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Correlation Study between Elevation, Population Density, and Dengue Hemorrhagic Fever in Kendari City in 2014–2018

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Abstract

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Keywords: Dengue hemorrhagic fever; Elevation; Population density; Kendari

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BACKGROUND: The incidence of dengue hemorrhagic fever (DHF) has experienced rapid development throughout the world in recent decades. Indonesia was reported as the 2nd country with the largest DHF cases among 30 endemic countries. Dengue virus can develop properly based on certain regional conditions. The elevation is an important factor that can affect the presence of dengue vector mosquitoes. High population density contributes to dengue transmission by increasing the contact between infected mosquitoes and human hosts.

AIM: This study aimed to determine the correlation between elevation and population density with the incidence of dengue in Kendari City in 2014–2018.

METHODS: This research is an observational analytic study with ecological study design. Data incidence of DHF in 2014–2018, elevation and population density were respectively obtain from the Health Office of Kendari City, Meteorology, Climatology and Geophysics Agency of Kendari City, Statistics Agency of Kendari City. The analysis of the data used in the study is univariate and bivariate analysis. Bivariate analysis using Pearson correlation test was performed.

RESULTS: The results showed that the correlation between elevation and DHF ($p = 0.014$, $r = 0.339$) and the correlation between population density and DHF ($p = 0.186$).

CONCLUSION: It can be concluded that there is significant correlation with positive direction between elevation and the DHF, and there is no significant correlation between population density and DHF incidence in Kendari City in 2014–2018.

Introduction

The incidence of dengue hemorrhagic fever (DHF) has experienced rapid development throughout the world in recent decades. Based on the World Health Organization, an estimated 390 million dengue infections occur each year. Cases in America, Southeast Asia, and the Western Pacific are estimated to have more than 3.2 million infected with dengue in 2015 [1]. Asia Pacific bore 75% of the dengue burden in the world between 2004 and 2010, while Indonesia was reported as the 2nd country with the largest DHF cases among 30 endemic countries [2].

In 2017, the number of DHF cases reported in Indonesia was 68,407 cases with an incidence rate of 26.10/100,000 population and a total of 493 deaths with a case fatality rate of 0.72%. Kendari City is a dengue endemic area, as many as 1093 cases were reported in 2016 with an incidence rate of 372.8/100,000 population and a total of 7 deaths with a case fatality rate of 0.64% [2].

In dengue transmission, population factors are emerging along with other climatic and environmental factors [3]. Dengue virus can develop properly based

on certain regional conditions. In a place with an elevation of more than 1150 m above sea level the chance of mosquitoes transmitting the virus is very small and in a place with an elevation of more than 1400 masl mosquitoes do not breed. The effect of height variations influences the ecological conditions required by the disease vector [4]. Several studies stated the reasons of increasing trends of dengue fever cases as population growth, urbanization, formation of slums, and increased population density [5], [6], [7]. This study aims to determine the correlation between elevation and population density with the incidence of dengue fever in Kendari City in 2014–2018.

Materials and Methods

The research was conducted in Kendari City, Southeast Sulawesi. This research is an observational analytic study with an ecological study design or population correlation study. This study aims to determine the correlation between elevation and

population density with the incidence of dengue fever in Kendari City in 2014–2018.

The population in this study was the incidence of DHF in 2014–2018 recorded in the Health Office of Kendari City. Population correlation study aims to see the correlation between certain characteristics with the incidence of disease in the whole population so that the unit of observation in this study is the whole population.

Incidence of DHF in 2014–2018, elevation and population density were, respectively, obtain from the Health Office of Kendari City, Meteorology, Climatology and Geophysics Agency of Kendari City, Statistics Agency of Kendari City.

The analysis of the data used in the study is univariate and bivariate analysis. Bivariate analysis using Pearson correlation test was performed.

Results

Table 1 presents the results of univariate analysis of research variables based on the parameters of centering size and the size of the spread. If the distribution of data is normal, the mean and standard deviations are used as a measure of concentration and distribution. If the data distribution is not normal, then the median and percentile are used as a measure of concentration and distribution.

Table 1: Distribution of DHF occurrence, elevation, and population density in Kendari City in 2014-2018

Variables	Min	Max	Mean	Median	Std. Deviation
DHF events per district	0	148	27.04	8.00	43.588
Elevation (m ASL)	3	45	21.23	18.39	10.263
Population density (hectare/population)	4.41	79.71	20.34	16.02	18.51

DHF: Dengue hemorrhagic fever.

Table 1 shows that the average distribution of DHF per district in Kendari City in 2014–2018 was 27 cases with the fewest cases being 0, and the most cases were 148 cases. The average height of places in Kendari City in 2014–2018 is 21.23 m above sea level with a minimum height of 3 m above sea level and a maximum height of 45 m above sea level. The average population density in Kendari City in 2014–2018 was 20.34 ha/person with a minimum density of 4.41 ha/person and a maximum density of 79.71 ha/person.

Table 2 presents the results of a bivariate analysis using a correlation test between the elevation and population density variables with the incidence of dengue in Kendari City in 2014–2018. Correlation test results between elevation with the incidence of dengue fever showed p value $0.014 < 0.05$, meaning that there is a significant correlation between the elevation with the incidence of dengue in Kendari City in 2014–2018. The correlation coefficient value of 0.339 indicates the direction of a positive correlation with the strength of

a weak correlation. Correlation test results between population density and dengue fever show p value of $0.186 > 0.05$, meaning that there is no significant correlation between population density and dengue fever in Kendari City in 2014–2018.

Table 2: Correlation test between elevation and population density with DHF in 2014–2018

Variables	DHF	
	r	Sig. (two-tailed)
Elevation	0.339	0.014
Population density	0.186	0.186

DHF: Dengue hemorrhagic fever.

Discussion

The results showed that elevation had a correlation with the incidence of dengue in Kendari City in 2014–2018, while the population density did not have a correlation with the incidence of dengue in Kendari City in 2014–2018.

The average height of places in Kendari City in 2014–2018 is 21.23 m above sea level. Correlation test between elevation and DHF incidence in Kendari City in 2014–2018 showed a p value of $0.014 < 0.05$, so it can be concluded that there is a significant correlation between elevation and DHF incidence in Kendari City in 2014–2018. The correlation coefficient value of 0.339 indicates a positive correlation with the strength of a weak correlation. A positive relationship means that the increase in height is also followed by an increase in the incidence of dengue fever.

A study conducted by Handayani *et al.* [8] showed that the elevation and the incidence of DHF have a moderate relationship with a negative pattern $r = -0.659$ with a significance (p) 0.038. This means that the lower the elevation, the higher the incidence of dengue hemorrhagic fever.

A study conducted by Kesetyaningsih *et al.* [9] showed that cases of dengue fever in Sleman Regency with a high category (50–80 cases/year) and very high (>80 cases/year) occurred at an elevation of <200 masl, especially at an elevation of 50–125 masl. Cases of dengue still occur at an elevation of 300–425 masl, even in the low category. Pearson correlation analysis showed a negative correlation between elevation and dengue cases even though the correlation strength was weak ($p = 0,000$; $r = -0.127$). The higher an area, the lower the incidence of dengue fever.

The elevation is an important factor that can affect the presence of dengue vector mosquitoes. These factors affect the air temperature and humidity of a place that will affect the development of vector mosquitoes and dengue viruses [10]. The occurrence of dengue has also spread from low altitudes to more than

1000 m above sea level [11]. The expansion of dengue is expected to increase under the influence of increases in minimum temperature and population migrations resulting from changes in transportation, globalization, trading, social-economic condition, housing, and viral evolution [12].

A study by Sayono *et al.* [13] in Central Java, Indonesia, reported that *Aedes* mosquitoes were found to be distributed at all altitudes in the study area up to 1.200 m ASL, indicating the influence of climate change. This is the highest altitude that dengue has yet been identified, and the first time such conditions have been recorded in the area; both indicate changes in dengue vector distribution in Indonesia occurring in response to climate change.

The existence of *Aedes* mosquitoes at high altitudes up to 1200 m ASL indicates that the physical and biological factors in the area are capable of supporting the mosquito lifecycle. *Aedes* mosquitoes have not previously been found at altitudes of 1000 m ASL due to the low temperature, which impedes the *Aedes* lifecycle [14]. People in mountainous localities use large, open cement tanks to store clean water, which have become the most common larval habitat at high altitudes [13].

The average population density in Kendari City in 2014–2018 was 20.34 ha/person with a minimum density of 4.41 ha/person and a maximum density of 79.71 ha/person. Correlation test between population density and DHF incidence in Kendari City in 2014–2018 showed a *p* value of 0.186 > 0.05; there was no significant correlation between population density and the incidence of dengue fever in Kendari City in 2014–2018.

A study by Sirisena *et al.* (2017) in Sri Lanka showed that the dengue incidence was high in areas where the population density is high, and this was clearly seen in the three major Districts, Colombo, Kandy, and Jaffna where the population density is high. The Colombo District from the Western Province has been experiencing a very high dengue incidence, and the highest number of cases reported from 2009 ± 2014 was from this district. The major reason behind the high number of reported cases in the Colombo District appears to be due to the high population density.

The dengue incidence is very low in the Nuwara Eliya District despite this being one of the highly populated district in the wet zone. High altitude seems to play a pivotal role in limiting the distribution of *Aedes aegypti* in the Nuwara Eliya district, which is situated at 1880 m above the sea level. Badulla District is situated in the next highest elevation of 670 m and has a lower population density than Nuwara Eliya, yet reported high dengue incidence in the past 5 years [15].

In India, *A. aegypti* breeding sites range from the sea level to 1000 m above the sea level. Lower elevations (<500 m) have moderate to heavy mosquito

populations, while mountainous areas (>500 m) have low mosquito populations [16].

High population density is thought to contribute to dengue transmission by increasing the contact between infected mosquitoes and human hosts. However, high population density areas in São Paulo had a lower incidence of dengue compared to low population density areas [17]. These high population density areas typically consisted of large residential buildings, while the low population density areas typically consisted of individual houses. In contrast, other studies have reported that areas with a predominance of independent houses had higher levels of *A. aegypti* larval infestation [18].

A study by Handayani *et al.* [8] showed that the population density with the incidence of DHF has a correlation of 0.360 with *p* = 0.307. Thus, it can be concluded that there is no significant positive relationship between population density with dengue fever (DHF).

Study conduct in Vietnamese reported that infrastructure characteristics (e.g., the lack of water supply), rather than population density, had the greatest effect on the transmission of dengue [5]. One previous study found that around 3000–7000 persons/km² in Vietnam was the condition for the highest risk for dengue epidemics, and the risk did not increase with density beyond that [5].

Studied in Mexico by Machado-Machado [19], the relative contribution of climate and socio-ecological factors was investigated by including 11 climatic variables on temperature and precipitation but only four socioecological variables in models, resulting in climatic variables having more influence on dengue transmission than socioecological factors. Relative contributions of climatic and socioecological factors were also analyzed in Singapore, where the relative risk of dengue due to population growth was 6 times higher than the relative risk associated with climate alone [20], [21], [22].

Most of these studies found a significant association between dengue and high population density. However, a single study in Argentina reported that rural areas with a low population density may experience severe epidemics in the absence of a tap water supply [17]. High population density might only facilitate the dengue transmission cycle between human beings and mosquitoes when the number of infected cases is large enough, and the trend will still need to be validated by more data in the future [5].

Recommendation

Environmental factors and climate change provide changes to the lifecycle of mosquitoes and virus evolution. Therefore, observing dengue fever trends is needed considering that this disease can become an epidemic at any time.

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