

## Geospatial Analysis of *Plasmodium sp* in Malaria Cases in Bitung City, North Sulawesi

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## Abstract

## Original Research Article

The bite of a female Anopheles mosquito, which carries the Plasmodium parasite, is the cause of human malaria. Malaria is still a disease that affects a number of countries around the world, including Indonesia. Based on API data for the last 5 years, Bitung City is a district that has not yet reached the malaria elimination area because malaria cases are still found. The aim of this study was to map the distribution of Plasmodium sp as the cause of malaria patients in Bitung City. The data collection technique is to conduct malaria laboratory tests on patients with malaria symptoms at Budi Mulia Bitung Hospital and map the spread of malaria from positive Plasmodium sp. samples living in the Bitung city area using Epicollect5 application and Quantum GIS application. The results of the investigation were obtained based on gender, out of 72 respondents with malaria, the highest number of patients with male sex were 43 people (59.72%), patients with adult age (18-45 years) were the most, a total of 29 people (40.28%), patients infected with Plasmodium vivax were 68 people (94.4%). The distribution map of average malaria morbidity in Bitung during the study period shows that the eastern part (Lembeh Island) is the malaria endemic area with the most malaria cases. A total of 42 cases (58.3%) of the total 72 cases were found on Lembeh Island.

**Keywords:** geospatial; *plasmodium sp*; malaria.

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## INTRODUCTION

Plasmodium species cause malaria, a disease that can be acute or chronic. Humans contract Plasmodium sp. naturally from female Anopheles sp. mosquitoes. Malaria affects people of all ages and sexes and is easily spread by the bite of female Anopheles mosquitoes. Malaria can also be transmitted directly by the introduction of infected red blood cells through needles or from pregnant women to their unborn babies. Chills, high fever, headache, anaemia and enlarged spleen are some of the main signs and symptoms of the disease (Prodjodipuro P *et al.*, 2004).

In general, the diagnosis of malaria is made on the basis of clinical symptoms, serological examination and identification of the parasite (Plasmodium) in the patient's blood. The species of Plasmodium that can be transmitted to humans include *Plasmodium ovale*, *Plasmodium vivax*, *Plasmodium falciparum* and *Plasmodium malariae*. Microscopic examination and immuno-serological tests are the two main types of laboratory tests used to diagnose malaria by looking for specific antigens against Plasmodium. (Harijanto *et al.*,

2010) In diagnosing malaria, microscopic examination remains the most important procedure because it allows accurate identification of the type of plasmodium as well as calculation of the number of parasites, which determines the level of parasitemia.(Suparman & Suryawan, 2004).

In Indonesia, 94 610 malaria cases were recorded in 2021, compared with 226 364 cases the previous year. Overall, malaria cases in Indonesia decreased in 2018. In 2019, however, malaria cases increased to 250,628 cases. The eastern part of Indonesia, especially the province of Papua, has the highest number of malaria cases (90.9%) of all malaria cases in Indonesia. In 2021, there were 86,022 malaria cases in the region ( Kementerian Kesehatan RI. Sekretariat Jenderal, 2023)

North Sulawesi Province is one of the malaria endemic areas. Data on malaria morbidity rate per 1000 population (API) in North Sulawesi Province in 2019 was 0.22%, in 2020 it was 0.39%, in 2021 it was 0.29%. In 2022, it was 0.40% and in 2023, the highest malaria morbidity rate (API) in the last 5 years was 0.49%.

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Looking at the API data for the last 5 years, Bitung City is a district that has not yet reached the malaria elimination area because the highest number of malaria cases are still found in the last 2 years, namely in 2022 with 223 cases and in 2023 with 167 cases. (North Sulawesi Provincial Health Office, 2024)

Spatial, georeferenced or geospatial data can be entered, stored, processed, analysed and generated using an information system called a Geographic Information System (GIS). Data with coordinate systems and images of an area on the earth's surface are called spatial data. The planning and management of land use, natural resources, the transport environment, urban facilities and other public services can be supported by the use of GIS in decision making. GIS can also be used to support monitoring systems in the health sector (Cahyati & Lukman, 2015; Hutrianto & Syakti, 2019).

Bitung City is a port, industrial and fishing area (Kota Cakalang). On the other hand, Bitung City promotes urban development through the tourism industry, which naturally attracts a large number of domestic and international visitors. With the activities of people going in and out of the area, it can lead to the transmission of the spread of various diseases, including malaria. Based on the above background, researchers are interested in spatializing/mapping the spread of Plasmodium sp in the incidence of malaria in Bitung City.

## RESEARCH METHODOLOGY

All malaria suspects who met the inclusion and exclusion criteria of the study at Budi Mulia Hospital, Bitung City from June 2023 to June 2024 were used as samples in this study. The samples were collected using incidental sampling technique. The sample size was calculated using the Lemenshow formula. For routine

malaria microscopy examination, blood collection and malaria microscopy examination were performed by a medical laboratory technician (ATLM) who is competent in the field of blood collection and malaria microscopy examination in hospitals. The results of malaria microscopy were used to determine the coordinates of the houses of malaria cases that were positive for Plasmodium sp.

The field data were collected in the form of coordinate points using the Epicollect5 survey application and then processed using the Quantum.GIS application to determine the distribution of malaria cases in the study area with the distribution unit according to the administrative division of Bitung City.

## RESULTS AND DISCUSSION

### 1. Characteristics of Respondents Based on Gender and Age

The gender distribution of the 72 respondents is shown in Table 1. A study conducted in Bitung, North Sulawesi, found that men had a higher incidence of malaria with 43 cases (59.72%) compared to women with 29 cases (40.28%). The findings of this study are consistent with the research conducted in Lampung by Ernawati *et al.* (2011), who found that men had a 54.6% higher incidence of malaria. In addition, 87.5% of malaria patients hospitalised at Panglima Sebaya Hospital, Paser Regency in 2015-2018 showed positive results. (Salsabila *et al.*, 2021) In contrast, research conducted in a number of hospitals in Padang City showed that there were 51.5% more female patients than male patients (48.5%). (Kustiah *et al.*, 2020) In general, malaria is a disease that can affect almost anyone. Men are more likely to get malaria because they do more work outside the home, such as walking at night, farming, keeping livestock and maintaining ponds (Mayasari *et al.*, 2016).

**Table 1: Characteristic of Malaria Patients Based on Gender and Age in Bitung City**

Gender	Amount of sample	%
<b>Gender</b>		
Male	43	59.72
Female	29	40.28
<b>Age</b>		
Infants (0-1 years)	1	1.39
Children and preschool (1-6 years)School	6	8.33
School-age children and adolescents (6-18 years)	23	31.94
Adults (18-45 years old)	29	40.28
Early old age (45-59 years)	11	15.28
Elderly (>/ 60 years old)	2	2.78

The age distribution of the 72 malaria patients who participated in the survey is shown in Table 1. On average, there were 29 respondents (40.28%), most of whom were in the age range of 18-45 years (adults). The results of this study are in line with the analysis of Indonesian Riskesdas data in 2013 which shows that the

age of 25-34 years is the age most at risk of malaria infection. (Mayasari *et al.*, 2016) This age is included in the productive age which is an active age to move around in activities, both in work and traveling outside malaria endemic areas. (Solikhah, 2012)

## 2. Microscopic Malaria Testing Results

**Table 2: Distribution of Malaria Patients Based on Plasmodium Type in Bitung City**

Types of Plasmodia sp	Amount of sample	%
<i>Plasmodium vivax</i>	68	94.44
<i>Plasmodium falciparum</i>	4	5.56
<i>Plasmodium ovale</i>	0	0
<i>Plasmodium malariae</i>	0	0

Table 2 shows the distribution of respondents by type of Plasmodium of the 72 respondents with malaria, most of whom were infected with *Plasmodium vivax*, a total of 68 people (94.44%). *Plasmodium vivax*, which causes tertian malaria, has seen a significant increase in cases over the past decade. In 2013, *Plasmodium falciparum* was the most common malaria infection found in Indonesia. (Penelitian P, *et al.*, 2019) However, in 2023, *Plasmodium vivax* became the largest contributor to malaria, accounting for 47.93% of all malaria cases in Indonesia. (Kemenkes RI, 2023). The results of this study are the same as research on hematologic profiles based on the type of plasmodium in malaria patients at the Padang City Hospital, where 97% of malaria patients were infected by *Plasmodium vivax*. (Kustiah *et al.*, 2020). Research conducted in Kotabaru, South Kalimantan, stated that the annual incidence of malaria parasites was significantly reduced by 87% from 2012 to 2016. *Plasmodium vivax* infection was significantly more common over time, followed by *Plasmodium falciparum* infection ( $p < 0.001$ ). (Juhairiyah *et al.*, 2021)

### 3. Map of malaria incidence distribution based on Plasmodium species in Bitung City

Bitung City is one of the cities in the province of North Sulawesi. Administratively, Bitung City is divided into 8 sub-districts and 69 villages. The city is located between 1°23'23" north latitude and 1°35'39" east longitude and 125°1'43" east longitude and 125°18'13" east longitude. Geographically, Bitung City is bordered by the Moluccan Sea to the north, Likupang Sub-district, North Minahasa Regency; by the same sea to the south; by Kauditan Sub-district, North Minahasa Regency to the west; and by no less than the Moluccan Sea to the east. Bitung City covers approximately 2.26 percent of the total area of North Sulawesi Province or 313.51 km<sup>2</sup>. Lembah Island, which lies to the east of Bitung City and is separated from the west by the Lembah Strait, is the larger of the two areas that make up the city. Administratively, Bitung City consists of 8 sub-districts and 69 urban villages. The sub-districts in each sub-district are Matuari sub-district with 8 sub-districts; Girian sub-district with 7 sub-districts; Ranowulu sub-district with 11 sub-districts; Madidir sub-district with 8 sub-districts; Maesa sub-district with 8 sub-districts; Aertembaga sub-district with 10 sub-districts; South Lembah sub-district with 7 sub-districts and North Lembah sub-district with 10 sub-districts. (Samsuddin, 2022)

Bitung City is a district with local and international seaports that serve as entry and exit points for people. The spread of malaria from endemic areas to non-endemic areas can be facilitated by the ease of regional travel. As a result, malaria continues to be a health problem in Bitung City for both locals and visitors. As malaria cases have been detected in Bitung City in the last five years, the area is still not free of the disease.

The Plasmodium distribution map in Bitung City is shown below. The Lembah Strait divides the city of Bitung into two main parts, the western part, which is located on the main island of Sulawesi, and the eastern part, which is located on Lembah Island. The distribution map of average malaria morbidity in Bitung during the study period shows that the eastern part (Lembah Island) is the malaria endemic area with the highest number of malaria cases. A total of 42 cases (58.3%) of the total 72 cases were found on Lembah Island.

In the map of the distribution of malaria cases based on the type of Plasmodium, the average distribution of malaria morbidity in Bitung during the study period shows that the eastern part (Lembah island) is the malaria endemic area with the most malaria cases. A total of 42 cases (58.3%) of the total 72 cases were found on Lembah island. In a study conducted in Kotabaru, South Kalimantan, high incidence was identified spatially clustered in the northern, western, and partly southern areas of Kotabaru. Two persistent high-risk clusters and four re-emerging high-risk clusters. (Juhairiyah *et al.*, 2021)

Plasmodium mapping was also conducted in Jiangsu Province, China. The prediction map of malaria distribution based on the total growing degree days (TGDD) showed that malaria transmission decreased gradually from west to east. The distribution map of average malaria morbidity in Jiangsu for 14 years shows that the central and western parts of Jiangsu are the most seriously endemic areas. The morbidity rates in areas along the Taihu valley, such as Suzhou, Wuxi and Changzhou, as well as Nantong and a number of counties in the north are the lowest (Yang *et al.*, 2002) A study conducted in India, obtained from 288 health centers, GIS identified 10 hotspots with very high risk of malaria and 14 hotspots with high risk of malaria. Malaria can

spread in these hotspots when there are favorable transmission conditions. (Nath *et al.*, 2013)

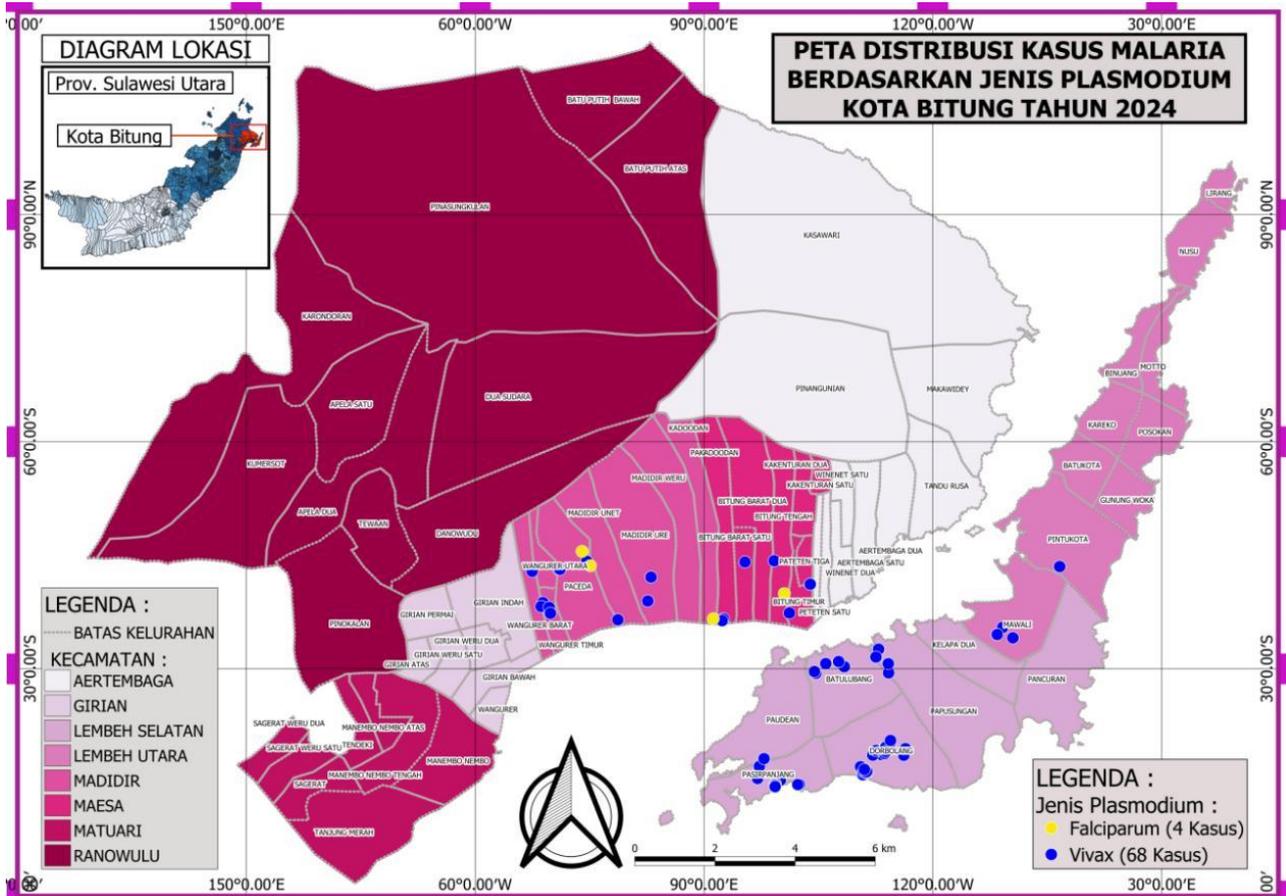


Figure 1: Map of malaria distribution based on Plasmodium species in Bitung City

## CONCLUSION

Bitung City is a district that has not yet achieved malaria elimination because malaria cases are still found. In the geospatial analysis, the map of the average distribution of malaria morbidity in Bitung during the study period shows that the eastern part (Lembeh island) is the malaria endemic area with the most malaria cases. Lembeh Island is located to the east of Bitung City and is separated from the west by the Lembeh Strait. A total of 42 cases (58.3%) of the total 72 cases were found on Lembeh island. It is hoped that the results of this research can provide input to policy makers in overcoming malaria

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