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ECOLOGICAL STUDY: CORRELATION OF RAINFALL WITH DENGUE HEMORRHAGIC FEVER USING TIME SERIES ANALYSIS AND GIS IN SEMARANG CITY (2017-2021)

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ABSTRACT
There are approximately 2.5 billion people worldwide who are under threat of dengue fever. There were 108,303 cases of DHF with 747 deaths recorded in Indonesia in 2020. Semarang City is one of the endemic areas of DHF in Indonesia. One of the factors that correlate with DHF is rainfall. This research aims to find out updates regarding the correlation of rainfall with DHF cases in Semarang City 2017-2021 through an ecological study design with a time series approach. Data analysis used univariate and bivariate analysis with the Pearson correlation test. Meanwhile, spatial analysis uses GIS software in the form of ArcGIS. The results of the correlation analysis showed that the value of p = 0.575, and the value of r = -0.340. The conclusion of this study is that there is no correlation between rainfall and DHF cases in Semarang City in 2017-2021 with moderate correlation strength and a negative direction. Areas with a high distribution of DHF cases are densely populated areas and are located in the highlands. Suggestions for future researchers are to add other variables related to DHF.

Keywords **:** DHF, Rainfall, Time-series, GIS

ABSTRAK
Terdapat kurang lebih 2,5 miliar orang di seluruh dunia berada di bawah ancaman demam berdarah. Tercatat sebesar 108.303 kasus DBD dengan 747 kematian di Indonesia tahun 2020. Kota Semarang menjadi salah satu wilayah endemik DBD di Indonesia. Salah satu faktor yang memiliki kolerasi dengan DBD adalah curah hujan. Penelian ini bertujuan untuk mengetahui keterbaruan mengenai kolerasi curah hujan dengan kasus DBD di Kota Semarang 2017-2021 melalui rancangan studi ekologi dengan pendekatan time series. Analisis data menggunakan analisis univariat dan bivariat dengan uji kolerasi Pearson. Sedangkan analisis spasial menggunakan perangkat lunak GIS berupa ArcGIS. Hasil analisis korelasi menunjukkan bahwa nilai p= 0,575, dan nilai r=-0,340. Kesimpulan dari penelitian ini adalah tidak adanya kolerasi antara curah hujan dengan kasus DBD di Kota Semarang tahun 2017-2021 dengan kekuatan kolerasi sedang dan arah negatif. Daerah dengan persebaran kasus DBD tinggi merupakan daerah yang padat penduduk dan terletak di dataran tinggi. Saran untuk peneliti selanjutnya adalah menambahkan variabel lain yang berkaitan dengan DBD.

Kata Kunci **:** DBD, Curah Hujan, Time-series, GIS

INTRODUCTION

Vector-borne diseases are diseases that must be watched out for, one of the vector-borne diseases that often attacks public health is dengue fever. Dengue Fever is an arboviral infection through the intermediary of the spread of the *Aedes* mosquito. This dengue fever has major public health consequences, which spread in more than 100 countries both tropical and subtropical countries (WHO, 2011). There are approximately 2.5 billion people worldwide who are under threat of dengue fever and its severe forms, namely Dengue Hemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS). Every year, it is estimated that there are 50 million cases of dengue fever worldwide, of which half a million people suffering from DHF require hospitalization (WHO, 2011).

Dengue Hemorrhagic Fever (DHF) is one part of dengue infection. DHF is an infectious disease caused by the dengue virus which is transmitted through intermediary mosquito vectors

of the *Aedes aegypti* or *Aedes albopictus* species (Profil Kesehatan Indonesia, 2021). The virus will remain in the mosquito's body throughout its life, it can be said that *Aedes* mosquitoes that have been infected with the dengue virus become DHF infective throughout their lives (Triwahyuni, 2020). There are approximately 2.5 billion people worldwide living in dengue endemic countries (WHO, 2011). In this case, Indonesia is one of the endemic countries for dengue infection (Laporan Kinerja Direktorat Pencegahan dan Pengendalian Penyakit Tular Vektor dan Zoonotik, 2021).

DHF cases were first discovered in Jakarta and Surabaya in 1968 with a mortality rate of 41.3% (Laporan Kinerja Direktorat Pencegahan dan Pengendalian Penyakit Tular Vektor dan Zoonotik, 2021 dan Salim & Syairaji, 2020). A person can be declared indicated for DHF if the diagnosis results from clinical and laboratory symptoms show a decrease in platelets <100,000/mm³ and a plasma leak characterized by an increase in hematocrit > 20%. In the 2017-2021 period, DHF cases in Indonesia have experienced an increase and decrease in cases. In 2017 there were 68,407 cases with 493 deaths (Profil Kesehatan Indonesia Indonesia, 2017), cases fell in 2018 with a total of 65.602 cases with 467 deaths (Profil Kesehatan Indonesia, 2018), but increased dramatically in 2019 with a total of 138.127 cases with 919 deaths (Profil Kesehatan Indonesia, 2019), cases fell again in 2020 where there were 108.303 cases with 747 deaths (Profil Kesehatan Indonesia, 2020), then in 2021 cases will also decrease, namely there will be 73.518 cases with 705 deaths (Profil Kesehatan Indonesia Indonesia, 2021).

Nationally, the CFR of DHF in Indonesia in 2021 will reach 0,96% and the IR will be 27 per 100.000 population (Profil Kesehatan Indonesia Indonesia, 2021). DHF CFR is said to be high if it has a number of more than 1%. In 2020 there are eleven provinces with a CFR above 1%, which includes Central Java Province with a CFR of 1,9%, this CFR figure will increase in 2021 to 2,7%. (Profil Kesehatan Jawa Tengah, 2021). Based on data from the Semarang City Health Office, in 2021 the Semarang City DHF CFR is 2,71%. Whereas for DHF IR in Semarang City in 2021 is 19,88 per 100.000 population. Based on one of the indicators of the 2020-2024 Strategic Plan, it states that the DHF CFR target is <2% and the IR target is <49 per 100.000 population (Kementerian Kesehatan Republik Indonesia, 2021), This shows that the DHF CFR in Semarang City has met the target, but for DHF IR in Semarang City it is still below the target.

Epidemiological triad, explains that there are three factors that have a role in the occurrence of disease, namely the host, agent, and environment. Environmental factors that influence DHF cases can be in the form of physical environmental factors. There are several physical environmental factors that can affect the life of the DHF vector, including rainfall, temperature and evaporation (Raksanagara SA, 2015). In this case, DHF is a disease that still needs attention, especially when entering the rainy season. The reason is that during the rainy season there are many stagnant waters which have the potential to become breeding grounds for mosquitoes which are vectors of DHF (Profil Kesehatan Indonesia, 2021). Rainfall is an important determinant in the transmission of DHF cases, this is because rainfall has an influence on air temperature which can affect the survival of adult mosquitoes, and in further cases rainfall and air temperature can affect the diet and reproduction of mosquitoes so that it has the potential to increase mosquito population density (WHO (2012). The population of *Aedes aegypti* mosquitoes depends on the mosquito breeding sites, where one of the factors that influence the existence of mosquito breeding places is rainfall (Triwahyuni, 2020). An increase in the amount of rainfall can lead to an increase in the breeding places for Aedes mosquitoes, which in turn causes the mosquito population to also increase (Azhari, 2017).

The *Aedes aegypti* mosquito breeds in clean water, where when rainfall is high and lasts a long time it can cause flooding, this will eliminate mosquito breeding places. However, different things will happen when the rainfall is small and lasts for a long time, where this can trigger the potential for additional mosquito breeding places, and will increase the mosquito

population (Majidah A, 2010). Research on the relationship between rainfall and DHF cases in the city of Semarang has been carried out, such as the research conducted by Lahdji (2017), which states that there is a positive correlation between rainfall and the incidence of DHF in Semarang City in the 2006-2015 period. However, there are also studies that show negative results, such as research conducted by (Tuyet-Hanh, 2018) in Hanoi Vietnam which stated that there was no significant direct correlation between rainfall and DHF cases in the 2008-2015 period.

Apart from rainfall, there are various other factors that can cause an increase in DHF cases, such as vectors, demographic factors (population density, population mobility, behavior, and socio-economic population), as well as geographical factors such as altitude. Therefore, it is also necessary to model risk factors through spatial epidemiology based on a geographic information system which will produce a map of the vulnerability of DHF areas. Where the map can be used as an input in planning the prevention and eradication of DHF and other decision making. The purpose of this research is to see the correlation of rainfall with dengue cases in Semarang City through a time-series analysis approach and spatial analysis through a geographic information system approach for the 2017-2021 period.

METHOD

The method used in this study is an ecological study design using a time-series approach. Time-series studies are studies that are used to determine the relationship between the frequency of a disease case and risk factors or existing health programs in the community from time to time (Salim, 2020). In this study time-series analysis will be presented through tables, graphs and maps.This research was conducted in Semarang City from November 2022 – January 2023. The data used in this research is secondary data in the form of dengue fever case data in Semarang City for the 2017-2021 period. The population of this study were all confirmed cases of DHF obtained from dengue fever case reports at the Semarang City Health Office from 2017 to 2021. Meanwhile, rainfall data for the 2017-2021 period was obtained from the Semarang City BMKG. There is also supporting data, namely population density data for the 2017-2021 period and regional elevation data obtained from the Semarang City BPS. In this study, spatial analysis was carried out. Spatial analysis was carried out using a geographic information system approach. In this case, the instruments used are location maps, and GIS software in the form of ArcGIS.

The analysis technique used in this study is to use univariate and bivariate tests through instruments in the form of software to process secondary data. Univariate analysis was used to find out the description of the distribution of DHF cases and the description of rainfall in Semarang City in 2017-2021. Meanwhile, to determine the correlation between rainfall and DHF cases, bivariate analysis was carried out. This study uses analytical methods so it is necessary to test the normality of the data, in this case the test used is the *Shapiro Wilk* test. This test was used because the data in this study totaled below 50 (Triwahyuni, 2020).

The results of the normality test showed that the data were normally distributed, so the bivariate test used was the *Pearson* test. To find out the relationship between rainfall and DHF cases in the city of Semarang, it is done by comparing the significant value (p-value) with the value of α (0,05). Meanwhile, to determine the strength of the relationship between variables can be seen based on the value of the correlation coefficient (r) (Dahlan, 2011).

RESULTS AND DISCUSSION

Time-series analysis is an analysis discovered by Box and Jenkins in 1970 (Salim, 2020). Time-series data is data that can be used as a basis for determining trends. The data collected

is data from time to time which is then seen for its development. In this case, trend data can be used as a basic reference in predicting a disease, it can help in planning decision making.

Table 1 Distribution of Rainfall and Dengue Cases in Semarang City 2017-2021

Variable	Year	Amount	Mean ± SD	Median (Min-Max)
Rainfall (mm)	2017	2774	231,17 ±146,461	238,50 (15-483)
	2018	2083	173,58 ± 165,213	172,00 (0-538)
	2019	1256	104,67 ± 100,570	88,50 (1-241)
	2020	2436	203,00 ± 118,943	236,50 (23-394)
	2021	2468	205,67 ± 177,458	150,00 (15-694)
DHF Case	2017	299	24,92 ± 29,237	8,50 (3-94)
	2018	103	8,58 ± 6,388	7,00 (4-27)
	2019	441	36,75 ± 35,211	20,50 (2-88)
	2020	320	26,67 ± 23,114	17,00 (7-71)
	2021	332	27,67 ± 19,246	21,50 (8-72)

Table 1 shows the frequency distribution of rainfall levels and DHF cases from 2017-2021. In the table it can be seen that the highest average rainfall occurred in 2017 of 231,17 mm, and the lowest average rainfall occurred in 2019 of 104,67 mm. Meanwhile, the highest average DHF cases occurred in 2019, namely 36,75 cases or 37 cases, and the lowest average DHF cases occurred in 2018 as many as 8,58 cases or 9 cases.

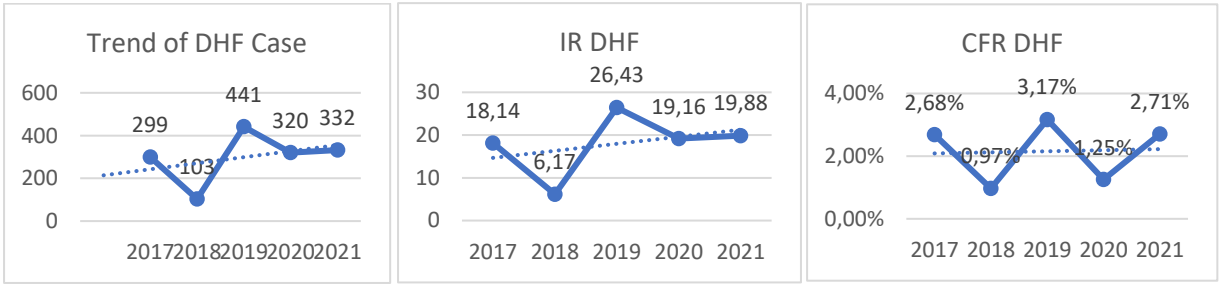

Figure 1 Trends of DHF Case, DHF IR, and DHF CFR in Semarang City 2017-2021

Figure 1 shows the trend of DHF cases, IR DBD, and CFR DBD in Semarang City from 2017-2021, where the highest cases of DHF were in 2019 with 441 cases, and the lowest cases of DHF occurred in 2018 with 103 cases. The highest DHF IR was in 2019 of 26,43 per 100.000 population, and the lowest IR occurred in 2018 of 6,17 per 100.000 population. The highest DHF CFR was in 2019 of 3,17%, and the lowest CFR occurred in 2018 of 0,97%. Where it can be concluded that in the 2017-2021 period the trend of DHF case, DHF IR, and DHF CFR in the city of Semarang has increased.

Figure 2 shows that there are differences in the number of cases each month. In 2017 the highest cases occurred in January with a total of 94 cases, and the lowest cases occurred in November with 3 cases. The highest cases in 2018 occurred in December with 27 cases, and the lowest cases occurred in September, October and November with 4 cases. In 2019, the highest cases occurred in March with 88 cases, and the lowest cases occurred in September with a total of 2 cases. In 2020, the highest cases occurred in March with 77 cases, and the lowest cases occurred in September with a total of 7 cases. Meanwhile for 2021, the highest cases occurred in December, namely 72 cases, and for the lowest cases occurred in July with a total of 8 cases.

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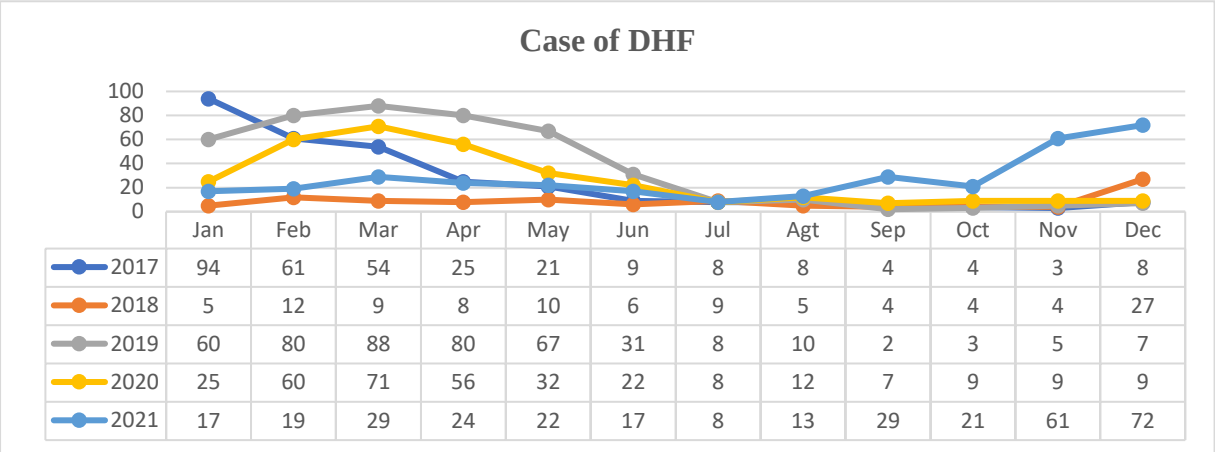
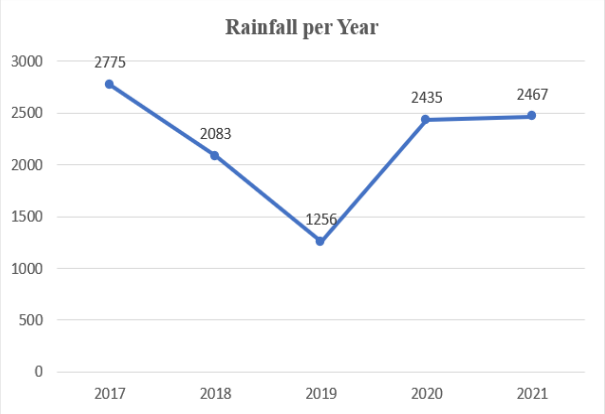
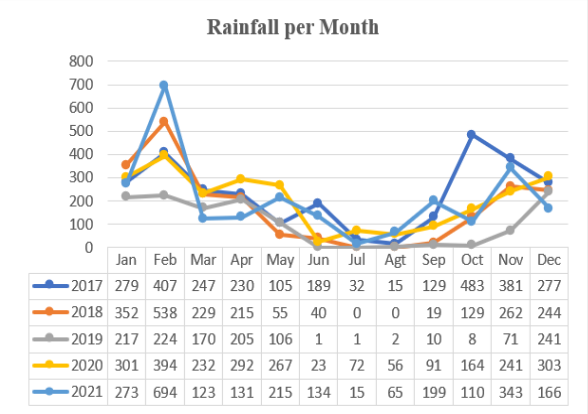


	Jan	Feb	Mar	Apr	May	Jun	Jul	Agt	Sep	Oct	Nov	Dec
2017	94	61	54	25	21	9	8	8	4	4	3	8
2018	5	12	9	8	10	6	9	5	4	4	4	27
2019	60	80	88	80	67	31	8	10	2	3	5	7
2020	25	60	71	56	32	22	8	12	7	9	9	9
2021	17	19	29	24	22	17	8	13	29	21	61	72

Figure 2 Monthly DHF Cases in Semarang City 2017-2021

Based on data on DHF cases in Sematang City for 2017-2021, it can be seen that an increase in DHF cases occurs on average in January-March, and has decreased in April-September. Meanwhile, from October to December, cases have again increased. This is in line with previous research conducted in Semarang City for the 2006-2011 period, where DHF cases increased in October-March and decreased in April-September (Wirayoga, 2013). However, based on figure 2 there is a different pattern in 2021 where there is an increase in cases in September, cases decrease in October, and cases increase again in November-December.





	Jan	Feb	Mar	Apr	May	Jun	Jul	Agt	Sep	Oct	Nov	Dec
2017	279	407	247	230	105	189	32	15	129	483	381	277
2018	352	538	229	215	55	40	0	0	19	129	262	244
2019	217	224	170	205	106	1	1	2	10	8	71	241
2020	301	394	232	292	267	23	72	56	91	164	241	303
2021	273	694	123	131	215	134	15	65	199	110	343	166

Figure 3 Rainfall Levels in the City of Semarang in 2017-2021

Figure 3 shows an overview of rainfall in Semarang City for the 2017-2021 period. Rainfall is the fall of rainwater in a certain amount in an area at a certain time. The unit of rainfall is millimeters (mm), this unit has the meaning of calculation (1mm X 1m X 1m), meaning that the volume of rainfall per square meter is one liter (Irma, 2021). Based on Figure 3, it can be seen that there has been a decrease in rainfall levels in 2017-2019, but in 2020-2021 rainfall levels have increased. In the 2017-2021 period, rainfall tends to increase in January-February, then continues to decrease in March-August, and again increases starting from September-December.

In 2017 the highest rainfall occurred in October of 483 mm, and the lowest rainfall was in August of 15 mm. In 2018 the highest rainfall occurred in February of 538 mm and the lowest occurred in July and August of 0 mm. In 2019 the highest rainfall occurred in December of 241 mm and the lowest occurred in June and July of 1 mm. In 2020 the highest rainfall occurred in February of 394 mm, and the lowest occurred in June of 23 mm. Then in 2021, the highest

rainfall will occur in February of 694 mm, and the lowest will occur in July of 15 mm. Rainfall levels per month that are small, up to 0 mm, can be caused by the absence of related measurements or reports.

Based on the results of the correlation analysis of DHF cases with rainfall in Semarang City for the 2017-2021 period, it shows that the r count is -0.340, the number of samples (N) is 60 samples with a significance of 0.575. From the results of the analysis, the calculated r value indicates a moderate relationship strength with a negative pattern, which means that an increase in DHF cases is not followed by an increase in rainfall. The significance value (p=0.575) shows a number that is greater than α (0.05), where it can be concluded that there is no significant relationship between DHF cases and rainfall during 2017-2021. This is in line with research conducted by Tuyet-Hanh (2018) in Hanoi, Viet Nam for the 2008-2015 period, stated that there was no significant correlation between DHF cases and rainfall, which could be caused by a lagging relationship. The same result is also stated by Salim (2020) in his research which stated that there was no significant relationship between rainfall and the incidence of DHF in Yogyakarta in 2013-2019. Likewise with research results Fadlirahman (2022) in the Administrative City of Jakarta in 2018-2020 which stated that there was no significant relationship between rainfall and DHF cases. The moderate strength of the relationship with a negative pattern can be caused by the inconsistency of the direction of the correlation between rainfall and DHF cases. Where this can be proven by one of the conditions, such as in February-May 2021. In February 2021 there were 19 cases of DHF with a rainfall of 694 mm. However, in March 2021 cases increased to 29 cases but rainfall decreased to 123 mm. In April cases decreased to 24 cases, while rainfall increased to 131 mm. In May, cases fell again to 22 cases, and rainfall increased to 215 mm.

The absence of a relationship between rainfall and DHF cases can be caused by other factors. There are many factors that have the potential to increase DHF cases, such as the existence of a DHF disease control program and community behavior. Where it is supported by research Simatupang (2021) which stated that the Mosquito Nest Eradication (PSN) activity had an effect on the incidence of DHF. This is also supported by research of Swara (2021) which stated that the JUMANTIK program was able to have an impact on reducing DHF cases and could be made a leading program in the community. In this case the Semarang City Government continues to develop an online-based system to improve preventive and curative efforts in improving health services for handling and controlling DHF, which are united in the Tunggal Dara program (United Respond to Dengue Fever). In addition to improving health services, community involvement is also necessary in controlling DHF cases. The city of Semarang itself has implemented several control programs that involve the community directly, including the One House One JUMANTIK/Juru Pemantau Jentik/Laws Monitoring Interpreter, and Student Larvae Monitoring (SICENTIK) programs. The JUMANTIK program is carried out by routinely monitoring the presence of larvae and eradicating mosquito nests (PSN). While SICENTIK is a larva monitoring activity carried out by elementary school students/equivalent and junior high school students/equivalent which is reported to the homeroom teacher every week.

In Figure 1 it can be seen that in the period 2017-2021 the trend of DHF cases in Semarang City tends to increase, so that even though there have been many DHF disease control programs in Semarang City, these control programs still need to be improved. In this there are possible causes that influence the success of DHF case control programs in the community. One of the factors that may influence the success of the DHF disease control program is the active role of the community in running the program. Efforts that can be made to increase community activity include health promotion. The health promotion aims to make people more aware and willing to carry out a control program. This is supported by research of Anggraini (2023) regarding the Analysis of Stakeholder Behavior in the Implementation of Dengue Hemorrhagic Fever (DHF)

Control in Semarang City which states that there is still a lack of stakeholder knowledge regarding the DHF control program, and there are still cadres who do not report to the single virgin system so that further socialization is needed.

Table 2 Population Density and Area Altitude Data per Subdistrict in Semarang City Year 2017-2021

Subdistrict	Population Density					Area Altitude (masl)
	2017	2018	2019	2020	2021	
Banyumanik	6072	6322	6421	4776,9	4763,89	300
Candisari	11613	11570	11752	11795,38	11716,59	2,5
Gajah Mungkur	6611	6587	6690	6018,11	5977,97	150
Gayamsari	12853	13235	13443	11296,14	11220,74	3,5
Genuk	4045	4278	4345	4746,52	4848,79	2
Gunungpati	2023	2161	2195	1682	1687,66	300
Mijen	1213	1301	1321	1431	1474,1	311
Ngaliyan	4050	4281	4348	3296,92	3306,32	11
Pedurungan	9839	10202	10361	9149,89	9148,8	6
Semarang Barat	7408	7475	7592	6868,19	6822,33	3
Semarang Selatan	11755	11713	11896	10431,67	10362,05	6
Semarang Tengah	9833	9798	9951	10643,31	10572,18	2
Semarang Timur	9722	9687	9839	12228,63	12146,92	2
Semarang Utara	10771	10738	10907	10322,85	10253,94	1
Tembalang	4394	4667	4740	4805,74	4853,37	125
Tugu	1008	1033	1049	1167	1171,48	1
Total	113210	115048	116850	110660,3	110327,1	

Source: Semarang City BPS 2017-2021

Table 2 shows the population density figures and regional elevations per sub-district in Semarang City for the 2017-2021 period. It can be seen that in 2017-2019 the population density in Semarang City tends to increase, while in 2020-2021 the population density has decreased. Semarang City has a population density that varies in each sub-district. In this case the researchers divided the altitude categories into four categories, namely low (<1735 people/km²), medium (1736-6631 people/km²), dense (6632-9947 people/km²), and very dense (> 9947 people /km²) (Alfiyanti, 2021). Based on the table, in the period 2017-2021, sub-districts with low population density included Mijen Subdistrict, Tugu Subdistrict, and Gunungpati Subdistrict (2020-2021). Subdistrict with moderate population density for the 2017-2021 period, namely Banyumanik Subdistrict, Genuk Subdistrict, Ngaliyan Subdistrict, Tembalang Subdistrict, Gajah Mungkur Subdistrict (2017-2018 and 2020-2021), and Gunungpati Subdistrict (2017-2019). Subdistrict with dense population density for the 2017-2021 period are West Semarang Subdistrict, East Semarang Subdistrict (2017-2019), Pedurungan Subdistrict (2017, 2020 and 2021), Gajah Mungkur Subdistrict (2019), and Central Semarang Subdistrict (2017-2018). Whereas sub-districts with very dense population density for the 2017-2021 period are Candisari Subdistrict, Gayamsari Subdistrict, South Semarang Subdistrict, North Subdistrict, Pedurungan Subdistrict (2018-2019), and Central Semarang Subdistrict (2019-2021).

The altitude of the area has a value that never changes every year. In this case the researchers categorize the area's altitude into three categories, namely the low category (0.75-3.49 masl), medium (3.5-90 masl), and the high category (90-348 masl) (Alfiyanti, 2021). In Semarang City, sub-districts with low altitude categories are Candisari Subdistrict, Gayamsari Subdistrict, Genuk Subdistrict, West Semarang Subdistrict, Central Semarang Subdistrict, and East Semarang Subdistrict, North Semarang Subdistrict, and Tugu Subdistrict. Districts with moderate altitude categories, namely Ngaliyan Subdistrict, Pedurungan Subdistrict, and South Semarang Subdistrict. As for the sub-district with the high-altitude category, namely Banyumanik Subdistrict, Gajah Mungkur Subdistrict, Gunungpati Subdistrict, Mijen Subdistrict, and Tembalang Subdistrict.

Based on Figure 4, it can be seen that DHF cases in Semarang City for the 2017-2021 period spread in all sub-districts in Semarang City. In this case the researcher categorizes the spread of DHF cases per sub-district in Semarang City into three categories, namely the low category which is marked with a soft-purple color, the medium category which is marked with a purple color, and the high category which is marked with a dark-purple color. In 2017, the district with the highest distribution of dengue cases was Tembalang Subdistrict. In 2018 there were three districts with a high distribution of dengue cases, namely Banyumanik Subdistrict, Pedurungan Subdistrict, and Tembalang Subdistrict. In 2019 and 2020 the spread of dengue cases with a high category occurred again in Tembalang Subdistrict. In 2021 the distribution of high category DHF cases will occur in Banyumanik Subdistrict, Ngaliyan Subdistrict, and Tembalang Subdistrict. Based on the map of the distribution of DHF cases, it can be seen that in the period 2017-2021 the district that most often has the highest distribution of DHF cases is Tembalang Subdistrict. Tembalang Subdistrict is a sub-district with a moderate population density and is located in an area with a high-altitude category.

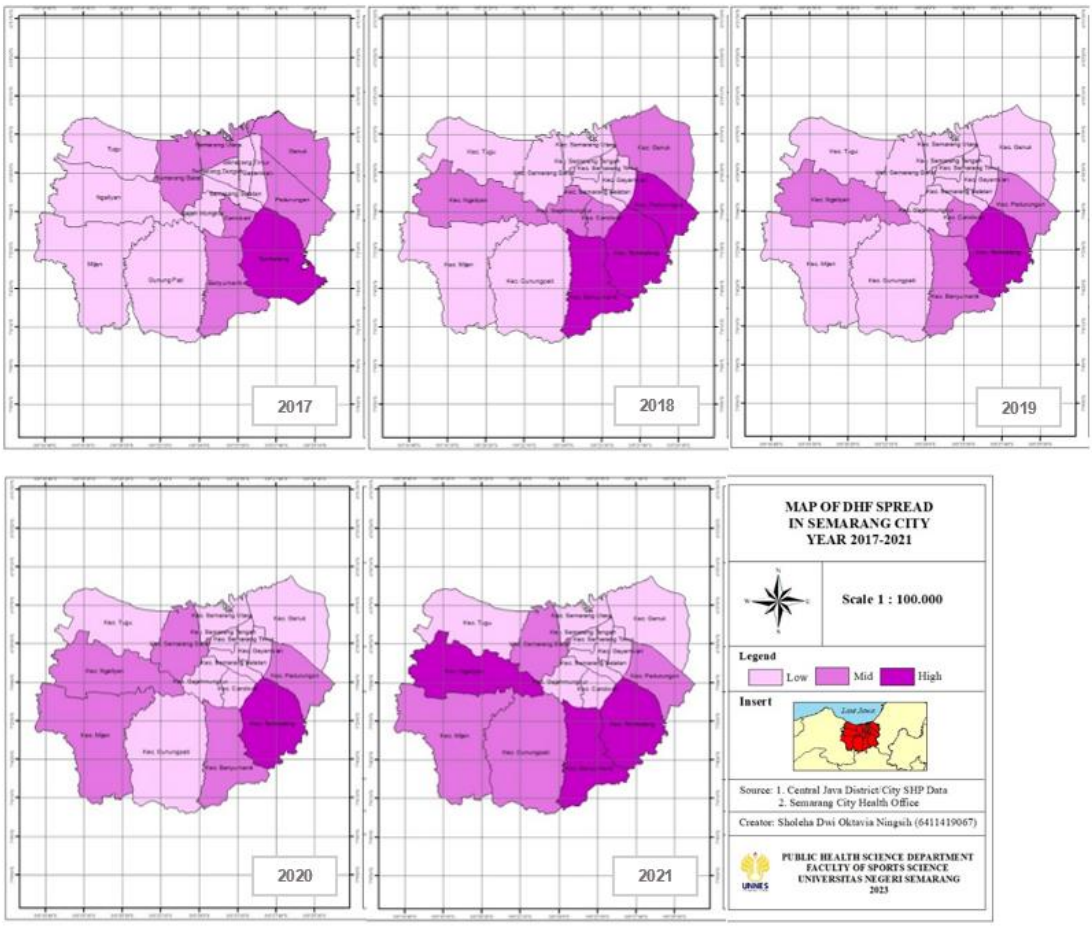


Figure 4 Map of the Distribution of DHF Cases in Semarang City in 2017-2021

Whereas in 2017 the sub-districts with a low distribution of DHF cases were Tugu Subdistrict, Ngaliyan Subdistrict, Mijen Subdistrict, Gunungpati Subdistrict, Gajah Mungkur Subdistrict, Gayamsari Subdistrict, South Semarang Subdistrict, Central Semarang Subdistrict, and East Semarang Subdistrict. In 2018, namely Tugu Subdistrict, Mijen Subdistrict, Gunungpati Subdistrict, South Semarang Subdistrict, Gayamsari Subdistrict, West Semarang Subdistrict, Central Semarang Subdistrict, East Semarang Subdistrict, and North Semarang Subdistrict. In 2019, namely Tugu Subdistrict, Mijen Subdistrict, Gunungpati Subdistrict, Gajah Mungkur Subdistrict, South Semarang Subdistrict, Gayamsari Subdistrict, West Semarang Subdistrict, Central Semarang Subdistrict, East Semarang Subdistrict, and North Semarang Subdistrict, and Genuk Subdistrict. In 2020, namely Tugu Subdistrict, Gunungpati Subdistrict, Gajah Mungkur Subdistrict, Candisari Subdistrict, South Semarang

Subdistrict, Gayamsari Subdistrict, Central Semarang Subdistrict, East Semarang Subdistrict, and North Semarang Subdistrict, and Genuk Subdistrict. Then in 2021, namely, Tugu Subdistrict, Gajah Mungkur Subdistrict, Candisari Subdistrict, South Semarang Subdistrict, Gayamsari Subdistrict, Central Semarang Subdistrict, East Semarang Subdistrict, and North Semarang Subdistrict, and Genuk Subdistrict. Based on the lowest distribution of DHF cases from 2017-2021 per sub-district in Semarang City, the sub-district that most often becomes a sub-district with a low category distribution of DHF cases is Tugu Subdistrict. Tugu sub-district is a sub-district with a low population density category and is located in an area with a low altitude category.

Based on research conducted by Indrayati (2013) which states that the distribution of DHF cases occurs more frequently in the lowlands and has densely populated residential conditions. A similar statement was also stated by Paomey (2019) regarding the Distribution of DHF Based on Altitude and Population Density, states that the distribution of DHF cases occurs more in areas with low altitude and high population density. This research gives similar results in terms of population density, but not with the height of the area. Where, the most common distribution of DHF cases in Semarang City for the 2017-2021 period was found in sub-districts with moderate to high population densities (Banyumanik Subdistrict, Pedurungan Subdistrict, Ngaliyan Subdistrict, and Tembalang Subdistrict). However, the distribution of DHF cases in Semarang City for the 2017-2021 period is more common in areas with medium to high altitude areas. This is in accordance with research conducted by (Alfiyanti, 2021) regarding the Spatial and Temporal Analysis of DHF Incidence in Semarang City in 2016-2019 which states that DHF incidents are more common in densely populated areas with high altitude areas. The density of the population and the height of the area will not be a problem if it is balanced with the application of good behavior in the DHF control program (Alfiyanti, 2021), such as with improvements in waste treatment, and an increase in PSN 3M Plus activities, so as to minimize mosquito breeding sites.

CONCLUSION

Based on the analysis carried out, it can be concluded that there is no correlation between rainfall and DHF cases in Semarang City for the 2017-2021 period, this lack of correlation can be caused by factors such as the lack of duration of data taken, and the influence of other factors that are more dominant. The time-series analysis shows that DHF, IR and CFR cases in Semarang City from 2017 to 2021 tend to increase. The distribution of DHF cases tends to spread to sub-districts with moderate to dense population density and moderate to high altitude areas.

Suggestions from researchers for future researchers are to add other variables such as air humidity and air temperature to the study or to increase the duration of the data studied so that other factors that are more dominantly correlated with the increase in DHF cases can be identified.

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