable. in November. In December regions with high category include Bantul and Gunungkidul. DHF risk distribution in DIY was increased during rainy season. Policy makers are expected to prioritize high-risk areas in creating policies.

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INTRODUCTION

Dengue Hemorrhagic Fever (DHF) is a mosquito-borne viral disease caused by the Dengue Virus (DENV), which is transmitted through mosquito bites from *Aedes* Genus (WHO, 2022). Dengue is a global public health burden affecting over 120 countries. In the last decade the number of DHF cases has increased significantly, to over 2.4 million in 2010, and 5.2 million in 2019 (WHO, 2022). Although 50% of the world's population is at risk of dengue, Asia contributes 70% of the global dengue burden (WHO, 2022).

In Indonesia, Incidence Rate (IR) of DHF in 2021 is 27/100,000 population, this figure is still lower than IR DBD in 2020, which is 40/100,000 population. Tiga provinsi dengan IR DBD tertinggi yaitu Kepulauan Riau (80,9%), Kalimantan Timur (78,1%) dan Bali (59,8%). Even though Indonesia's DHF IR has decreased, Indonesia's DBD IR has increase, 0.69% in 2020 up to 0.96% in 2021 (Kemenkes RI, 2021). In 2021, DHF cases in DIY Province up to 1,188 cases. IR of DHF in DIY Province in 2021 was 31/100,000 population. While the CFR of DHF in DIY Province is 1.01%, this figure is still higher than the national target (<1%).

Based on Triad Epidemiology, the occurrence of disease cannot be separated from its risk factors including agents and environments. Some of the risk factors that cause DHF are related to an increase in dengue virus transmission, including human factors, vector factors, and environmental factors. Risk factors related to human problems include population density, type of settlement, mosquito nest eradication behavior, and larvae-free numbers (LFI). Vector factors include mosquito population density with indicators such as *House Index* (HI), *Container Index* (CI), and *Breteau Index* (BI). Meanwhile, environmental factors include climate and other environmental factors that can affect mosquito populations. Risk factors that are related to the incidence of DHF include sociodemographic, environment, Place Dwelling and climatology (Ismah, 2021). Disease agents such as bacteria, viruses or parasites, and vectors are sensitive to air humidity, air temperature, and environmental conditions. According to research (Ramadona, 2016; Tosepu, 2018; Kesetyaningsih, 2021), climatic factors such as rainfall, temperature, and humidity can be the cause of the increase in DHF cases. Not only climate factors, but also population factor can influence DHF incidence. According to (Kusuma, 2016), there is a relationship between population density and the pattern of DHF transmission. Areas with high population density show a cluster or clustered pattern and the prevalence is more often than areas that has lower population density. In previous study, it was shown that population density affects the incidence of DHF, the higher the population density, the higher the incidence of DHF (Paomey, 2019; Kusumawati, 2020; Alfiyanti, 2021).

One of the actions to control DHF can be done by mapping it risk factors. In a previous study (Chandra, 2019), mapping can describe the level of DHF risk in Jambi City. The rapid development of technology brings progress in various aspects of human life, including health. A Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, organize and display all types of geographic data (Irwansyah, 2013). GIS in the health sector means a computer-base geographic program, which is health data that are regularly interrelated, thus forming a whole description (information) in the form of visualizations or map images that make it easier for health workers to analyze health situation data in a certain space, place, region and time. In more detail, a risk map can be interpreted as a map consisting of certain data sets, which can describe the topography of the area, threats/dangers, demography, natural resources, and so on (Husein, 2017).

In the previous study (Sekarrini, 2020), this study shows that the use of GIS is very useful for predicting DHF risk in an area and makes it easier to determine interventions that can be carried out to prevent DHF in the future. Then, based on the (Mufti, 2021) research, in this study, the research variables were divided into three categories using the range formula, then accumulated using the disaster risk formula. Although this research use the same approach and method with the previous researchs, in this research the researcher focuses more on variables that have a correlation with the incidence of DHF. Furthermore, the research location and research variables are different from previous study. So the results will be different from the previous researchs. Then, this research will be carried out to complete the existing DHF mapping in DIY Province, which focuses on LFI and HI. Meanwhile, in this study the researchers attempted to complete the DHF risk map with climate variables which included (rainfall, humidity, and temperature).

Based on background of the problem above, researchers conducted this research related to the use of GIS in mapping DHF risk in DIY Province in 2021. The aims of this research is to determine the DHF transmission risk level in DIY Province during 2021, with the initial hypothesis that there is a correlation between demographic variables and climate variables with the incidence of DHF.

METHOD

This research is a analytical observational study with a cross-sectional design and mapping approach with population analysis units (ecologic). The populations in this research including all confirmed cases of DHF per city/regency, DHF mortality data, population density data, HI data, Larva Free Index (LFI) data, and climate data (rainfall, humidity, and temperature) in DIY Province during 2021. This research use total sampling method, the samples in this research are monthly DHF confirmed cases, DHF mortality, HI, LFI, climate data (rainfall, humidity, and temperature) and population density data in a year at DIY Province during 2021. The dependent variable in this research is IR of DHF in each city/regency in DIY Province. Meanwhile, the independent variables in this research consisted of population density, CFR, HI, LFI, rainfall, humidity, and temperature.

The research was conducted in the DIY Province. DIY Province is located in the southern part of Java Island, and is bordered by Central Java Province and the Indian Ocean. Astronomically, it is located between 7.33-8.12 South Latitude and 110.00-110.50 East Longitude, recorded to have an area of 3,133.15 km or 0.17% of Indonesia's area (1,860,359.67 km). DIY Province concist of four regencies and one city, namely: Kulon Progo Regency, Bantul Regency, Gunungkidul Regency, and Yogyakarta City. DIY Province in the south is bounded by the Indonesian Ocean, while in the northeast, southeast, west and northwest it is bordered by the Central Java region which namely: Klaten Regency in northeast, Wonogiri Regency in the southeast, Purworejo Regency in the west, and Magelang Regency in the northwest.

Process of data collection in this study can be seen in the Figure. 1. First, 1.188 records data of confirmed DHF cases and 12 death cases data was collected from the Provincial Health Office of DIY. Second, 5 records of population density data at city/regencies level was taken from the Central Statistics Bureau of DIY. Then, from the data on confirmed cases, death cases, and population density, IR and CFR data were obtained. Third, 1.259 records of LFI data and 1.359 HI data record were obtained from the Sistem Surveilans Vektor dan Binatang Pembawa Penyakit (SILANTOR 2.0). Fourth, 730 rainfall data records, 730 records of air humidity data, and 730 records of temperature data were obtained from the Meteorological, Climatology, and Geophysics Bureau of the DIY. Then, data regarding DHF special regulations, One House One Movement data, and the Wolbachia program data were obtained through interviews with DHF Programmer at the Provincial Health Office of DIY.

This study uses a total sampling technique. The research sample included 1,188 confirmed DHF case records, 12 DHF death case records, 5 population density data at the city/district level, 1,259 ABJ data and 1,359 HI data, 638 rainfall data (121 data missing), 727 humidity data (3 data missing), and 727 temperature data (3 data

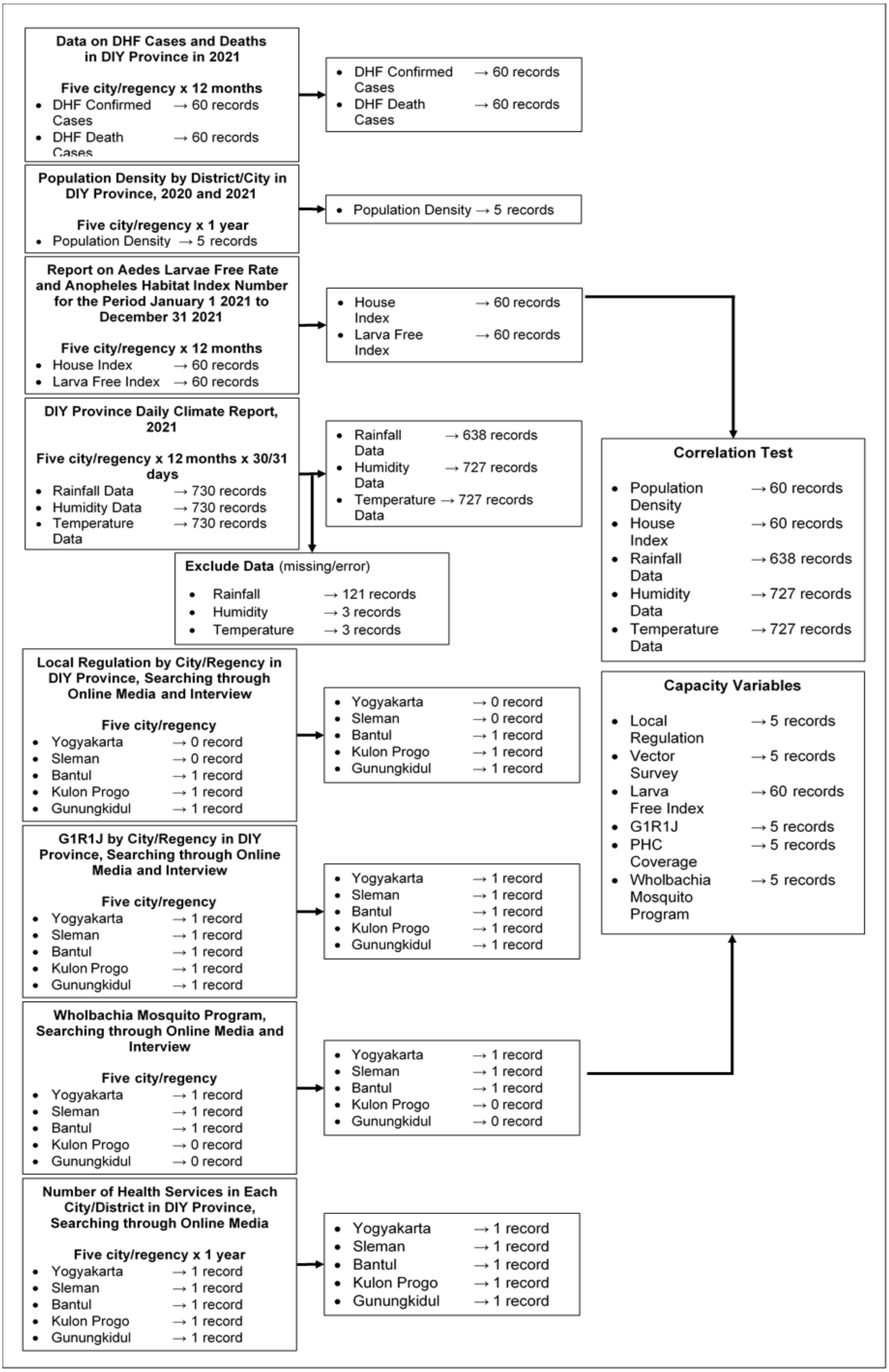

Figure 1. Chart of Research Variable Data Collection Process in Diy Province in 2021

missing). The obtained data will be calculated on an average per month include, DHF IR, DHF CFR, HI, and climate data (rainfall, humidity, and temperature). Meanwhile, population density data will be categorized per city/district for 2021.

Data analysis carried out using *Jamovi software version 1.6.15*, the data will be analyzed univariately used to find out the frequency distribution of each variable and to find out the correlation between bound variables and free variables researchers using Spearman Rank bivariate analysis. Spatial analysis was also carried out to describe the spatial pattern of tuberculosis risk based on significantly correlated variables, using *QGIS software version 3.16.14*.

The sample data will be scored using the range formula. Scoring process is used to determine which regions are at risk for DHF transmission. Scoring is given based on the predefined categories of each variable. There are three scoring categories, namely: a) low category (1 score), b) moderate category (2 scores), and c) high category (3 scores). The range formula is as follows,

$$Range = \frac{NMax - NMin}{Number\ of\ Classes}$$

Note:

- Nmax : The highest data (maximum score)
- Nmin : The lowest data (minimum score)

Then, capacity data is divided into two categories, namely the presence or absence of special programs related to DHF control. For scoring on capacity data, if it is in the "Yes" category it gets one score and if it is "No" it gets zero score.

The DHF vulnerable zone score is calculated based on the sum of the scores for each variable adjusted for the formula from the book, (Husein, 2017), while the formula is as follows,

$$\text{Risk} = \text{Treat x } \frac{Vulnerability}{Capacity}$$

Note:

- Treat : Treat score based on Incidence Rate (IR) and Case Fatality Rate (CFR) for each city/district in DIY Province.
- Vulnerability : Vulnerability scores are based on House Index (HI), population density, rainfall, average humidity, average temperature.
- Capacity : Capacity scores are based on local regulations, vector surveys, Larva-Free Index (LFI), 1 House 1 Jumantik Movement (G1R1J), PHC coverage based on population density, andthe *Wolbachia* mosquito program.

The sum of the risk scores for each variable is calculated using *Range* formula to obtain a classification, while the calculation is as follows: a) low category (X<9), b) moderate category (9-14), and high category (X>14).

This research was carried out after obtaining Ethical Clearance (EC) approval from KEPK (Komite Etik Penelitian Kesehatan), Universitas Negeri Semarang with letter number (460/KEPK/EC/2022).

RESULT AND DISCUSSION

Data of DHF cases in DIY Province 2021 recorded in the Provincial Health Office of DIY data source shows that there are 1.188 confirmed cases of DHF in all regions of DIY Province. Bantul Regency is the area with the largest number of DHF cases with 410 cases, while the area with the smallest cases is Yogyakarta City with 93 cases. The IR of DHF in DIY is 31,99 per 100.000 population during 2021 with an average value for each city/district is 32,76 per 100.000 population. Meanwhile, the average monthly IR for each city/district in the Province of DIY reaches 2,73 per 100.000 population. Bantul Regency is the area with the highest IR of DHF in DIY Province in 2021 (December), it is 14,22 per 100.000 population, while the area with the lowest IR of DHF is Gunungkidul Regency (in July & August), it is 0,00 per 100.000 population. CFR of DHF in DIY Province is 1,01% with an average CFR per city/regency is 1,21%. This figure is higher than the national CFR target (< 1%). Kulon Progo Regency was the area with the highest CFR of DBD in DIY Province in 2021 (August) with 25%.

The population used in this study is the population in the DIY Province, so the results of this study can only be generalized to the DIY Province at population level. The average population density of each city/regency in DIY Province is 3.358 people/km^2. Yogyakarta City as the area with the highest population density with 11.579 people/km^2 and Gunungkidul Regency with the lowest population density of 510 people/km^2. Based on DHF case data and population data in DIY, the incidence of DHF can be determined as shown in Figure. 2.

There are 60 datas for each vulnerability variables (HI, population density, rainfall, humidity, temperature). This amount is obtained through the process of converting data into monthly data. This number is obtained after eliminating blank and error data, then it is categorized into a monthly average. The LFI is one of the important indicator related to DHF. Overall, the average LFI in DIY Province reaches 85%, this figure is still far from the target, which is more than 95%. The area with the highest LFI in DIY during 2021 is Yogyakarta City (July) reached 96%, while Kulon Progo Regency is the area with the smallest LFI (July) reached 56%. The distribution of the characteristics of the research variables can be seen in Table. 1 below.

Table 1 shows the variables that are normally distributed with the IR of DHF in the DIY Province in 2021. First, the average HI in DIY Province is 13% with an SD of 5,71. Second, the average humidity per month reaches 83,4% with an SD of 2,99. Finally, the average temperature per month reaches 26,4ºC with an SD of 0,359. Meanwhile, there are several variables that are not normally distributed. First, IR of DHF, it median in DIY Province is 2,03% per 100.000 population with the lowest IR being 0% and the highest IR value reaching 14,2%. Second, DHF CFR, the median of DHF CFR is 0% with the lowest incidence being 0% and the highest incidence reaching 25%. Third, rainfall, which shows a median of 223 mm^3 with the lowest rainfall being 2,30 mm^3 and the highest rainfall being 496 mm^3.

The HI variable in DIY Province has a fluctuating pattern. In December Gunungkidul Regency was the area with the highest HI (28,3%) and Yogyakarta City was the area with the lowest HI (3,57%) in July. The fluctuating pattern is also shows by the CFR of DHF variable.The highest CFR percentage occurs in August, with Kulon Progo Regency being the region with the highest CFR (25%).

Based on the results of the bivariate analysis in Table. 2, it shows that variables of rainfall, humidity, and temperature have a significant relationship to the IR of DHF for each city/district in the DIY Province during 2021. Rainfall having a moderate correlation with a positive relationship (r = 0,584) with monthly DHF cases for each city/district in the DIY Province during 2021. Determination coefficient (r^2) = $(0,584)^2$ = 0,341 = 34,1%, thus the incidence of DHF in DIY Province is 34,1% determined by rainfall, and the rest 65,9% is

Table 1. Univariate Analysis Results of DHF Risk Factors and IR of DHF per City/Regency in DIY Province for 2021

Variables (Normal Distributed)	**Central Tendency**			**Dispersion Measure**	
	Mean	**Median**	**Mode**	**SD**	**Variance**
House Index (HI) (% Average per month)	13	12,1	9,95	5,71	32,6
Humidity (%Average per month)	83,4	83,4	78,2	2,99	8,95
Temperature (°C Average per month)	26,4	26,3	26,0	0,359	0,129

Variables (Not-Normal Distributed)	**Central Tendency**		**Dispersion Measure**	
	Median	**Mode**	**Min-Max**	**Range**
DHF IR (per 100.000 population)	2,03	2,46	0-14,2	14,2
DHF CFR (% Average per month)	0,00	4,08	0-25	25,0
Rainfall (Per mm^3)	223	137	2,30-496	493

Sources: Provincial Health Office of DIY 2021, dan BMKG DIY 2021.

determined by other factors. Air humidity variable has a moderate correlation with a positive relationship with DHF (r = 0,543). Determination coefficient (r^2) = $(0{,}543)^2$ = 0,2948 = 29,48%, thus the incidence of DHF in DIY Province is 29,48% determined by humidity, and the rest 70,52% is determined by other factors. Then, the temperature variable has a weak correlation with the incidence of DHF (r = 0,327). Determination coefficient (r^2) = $(0{,}327)^2$ = 0,1069 = 10,69%, thus the incidence of DHF in DIY Province is 10,69% determined by temperature, and the rest 89,31% is determined by other factors.

Meanwhile, the HI variable did not has a significant relationship with the IR of DHF in DIY Province. In line with the previous research about relationship between the presence of *Aedes sp* larvae and DHF cases in North Semarang Sub-District, it shows that there is no significant relationship between the HI (p-value = 0,497) and the incidence of DHF (Retnaningrum, 2019). The same results were also found in the city of Bandung, where the density of *Aedes sp* mosquito larvae was not a direct cause of DHF cases in the city of Bandung during 2011-2013, the density of larvae was only related to the population and bionomics of *Aedes sp* mosquitoes. (Hakim, 2015). Another study found that areas with mosquito densities reaching HI>5%, may be caused by mosquitoes that are resistant to the insecticides used, have a high risk of DHF transmission (Izza, 2023). Rainfall, humidity, and temperature variables have a positive relationship with the incidence of DHF. This indicates that the higher the rainfall, humidity, and temperature in an area, IR of DHF in that area will be higher. In previous study shows that rainfall has a significant influence on DHF cases (Syahbani, 2020). Similarly to the study (Nugraha, 2019; Yushananta, 2021a), rainfall and humidity are positively correlated with the increase in dengue cases.

The rainfall data is divided into three categories, namely the high category with a range of >331 mm^3, the moderate category with a range between 167 mm^3 – 331 mm^3, and the low category with a range of <167mm^3. It can be seen in Figure 2 that, in January, high rainfall occurs in all provinces of DIY. February is dominated by moderate rainfall. In the following month, rainfall in Kulon Progo and Bantul was classified as low, while for other areas it was classified as moderate. Rainfall begins to decrease in April which is the start of the dry season, with the lowest rainfall is 2,3 mm^3 in May. However, there was an anomaly in the rainfall in June where the rainfall increased to a moderate category. Then, rainfall in DIY Province begins to increase in October until December which is the beginning of the rainy season with the highest rainfall in Kulon Progo and Bantul Regency reaching 495,5 mm^3 in November. (The monthly rainfall map in DIY Province during 2021 can be seen in Supplementary Appendix S5).

Based on BMKG Monthly Rain Bulletin June 2021 edition, there is an anomaly in rainfall that occurred in DIY Province. This anomaly arises because there is a temperature difference on the water surface in the Indian Ocean, where the difference occurs between the western seas of Indonesia and the eastern seas of Africa. This phenomenon is known as Indian Ocean Dipole (IOD) (BMKG, 2021). In June IOD was

Table 2. Bivariate Analysis of Population Density, HI, Rainfall, Air Humidity and Temperature with DHF IR in DIY Province 2021

Variable	Incidence Rate (IR)		
	p-value	R	R^2
Population Density (per km^2)	0,861	0,023	0,0005
House Index (HI) (% Average per Month)	0,497	0,089	0,0079
Avg. Rainfall (Per mm^3)	0,001***	0,584	0,3410
Avg. Humidity (% Average per Month)	0,001***	0,543	0,2948
Avg. Temperature (°C Average per Month)	0,011*	0,327	0,1069

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

observed in the negative phase with a dipole mode value of -0.46. This shows that the temperature of the oceans in the western seas of Indonesia has a higher surface temperature than the eastern seas of Africa. This negative phase has an impact on increasing the movement of convective clouds in the Indonesian region which causes rainfall to increase.

Spearman-rho correlation test result shows that rainfall has a significant effect on DHF incidence in DIY Province during 2021 with a p-value = 0,001. Rainfall with DHF incidence shows a moderate relationship (r = 0,584) and has a positive pattern, which means that the higher the rainfall, the incidence of DHF will also increase. In line with Ishak's research, which shows a significant relationship between rainfall and DHF incidence. High rainfall and flood can cause many problems in the sanitation system, making people in areas with poor sanitation vulnerable to disease (Ishak, 2018). Supported by research (Rompis, 2020; Triwahyuni, 2020), which shows an increase in dengue cases when rainfall also increases. In other research also shows a correlation between rainfall and DHF (Ali, 2018). Research results with a positive correlation were also reported in Bandar Lampung (Yushananta, 2020, 2021b). Kleden discribe that high rainfall make the risk of DHF increase, in line with the increasing number of mosquito breeding grounds due to rain (Kleden, 2021). Rainfall make puddles of water to appear in various places, which can become breeding grounds for mosquitoes. The availability of mosquito breeding sites can cause the mosquito population to increase, which can lead to an increase of DHF incidence (Nyarmiati, 2019). In addition, rainfall also increases humidity which also supports the life cycle of mosquitoes.

The monthly humidity average is divided into three categories: 1). a high category with a range of >86%, 2). a moderate category with a range between 82%-86%, and 3). a low category with <82%. Humidity distribution in DIY Province shown in Figure 2. From January to February, Kulon Progo and Bantul are classified as areas with high humidity, while other areas are in the moderate category. In March, all regions in the DIY Province were classified as moderate. Average humidity levels decrease in May and April, which is the beginning of the dry season. The lowest humidity average occurs in Sleman Regency, Yogyakarta City, and Gunungkidul Regency at 78,23% in September. However, in June the entire area in DIY Province experienced an increase in humidity to the moderate category. In the Figure 2, it can be seen that the humidity starts to increase in October, which is the beginning of the rainy season with the highest humidity in Kulon Progo Regency and Bantul Regency with 90,53% in November. (In detail, the monthly humidity map in DIY Province during 2021 can be seen in Supplementary Appendix S6).

Based on the Spearman-rho correlation test, the humidity variable has a significant impact on DHF incidence in DIY Province during 2021 with a p-value = 0,001. It showed a moderate correlation with DHF incidence (r = 543) and was positively direction, it means that the higher the humidity, the DHF incidence was also higher. This result is in line with previous research, it shows that high humidity can affect mosquito oviposition level and life sustainability of the *Aedes aegypti* mosquitoes (Salim, 2020). This result is supported by research conducted in Surabaya, Bau Bau, and Kupang was states the relationship between humidity and the incidence of dengue fever (Paramita, 2017; Sholihah, 2020; Irma, 2021). Oviposition in insects (especially mosquitoes) can be interpreted as the process of laying eggs in breeding places. High humidity higher than 80% can influence mosquito ovipositional to be increase (Daswito, 2019). Humidity has a significant correlation with rainfall (p = <0.001) with a strong correlation (r = 0.711) and has a positive direction, which means that high humidity occurs when rainfall is high, and vice versa. In line with (Tosepu, 2018), Humidity has significant correlation with rainfall and temperature. Humidity levels become high when rainfall and temperatures are high. These conditions are conducive for the vector to reproduce and live, which indirectly affects the rapid r eplication of the virus.

Temperature average is divided into three categories, 1). a high category with a range of > 27°C, 2). a moderate category with a range of 26°C – 27°C, and 3). a low category with a range of <26°C. From January to April the entire territory of the DIY Province is categorized in the moderate category. Temperature average in DIY Province began to increase in April or in the beginning of the dry season with the peak temperature average occur in Yogyakarta City, Sleman Regency and Gunungkidul Regency with 27,07°C in May. Temperature average start to decrease in June with the lowest humidity average occurs in Bantul Regency, and Kulon Progo Regency with 25,65°C in July. Then, until the end of the year, the average temperature in DIY Province was in the moderate category. (The monthly temperature map in DIY Province during 2021 can be seen in Supplementary Appendix S7).

Spearman-rho correlation test result shows that there was weak correlation with positive (p-value = 0.011; r = 0,327) between temperature average with DHF incidence in DIY Province during 2021. This result is in line with the previous research that conducted in Yogyakarta identified temperature had weak correlation with DHF cases in Yogyakarta City (Salim, 2020). In this study, temperature has a positive correlation with DHF incidence, which means that the higher the temperature, the higher the DHF incidence in that region. Based on the correlation test, temperature is not correlated, either with rainfall or humidity. However, in the previous study, the increase of temperature has been found to be associated with DHF. The arrival of summer and autumn, the temperature in central and northern China has gradually increased, the rainfall has increased, mosquito vectors have gradually become active, and DHF cases have increased (Yue, 2021). Other studies show different results, mosquitoes may survive long enough to transmit the virus at low temperatures (Tang, 2020). The optimum temperature followed by high relative humidity will affect the level of mosquitoes' oviposition and also the life sustainability of *Aedes aegypti* mosquito. Usually, mosquitoes will lay their eggs at a temperature of about 20°C - 30°C (Daswito, 2019; Triwahyuni, 2020). However, the results of this study are not in line with research conducted in Bandar Lampung, Manado, and Tangerang, that shows there were no positive correlation between temperature and DHF incidence (Asmuni, 2020; Putri, 2020; Bone, 2021).

Capacity can be defined as an ability to manage a community's resources and strengths to defend and prepare themselves, especially to recover quickly from disasters. The capacity variables are the DHF special regulation, vector surveillance activities, larva free rate (LFI), Gerakan 1 Rumah 1 Jumantik (G1R1J), PHC coverage based on population density, and the *Wolbachia* mosquito program. Based on an interview with a DHF Programmer at the Provincial Health Office of DIY and searches on city/regency government web pages in DIY Province. In 2021, there are already several regional regulations related to dengue prevention at the city/district level in the DIY Province, covering the Bantul, Kulon Progo and Gunungkidul regions. Meanwhile, vector surveillance has been carried out in each city/district in DIY province which can be seen through the vector surveillance system (SILANTOR 2.0). Even though surveillance has been carried out, the average LFI for each city/district is still below the national target (>95%). Then, the variable of Gerakan Satu Rumah Satu Jumantik (G1R1J), overall this movement has been implemented in each city/district. In 2021, the coverage of Community Health Centers for the population per city/district in the DIY 2021 Province as a whole is still below the national standard, namely (> 1). The last variable is the Wolbachia mosquito program, in 2021 this program will only be implemented in three regions including Yogyakarta City, Sleman, and Bantul. Based on the explanation above, the capacity scores for each city/regency are as follows, 1) Yogyakarta City: 3 (three), 2) Bantul: 4 (four), 3) Kulon Progo: 3 (three), 4) Gunungkidul: 3 (three), and 5) Sleman: 3 (three). (In detail, the capacity variables

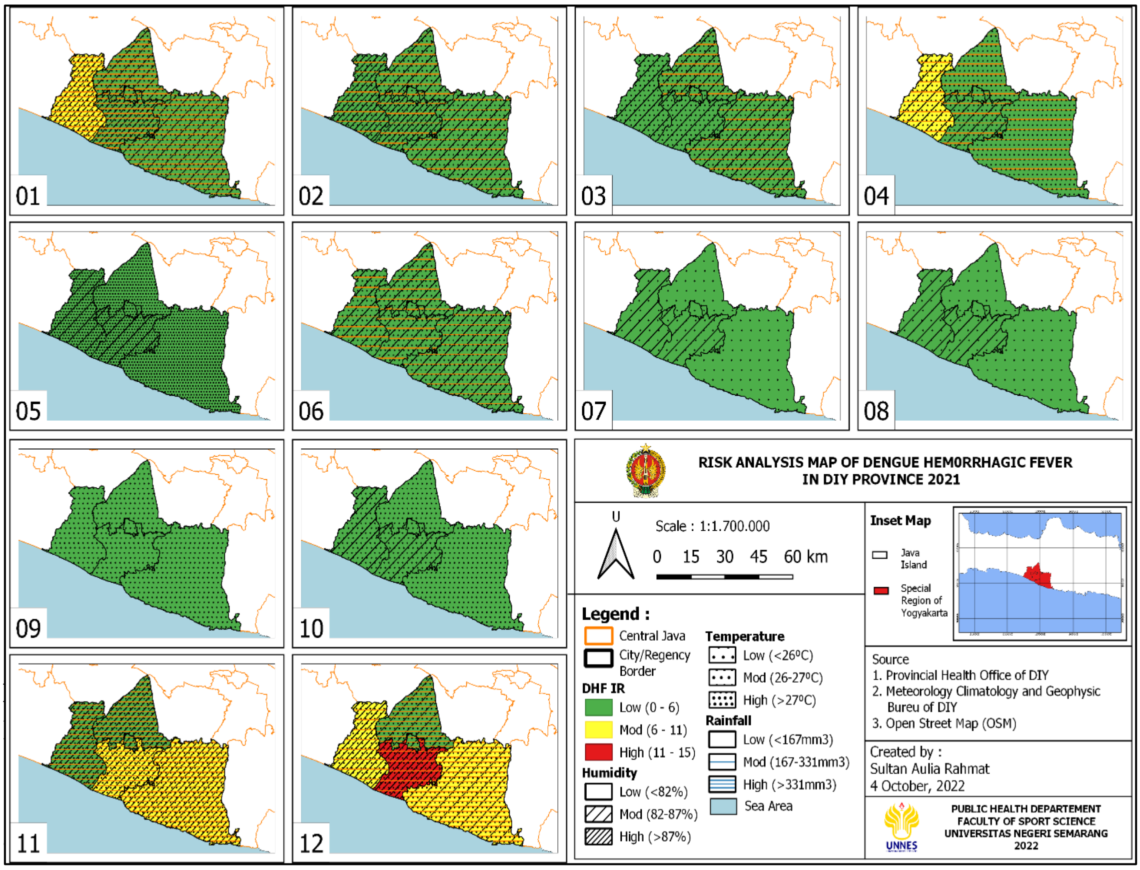

Figure 3. Monthly Map of DHF IR, Humidity, Temperature, and Rainfall for Each City/Regency in DIY Province During 2021 (from left to right: January-December).

measurement in DIY Province during 2021 can be seen in Supplementary Appendix S6).

The risk level of DHF transmission is calculated based on the results of scoring and categorization of each variable. Scoring results will be processed in the formula for determining the risk zone. The variables included in the risk zone formula are population density, HI, rainfall, humidity, temperature, CFR, and IR of DHF.

Figure 3 shows the distribution of DHF risk for each city/district in the DIY Province during 2021. It can be seen that the risk of DHF is dominated by high vulnerability at the beginning and end of the year, namely during the rainy season. In January there was one region with a high category (Kulon Progo), two regions with a moderate category (Yogyakarta City and Gunungkidul), and two regions with a low category (Sleman and Bantul). In November there was one region with a high category (Gunungkidul). In January there were two regions with high categories (Yogyakarta and Kulon Progo), one region with moderate categories (Gunungkidul), and two regions with low categories (Sleman and Bantul). In November there was one region with a high category (Gunungkidul), two regions with a moderate category (Kulon Progo and Bantul), and two regions with a low category (Sleman and Yogyakarta City). Then in December, two regions were in the high category (Bantul and Gunungkidul), one region in the moderate category (Kulon Progo), and two regions were in a low category (Sleman and Yogyakarta City).

This research is a cross-sectional study that only captures an event at a specific time and is only to prove the conditions that occur during this research, changes that may or will occur cannot be observed (Wang, 2020). Then, the data used in this research is secondary data whose correctness, completeness and accuracy depend on the available data. Researcher does no

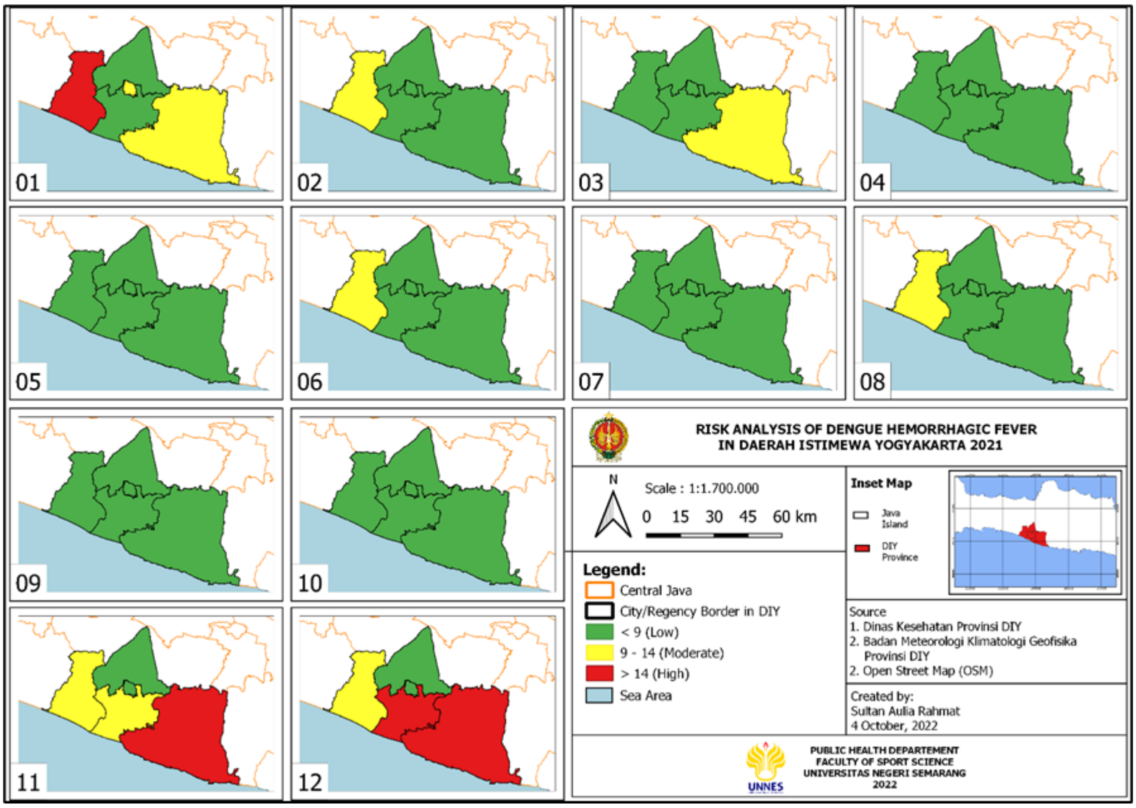

Figure 4. DHF Risk Distribution Map for Each City/Regency in DIY Province Based on Risk Calculation in 2021 (from left to right: January-December).

directly collect data, researcher cannot control the quality and validity of the data used, and researcher does not know the actual conditions in the field so the discussions carried out are not in-depth. This research uses variables that are limited to certain variables for which data is available, so researcher cannot add other factors related to DHF.

Another limitation is the possibility of bias in this study, some of the biases that may occur in this study include information bias, interpretation bias, and confounding/confounder bias. There is an information bias in the secondary data used in research, where the data used is the data that has been processed and may not be in accordance with the conditions in the field. Second, there is a bias in the interpretation of the research results, the results of this study are aggregate results or at the population level, but do not necessarily describe the same results at the individual level. Then there is a confounding bias, the data used in this study is data available from third parties, so there are limited data on DHF risk variables and most likely there are still other variables that can affect the incidence of DHF outside the variables in this study.

CLOSING

Based on the research results, it can be seen that the pattern of increasing the DHF incidence in DIY Province during 2021 occurs in January, November, and December. There is a relationship between climate factors (rainfall, humidity, and temperatures) and DHF disease. Climate variables and DHF incidence are positively correlated, meaning that areas with high average rainfall, humidity, and temperatures will have a higher incidence of DHF. The relationship varies according to the time lag of each month. The risk distribution map in this research is expected to be optimized by adding parameters that are adjusted to the latest government programs such as governor circulars on DHF and the latest data on DHF cases.

The results of this study are expected to be a recommendation for the Provincial Health Office of DIY in an effort to prevent and reduce the spread of DHF. Stakeholders at the Health Office can use weather data from the BMKG in planning and implementing DHF prevention programs. Then, for further research, it is hoped that more DHF-related variables can be added, such as the type of settlement, geographical conditions and land use, so that the accuracy of risk map can be improved. In addition, the next author is expected to be able to update the determination of the DHF risk zone, which is adjusted to the latest government programs and regulations.

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