Prevalence and Risk Factors of Malaria in Iwaka District, Mimika, Papua

Novyan Lusiyana*

Department of Parasitology, Faculty of Medicine Universitas Islam Indonesia, Yogyakarta, Indonesia.

Corresponding Author:
Novyan Lusiyana, MD. Department of Parasitology, Faculty of Medicine Universitas Islam Indonesia. Jl. Kaliurang Km 14,5, Yogyakarta, Indonesia. Email: 107110411@uii.ac.id

ABSTRACT

Background: *Papua is a high-endemic region for malaria in Indonesia. Malaria transmission is heavily influenced by environmental factors, particularly those related to vector breeding habitats and the homes of infected individuals. Communities in high- endemic areas also exhibit risk behaviors that can increase the likelihood of malaria transmission.* ***Methods:*** *This cross-sectional study was conducted in Iwaka District, Mimika, Papua, and included residents aged 18 years and older who had lived in the district for at least six months and exhibited symptoms of malaria. Subjects with a history of malaria or those under antimalarial treatment in the last two weeks were excluded. We collected demographic characteristics, malaria history, environmental factors, and behavioral components using a structured questionnaire. Each subject underwent a malaria examination using a rapid diagnostic test (RDT). Data were analyzed using STATA software.* ***Results:*** *A total of 863 subjects met the inclusion and exclusion criteria. Of these, 429 (49.7%) were diagnosed with malaria. Malaria cases were predominantly found among males, individuals aged 21– 40 years, those with secondary education, and those working as farmers. Malaria incidence was associated with having family members who had malaria, living near stagnant water, and residing within 100 meters of forests or fields ($p < 0.05$). The use of bed nets, mosquito repellents, and long-sleeved clothing was low, and most houses had wooden walls without wire mesh protection.* ***Conclusion:*** *Malaria prevalence in Iwaka District is extremely high, with risk factors including age, gender, proximity to stagnant water and forests/fields, and family history of malaria.*

Keywords: *malaria, prevalence, risk factors, Papua.*

INTRODUCTION

Malaria remains one of the endemic diseases in 85 countries, although nearly 94% of cases are concentrated in Africa, with an estimated 233 million cases in 2022. In contrast, the Southeast Asian region accounts for 2% of global malaria cases, with an estimated 5 million cases in 2022. This figure has decreased by 83% over two decades, with India contributing the majority of cases (66%). An additional 11.9% of cases were contributed by Bangladesh, Indonesia, Myanmar, and Thailand.[1]

In Indonesia, the malaria incidence rate in 2023 was 1.5 per 1,000 population, an increase since 2021.[2] Several provinces have yet to achieve malaria elimination status and remain highly endemic, including Papua Province. Mimika Regency in Papua contributes the highest number of malaria cases in Indonesia, with an Annual Parasite Incidence (API) of 156.59 per 1,000 population.[2] The high malaria incidence in this region demands serious efforts to identify risk factors for malaria transmission.

Controlling risk factors is key to malaria elimination, as transmission risk factors vary across endemic regions.[3,4] A study in Zanzibar, another high-endemic area, showed that age, fever history, and travel history were associated with malaria incidence, while other factors such as gender, bed net use at night, bed net ownership, and the application of Insecticide Residual Spray (IRS) were protective factors.[3] Similarly, a study in Indonesia highlighted environmental factors such as altitude, type of wall materials, insecticide use, and proximity of houses to mosquito breeding sites as key variables associated with malaria.[4] In high-endemic areas, many mosquito breeding habitats are linked to the presence of stagnant water, with numerous water bodies testing positive for Anopheles larvae.

The abundance of Anopheles breeding habitats increases the potential for malaria transmission, and controlling these habitats can help prevent transmission. In endemic areas, the existence of mosquito breeding sites is influenced by both human activities and climate factors.[5,6] In addition, other environmental factors, such as the use of window screens in homes, can also reduce malaria transmission risk. A study in Kenya demonstrated that house modifications with window screens could effectively prevent malaria transmission.[7]

Besides sociodemographic and environmental factors, behavioral factors also play a significant role in malaria transmission in endemic regions, particularly high-risk behaviors. Certain groups are more at risk of being bitten by Anopheles mosquitoes due to nighttime outdoor activities.[8] Outdoor activities at night increase the likelihood of being bitten by mosquitoes.[9] By identifying the specific risk factors in a malaria-endemic region, control efforts can be more targeted, as current malaria control strategies mainly focus on preventing mosquito bites indoors.[10] This study aims to determine the prevalence and risk factors of malaria in Iwaka District, Mimika, Papua.

METHODS

Study Design

This was an observational study using a cross-sectional design. The study received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Islam Indonesia, under certificate number 9/Ka.Kom.Et/70/KE/IV/2023.

Study Location

The study was conducted in Iwaka District, Mimika Regency, Papua. Iwaka District is one of the malaria-endemic subdistricts in Mimika Regency, Papua, located 30 km from the capital of Mimika Regency.[11] The study was carried out over three months, from February to April 2023.

Population and Sample

The subjects involved in this study were those who met the inclusion and exclusion criteria. The inclusion criteria were male and female subjects aged >18 years, residing in Mimika for at least six months, seeking health services for symptoms suggestive of malaria (fever, chills, sweating, headache, joint pain), and consenting to participate by signing an informed consent form. The exclusion criteria included subjects with a history of malaria or those who had undergone antimalarial treatment in the past two weeks.

Malaria Examination

Malaria detection in this study was performed using the RDT® Abbot test. Trained healthcare workers at the Limau Asri health center conducted the malaria tests. Blood samples were collected from the tip of the left middle finger using a lancet. Before the puncture, the finger was disinfected with an alcohol swab. After the alcohol dried, the fingertip was punctured to a predetermined depth with the lancet. The first drop of blood was wiped off with a dry cotton swab, and the subsequent blood was used for testing. The blood was placed in the sample well, followed by the addition of buffer reagent, and the result was read after 20 minutes.

A positive result was indicated by the presence of at least two red lines: one on the control line and one on the Plasmodium infection indicator (Pf or Pan). A negative result was interpreted if only the control line appeared. If no red line appeared on the control indicator, the test was repeated, and the result was deemed invalid.

Study Variables

There were five domains of variables in this study: malaria prevalence, demographic characteristics, malaria history, household environmental characteristics, and malaria prevention behaviors. Malaria prevalence was determined by calculating the proportion of both new and existing malaria cases during the study period, divided by the total number of subjects, and expressed as a percentage.[12]

Demographic variables included age (grouped into <20, 21–30, 31–40, 41–50, 51–60, 61–70, >70 years),[12] gender (male and female), education level (low [elementary school], medium [junior high school, high school], high [college/university]), and occupation (civil servants, laborers, teachers, housewives, private employees, students, religious leaders, farmers, self-employed, unemployed).[4]

The malaria history variables included the subject's personal history of malaria (yes/no) and family history of malaria (yes/no). Household environmental variables included house type (made of wood and brick, or wood only), the presence of window screens (yes/no), stagnant water within 100 meters of the house (yes/no), and proximity of the house to forests or fields within 100 meters (yes/no).[4] Malaria prevention behavior variables included outdoor nighttime activity (yes/no), use of mosquito repellent (yes/no), overnight stays in fields (yes/no), use of long-sleeved clothing (yes/no), and use of bed nets (yes/no).[9]

Data Analysis

Demographic characteristics, malaria history, household environment, malaria prevention behaviors, and malaria test results were presented descriptively in tabular form. The analysis of the relationship between variables and malaria incidence was performed using STATA 14 software. Results were considered significant if $p<0.05$ with a 95% confidence interval.

RESULTS

A total of 863 respondents participated in this study, comprising both new and existing malaria cases. Among these, 429 individuals were diagnosed with malaria, yielding a malaria prevalence of 49.7%. The demographic characteristics of the subjects based on malaria cases are presented in **Table 1**. The majority of the subjects were aged 21-40 years, male (59.1%), had a middle-level education (79.3%), and were predominantly farmers (33.5%). Malaria testing using RDT revealed that 429 out of 863 subjects were infected with Plasmodium. The analysis showed that malaria cases were significantly associated with age ($p=0.00$) and gender ($p=0.01$), while education level and occupation were not significantly associated with malaria incidence ($p>0.05$).

Table 1. Demographic Characteristics and Their Association with Malaria Incidence

Demographic Characteristics	Malaria		Total	p-value
	No	Yes		
n (%)	434 (50.3)	429 (49.7)	863 (100.0)	
Age Category				
<20	8 (1.8)	9 (2.1)	17 (2.0)	0.00*
21-30	131 (30.2)	170 (39.6)	301 (34.9)	
31-40	138 (31.8)	145 (33.8)	283 (32.8)	
41-50	92 (21.2)	68 (15.9)	160 (18.5)	
51-60	46 (10.6)	30 (7.0)	76 (8.8)	
61-70	15 (3.5)	7 (1.6)	22 (2.5)	
>70	4 (0.9)	0 (0.0)	4 (0.5)	
Gender				
Male	237 (54.6)	273 (63.6)	510 (59.1)	0.01*
Female	197 (45.4)	156 (36.4)	353 (40.9)	
Education Level				
Low	97 (22.4)	78 (18.2)	175 (20.3)	0.20
Middle	336 (77.4)	348 (81.1)	684 (79.3)	
High	1 (0.2)	3 (0.7)	4 (0.5)	
Occupation				
Civil Servant	13 (3.0)	9 (2.1)	22 (2.5)	0.15
Laborer	16 (3.7)	26 (6.1)	42 (4.9)	
Teacher	13 (3.0)	8 (1.9)	21 (2.4)	
Housewives	145 (33.4)	119 (27.7)	264 (30.6)	
Private employee	4 (0.9)	7 (1.6)	11 (1.3)	
Student	9 (2.1)	12 (2.8)	21 (2.4)	

Religious leader	1 (0.2)	1 (0.2)	2 (0.2)
Farmer	139 (32.0)	150 (35.0)	289 (33.5)
Unemployed	23 (5.3)	12 (2.8)	35 (4.1)
Enterpreneur	71 (16.4)	85 (19.8)	156 (18.1)

*p<0,05

As shown in **Table 2**, of the 429 malaria cases, 41 (4.8%) reported having family members who also suffered from malaria, and family history of malaria was significantly associated with malaria incidence (p=0.03). A total of 700 (81.1%) respondents had a prior history of malaria, but this was not significantly associated with malaria incidence (p=0.17).

According to **Table 3**, the majority of houses in Iwaka District had wooden walls (579/863, 67.1%). However, the proportion of malaria cases among those living in houses with wooden walls was similar, and there was no statistically significant relationship (p=0.57). Similarly, the proportion of infected and non-infected individuals using window screens was almost identical. While more residents did not use window screens, there was no statistically significant association with malaria incidence in Iwaka District (p=0.76).

One environmental factor associated with malaria transmission was the presence of stagnant water within 100 meters of the house (**Table 3**). While not all houses had stagnant water nearby, more than 35% of malaria cases reported its presence around their homes (p=0.01). Additionally, 46.0% of the study population lived within 500 meters of a forest or field. Of the malaria cases, 50.3% resided within 500 meters of a forest or field, and this proximity was significantly associated with malaria incidence (p=0.01) (**Table 3**).

Table 2. Relationship Between Malaria History and Malaria Incidence

Malaria History	Malaria		Total
	No	Yes	
n (%)	434 (50.3)	429 (49.7)	863 (100.0)
Malaria history			
Yes	74 (17.1)	89 (20.7)	163 (18.9)
No	360 (82.9)	340 (79.3)	700 (81.1)
Family with malaria			
Yes	420 (96.8)	402 (93.7)	822 (95.2)
No	14 (3.2)	27 (6.3)	41 (4.8)

*p<0,05

Table 3. Relationship Between Malaria and Household Characteristics

Household Environmental Characteristics	Malaria		Total	p-value
	No	Yes		
n (%)	434 (50.3)	429 (49.7)	863 (100.0)	
House Type				
Wood and brick	64 (14.7)	63 (14.7)	127 (14.7)	0.57
Brick	73 (16.8)	84 (19.6)	157 (18.2)	
Wood	297 (68.4)	282 (65.7)	579 (67.1)	
Use of Window Screens				
No	329 (75.8)	329 (76.7)	658 (76.2)	0.76
Yes	105 (24.2)	100 (23.3)	205 (23.8)	
Presence of Stagnant Water within 100 m				
No	309 (71.2)	271 (63.2)	580 (67.2)	0.01*
Yes	125 (28.8)	158 (36.8)	283 (32.8)	
Proximity to Forest/Field within 100 m				
No	253 (58.3)	213 (49.7)	466 (54.0)	0.01*
Yes	181 (41.7)	216 (50.3)	397 (46.0)	

*p<0,05

Table 4. Relationship Between Malaria and Malaria Prevention Behaviors

Malaria Prevention Behaviors	Malaria		Total	p-value
	No	Yes		
n (%)	434 (50.3)	429 (49.7)	863 (100.0)	
Outdoor Night Activity				
No	403 (92.9)	392 (91.4)	795 (92.1)	0.42
Yes	31 (7.1)	37 (8.6)	68 (7.9)	
Use of Mosquito Repellent				
No	355 (81.8)	371 (86.5)	726 (84.1)	0.06
Yes	79 (18.2)	58 (13.5)	137 (15.9)	
Habit of Staying Overnight in Fields				
No	403 (92.9)	392 (91.4)	795 (92.1)	0.42
Yes	31 (7.1)	37 (8.6)	68 (7.9)	
Use of Long Clothing				
No	372 (85.7)	376 (87.6)	748 (86.7)	0.40
Yes	62 (14.3)	53 (12.4)	115 (13.3)	
Use of Mosquito Nets				
No	218 (50.5)	217 (50.8)	435 (50.6)	0.92
Yes	214 (49.5)	210 (49.2)	424 (49.4)	

Malaria prevention behaviors among the residents of Iwaka District that need improvement include personal protection use (15.9%), wearing long-sleeved clothing during outdoor activities at night (13.3%), bed net usage (50.6%), and mosquito repellent use (15.9%). However, a notable behavior was the high proportion of residents who refrained from outdoor activities at night (92%). None of the malaria prevention behaviors among residents were significantly associated with malaria incidence (p>0.05).

DISCUSSION

The prevalence of malaria in this study was 49.7%, with the highest incidence observed in the 21–40 year age group. This result is higher than that of a similar study in Ethiopia, another highly malaria-endemic region, where the prevalence was only 21.1%, though the age group affected by malaria was similar (25–34 years).[13] Malaria cases were more prevalent among males than females, and malaria in Mimika, Papua, was found to be associated with gender (p = 0.01).[14] This finding aligns with research from Ethiopia, which also demonstrated a gender-related association, showing that males are at a higher risk of contracting malaria than females.[15] Moreover, a study from Senegal revealed that males possess lower knowledge about malaria compared to females[16], and they are also known to exhibit poorer malaria prevention practices.[17] Both men and women have an equal chance of being infected by *Plasmodium*, as mosquitoes do not discriminate between sexes when feeding on blood.[18] However, contrasting results were observed in a study from Ghana, where females were at a higher risk of malaria compared to males. This was attributed to educational and external factors related to *Plasmodium* infection.[19] A study in Northwestern Ethiopia revealed persistent misconceptions about the causes, symptoms, signs, modes of transmission, and preventive practices for malaria[20], which may increase the risk of contracting the disease. However, the results of this study show no significant association between education level or occupation and the incidence of malaria.

This study revealed that 93.7% of individuals diagnosed with malaria reported that other family members within the same household also suffered from malaria. This result is higher than a study in Equatorial Guinea, which found that 80% of *Plasmodium* infection cases occurred within the same family.[21] The incidence of malaria in Iwaka District was associated with the presence of family members with malaria (p = 0.03), but not with a previous history of malaria. This is possibly due to the low proportion of subjects with a prior history of malaria (18.9%). This finding aligns with a study conducted on the Thailand-Myanmar border, which showed that having family members with malaria in the same household at the same time is associated with malaria incidence.[22] The presence of malaria cases within a household indicates a source of transmission near the patient's residence. Each region has varying levels of risk, characterized by high, medium, or low transmission sources, making it necessary to implement integrated control efforts targeting the source of transmission.[23] One strategy to detect other transmission sources is through case detection targeting family members and neighbors using the reactive case detection (RACD) method.[24]

Malaria transmission is related to environmental factors. A total of 32.8% of residents in Iwaka District reported no stagnant water near their homes, yet the malaria prevalence in this study approached 50%. Studies in Uganda and Senegal, both high malaria endemic areas, found that the high number of malaria cases was associated with the presence of multiple positive Anopheles larval breeding habitats.[25,26] However, the limited presence of stagnant water in a high endemic area does not necessarily indicate the absence of Anopheles vectors, as the flight distance and capabilities of these vectors vary by species.[27] This study's results are consistent with findings from Southwest Ethiopia, which demonstrated that living near stagnant water significantly increases malaria risk, with an adjusted odds ratio (AOR) of 8.996.[13]

The presence of stagnant water may be due to high rainfall,[25] as reported by the Meteorological, Climatological, and Geophysical Agency of Mimika, Papua, which classifies Mimika as having high annual rainfall (>500 mm).[11,28] This high rainfall, combined with hydromorphic and halomorphic soil types, enables effective water retention.[26] Furthermore, during the rainy season, the flight capability of Anopheles mosquitoes peaks[27], and this study was also conducted during the rainy season. Stagnant water that poses a risk for malaria is water that contains Anopheles larvae.[25,26] Studies in high malaria endemic areas in Senegal demonstrated that malaria cases frequently occur in villages with numerous Anopheles breeding habitats.[26] A study conducted in Papua, including Mimika District, showed that Anopheles larvae were found in every water body near residents' homes.[29] Based on this information, it is necessary to identify Anopheles breeding sites around residential areas in Iwaka District.

The abundance of Anopheles mosquito breeding sites ensures a sustainable vector population, which increases the risk of malaria transmission. Therefore, preventive measures are essential to avoid Anopheles mosquito bites. In Iwaka District, prevention behaviors remain low and need improvement, particularly in the use of mosquito nets (49.4%), repellents (15.9%), and long-sleeved clothing at night (13.3%). The use of mosquito nets in Iwaka District is higher than in a study conducted in Ethiopia (26.8%)[14], but lower compared to Cameroon (59%)[30]. The low usage of mosquito nets may be influenced by factors such as net availability, education level, socioeconomic status, understanding of toxicity effects, and overall awareness.[14,30] Currently, malaria prevention efforts in eastern Indonesia focus on preventing mosquito bites inside the home using mosquito nets, yet their usage in high-endemic areas remains low.[30] Meanwhile, Anopheles mosquitoes in Papua exhibit both indoor and outdoor biting behavior.[29] Thus, optimizing the use of mosquito nets and the installation of wire mesh screens is crucial. In this study, only 49.4% of individuals reported using mosquito nets, and only 23.8% used wire mesh.

Multiple studies have proven that the use of mosquito nets protects individuals from malaria.[31] However, the results of this study show no significant association between net use and malaria incidence. This may be due to the small difference in the percentage of people using and not using nets, as the protective effect of nets is typically observed when more than 70% of the population uses them.[32]

Malaria prevention measures related to environmental factors still require attention, such as the installation of wire mesh screens (23.8%) and the use of wooden wall materials in most homes (67.1%), as these factors are determinants of malaria transmission.[14] A study in Kenya demonstrated that wire mesh can reduce the density of mosquito vectors,[33] and fewer mosquitoes were collected in houses with mesh screens.[7] One effective malaria prevention behavior observed among subjects in Iwaka District was avoiding outdoor activities at night and not staying overnight in the fields. A study in Ethiopia found that outdoor activities at night are a determinant of malaria[9] and may hinder malaria control efforts.[8] Outdoor activities increase the likelihood of Anopheles mosquito bites, with men being more active outdoors at night.[8] This finding aligns with the results of this study, where malaria was more common among men.

CONCLUSION

The prevalence of malaria in Iwaka District remains high, predominantly affecting young males. Malaria is associated with the presence of stagnant water within 100 m, the distance of homes from forests being ≤100 m, and a family history of malaria. Optimizing malaria prevention, both indoors and outdoors, is essential to reduce mosquito bites.

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CONFLICT OF INTEREST

We declare no conflicts of interest in this research, from the proposal stage to the final report and publication of this article.

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