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Research Article

Malaria Risk Factor at the Tabalong Cross-Borders, South Kalimantan, Indonesia

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ABSTRACT

Background: This study aims to determine risk factors related to malaria incidence in Muara Uya and Jaro in Tabalong, South Kalimantan.

Materials and Methods: This is a cross-sectional study conducted on communities. The research was conducted in November 2021. Thin and thick blood films were prepared, stained, and examined microscopically following standard protocol. Data were analysed by Fisher exact using Statistical Package for Social Sciences Software.

Results: 59% of the 311 respondents were male. Most of the respondents were between the ages of 15 and 30 years (39%). The majority had a non-risky occupation. There were 5 (1.6%) positive malaria cases among 311 people. *Plasmodium falciparum* was the most common cause of infection (60%), followed by *Plasmodium vivax* (20%) and mixed infections (20%). There was a significant relationship between the behaviour of staying in the forest and occupation with malaria incidence. The forest is bounded by malaria-endemic districts in East Kalimantan. According to the questionnaire, the respondent's knowledge was quite good (55-67.5%). Despite the fact that community awareness was quite high, occupational factors contributed significantly to the spread of malaria.

Conclusion: We discovered a role for cross-border transmission in the context of individual occupational risks. Optimisation of cross-border monitoring is required to help determine the dynamics of cross-border malaria in order to achieve accelerated malaria control and elimination.

These findings imply that the epidemiology of imported malaria should be updated on a regular basis in order to review and refine malaria prevention strategies.

Keywords: Cross-Border, Malaria, Risk Factor, Tabalong

Introduction

Malaria is a parasitic disease transmitted to humans through the bite of female Anopheles mosquitos, infecting millions of people worldwide as well as causing major deaths and morbidity.

Plasmodium falciparum, *Plasmodium vivax*, *Plasmodium ovale*, *Plasmodium* malariae, and *Plasmodium knowlesi* parasites cause human malaria. P. *falciparum* and P. *vivax* are the most common source of malaria, and P. *falciparum* is also the most likely to be fatal. *Plasmodium* knowlesi, the primary cause of malaria in Southeast Asia, has been known to infect humans since 2004.[1] Malaria cases have spread all over the world, with Africa (88%), Southeast Asia (10%), and the Eastern Mediterranean (2%) having the highest prevalence.[2] From 227 cases in 2019, there has been an increase of approximately 241 million malaria cases worldwide in 2020,[3] with 671,000 people dying as a result of the disease. The number of deaths caused by malaria decreased from 2000 to 2019, but increased by about 12% in 2020.[4]

Malaria is one of five infectious diseases that continue to be a public health concern in Indonesia. Maluku, Papua, as well as West Papua, had the highest malaria endemicity in 2021. In 2021, up to 32.5% of districts/ cities in Indonesia were still malaria-infested. Annual Parasite Incidence (API) was expected to rise by 1.1 per 1000 population in 2021 as compared to 2020.[5]

Kalimantan is a province with forests and swamps, which serve as breeding grounds for the Anopheles mosquito. Furthermore, South Kalimantan remains a malaria-endemic area. According to the 2021 health profile report, there were still approximately 31% more areas in South Kalimantan that have not eliminated malaria. In 2020, Tabalong, including the district, reported an API of less than 1 case per 1000 population at risk (API = 0.4). So this district is in Category 1: the Elimination Phase.[6]

Istiana et al. discovered 38 positive malaria cases out of 107 residents, for a prevalence of 35.5%. The prevalence of malaria transmission in Tabalong Regency is linked to mining areas, as well as rubber and oil palm plantations, which have a significant impact on malaria transmission in the area.[7]

Cross-border malaria is a significant impediment to elimination efforts.[8] The malaria burden at the Venezuela-Guyana-Brazil border is exacerbated by cross-border malaria. The discovery of distinct profiles of case importation highlights the need for increased border surveillance and implement adaptation strategies for various mobility routes, such as the movement of refugees and Brazilians having to work in mining.[9]

Among the 2030 Sustainable Development Goals, are the end of the epidemic of AIDS, tuberculosis, malaria, and neglected tropical, water-borne and other communicable diseases.[10] The Indonesian government is dedicated to improving the malaria elimination programme by distributing insecticide-treated bed nets and using microscopic and molecular diagnostics. Elimination targets are carried out both in areas with high malaria endemicity and low malaria endemicity, so it is hoped that by 2030, Indonesia will be free of malaria. Tabalong is one of the endemic malaria districts targeted for elimination. It is still endemic for malaria, so it is important to conduct risk factor-related malaria incidence in Tabalong, South Kalimantan to support integrated surveillance in achieving elimination by 2030.

Materials and Method

Ethics

This study protocol was reviewed and approved by the Faculty of Medicine and Health, Christian Krida Wacana University numbered 1177/SLKE-IM/UKKW/FKIK/KE/X/2021.

Study Design

This is a cross-sectional study that was conducted in Muara Uya and Jaro, Tabalong, South Kalimantan, which is adjacent to Paser Regency, East Kalimantan (Figure 1). The research was carried out from November to December, 2021.

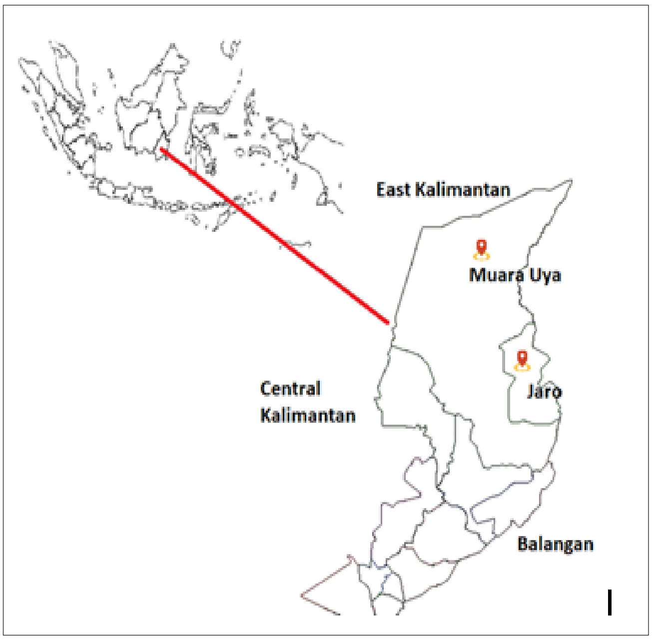

Figure 1.A Map Showing Study Area, Puskesmas Muara Uya Dan Puskesmas Jaro

Sampling of Study Participants

The number of samples was calculated using Stanley Lemeshow et al.'s estimation formula for one proportion with simple random sampling: n = [Z2 1-a2. P(1-P)]/d2,

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where n = the number of samples, Z2 1-a2 = 1.960 (95% CI), P=0.28, d = 0.05. The calculated sample size was 310.[11] Participants in this study were residents who had lived in sampling areas for at least 1 year and were 15 years of age or older. Participants who agreed to be interviewed after signing the informed consent form comprised the research sample, which turned out to be 311.

Inclusion Criteria

People aged 15 years and older who resided in Tabalong Regency, South Kalimantan were included. According to the study's findings, the majority of malaria cases occurred in people aged 15 to 64 years.[12] Furthermore, Istiana et al.'s study revealed that the most infected people were between the ages of 16 and 60 years.[13]

Exclusion Criteria

Respondents who were less than 15 years of age, not willing to be interviewed and did not sign the informed consent form were not included in the study.

Parasitological Survey

The survey was conducted in healthcare facilities or places where people can easily reach them. The consenting individual provided a finger-prick blood sample of 6 µl (12 mm diameter) for the thick film and 2-3 µl for the thin film, which was collected with disposable lancets and micropipettes. For quality assurance, this study involved a district-level certified microscopist. The thin blood films were fixed by plunging them briefly in absolute methanol for a few seconds and then allowing the slide to air dry. The thin film was dried at an acute angle, with the film-side of the slide facing up and the thin film facing down. This inhibits the thick film from being fixed by methanol vapour and being outrun. The thick film must not be fixed. This was followed by 45 minutes of staining with Giemsa 3% staining racks and washing the smearing. The asexual parasite density was counted against 200 White Blood Cells (WBC) assuming an average WBC count of 8,000 per microlitre of blood. Before declaring the thick smear-negative, at least 100 fields containing approximately WBCs were screened.[14] The stained specimens were examined by a certified microscopist.

Knowledge & Perception Study

Following blood collection, the participants were interviewed using a knowledge questionnaire, which included questions about the participants' perceptions of malaria, as well as the state of the environment in which they lived. The questions focused on the participants' knowledge of disease symptoms, whether they had previously been infected with malaria, malaria prevention practices, and disease treatment that has been and can be done if infected. In terms of environmental risk factors they are more likely to be around forests, where they worked, the environmental conditions around their house, and their participation in community activities prior to midnight, if they used mosquito repellent cream whenever they went outside, and provided information if there are any puddles, ponds, or cattle pens near the house.

Statistical Analysis

The collected data were entered and coded in Excel (version 2011) before being analysed in SPSS Ver. 22 software (SPSS Inc., Chicago, Illinois, USA). Data were analysed by Fisher's exact test.

Results

Out of 311 respondents, 59% were male, while 41% were female. According to age, 39% of respondents were 15-30 years old, 38% were 31-46 years old, and 23% were 47 years of age and older. According to educational level, 36% of respondents had graduated from elementary school, 30% had graduated from junior high, 22% had completed high school, 2% had graduated from college/ university, and 11% had no diploma.

In contrast to risk occupations such as forest workers, gathering woodworkers, and bird catchers, 65.3% of participants worked in non-risk occupations such as farmers, entrepreneurs, rubber farmers, planters, couriers, nurses, village officials, midwives, labourers, unemployment, teachers, domestic workers, private employees, and breeders. The majority of respondents were Banjarese (79.4%), Javanese (18.3%), Bugis and Dayak (0.6% each), and Bekampal, Paser, and mixed tribes (0.3% each). 24% of respondents were from Solan Village, 23% were from Muara Uya, 14% were from Simpang Layung, 13% were from Palapi Village, 12% were from Jaro, and 7% were from Garagata and Temperak each (Table 1).

Malaria Prevalence

A microscopic examination revealed that 5 people (1.6%) tested positive for malaria, while the remaining 306 (98.4%) tested negative. The most common cause of malaria cases is *Plasmodium falciparum* (60%), *Plasmodium vivax* (20%), and mixed infections (20%) (Figure 2).

Characteristics of Knowledge and Perceptions of Participants

58% of all respondents were aware that malaria is spread through the bite of an infected mosquito. In terms of prevention, the use of bednets was mentioned by a higher percentage of respondents (61.1%) as the most beneficial to avoid mosquito bites. 12.9% of inhabitants used wire gauze to protect themselves from flying insects (Table 2).

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Table 1.Distribution and Characteristics of Respondents based on Gender, Age, Education Level, Occupation, Ethnic Group, and Village

Characteristics	N	%
Gender		
Male	183	59
Female	128	41
Age (Years)		
15-30	123	39
31-46	117	38
≥47	71	23
Educational Level		
Not completed primary school	33	10.61
Primary school	111	36
Junior high school	93	30
Senior high school	68	22
University	6	2
Occupation		
Work with no risk (not-related to forest)	203	65.3
Work-involving risk (related to forest)	108	35
Ethnic Groups		
Banjarese	247	79.4
Bakampal	1	0.3
Bugis	2	0.6
Dayak	2	0.6
Javanese	57	18.3
Mix Java and Banjar	1	0.3
Paser	1	0.3
Villages		
Garagata	23	7
Jaro	36	12
M. Uya	71	23
Palapi	40	13
Temperak	22	7
Solan	74	24
Sp Layung	45	14

Table 2.Behaviour Characteristics of Respondents

Behaviour Characteristics	N	%
Knowledge, Attitude, and Practice		
Ways of Spread of Malaria		
Disease transmitted by mosquitoes	180	58
Weather-related disease	44	14.1
Illness attributed to supernatural forces	5	1.6
Illness posed by breaking taboos	33	11
Other	49	16
Malaria Symptoms		
Fever, chills, headache, nausea	75	24.1
Fever, chills, nausea	31	9.9
Fever, chills	44	14.1
Don't know	105	33.7
Time of Mosquito Bites		
Evening	210	67.5
Afternoon	57	18.3
Morning	24	8
Is Malaria a Deadly Disease?		
Yes	169	54.3
No	142	46
Efforts to Avoid Getting Mosquito Bites at Night		
Use of mosquito repellents	41	13.2
Use of mosquito nets before sleeping	190	61.1
Use of mosquito coils	57	18.3
Spraying the bedroom with mosquito repellent sprays	13	4.2
Wearing long sleeves	6	2
Others	4	1.3
Environmental		
Use of Wire Gauze to Protect them from Flying Insects		
Yes	40	13
No	271	87.1
Is there a puddle near the house?		
Yes	163	52.4
No	148	48
Is there a pond close to the house?		
Yes	48	15.4
No	263	85

Table 3 summarises the risk factors considered in this study, which were divided into four broad categories: age, gender, education, and prevention effort (including the use of wire gauze and nets). Two of the risk behaviours investigated in the study were found to be significantly related to malaria. These included working in the forest and sleeping habits in the forest with respective odds ratios of 1.049 and 0.067. Respondents who stayed in the forest had a risk of malaria of 0.067 times, while those who worked in the forest had a risk of malaria of 1,049 times. More than 2.7% of the men (n = 183, 2.7%) reported having malaria while working in the forest and were of productive age.

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Table 3.Analysis of Risk Factors for Malaria

Characteristics	n	Positive Cases of Malaria n (%)	P-value	OR	95% CI
Gender					
Male	183	5 (2.7)	0.08	0.973	0.946-0.997
Female	128	0 (0.0)			
Age (years)					
Productive (15-46)	239	5 (2.1)	0.216	0.593	0.961-0.997
Non-productive (≥ 47)	72	0 (0.0)			
Education level					
No diploma	305	5 (1.6)	1.000	0.984	0.969-0.998
University	6	0 (0.0)			
Prevention efforts					
Use of wire gauze					
No	271	3 (1.1)	0.125	4.702	0.761-29.052
Yes	40	2 (5)			
Use of nets					
No	216	3 (1.4)	0.644	0.655	0.108-3.985
Yes	95	2 (2.1)			
Stay in the forest					
No	242	1 (0.4)	0.009	0.067	0.07-0.614
Yes	69	4 (5.8)			
Occupation					
No-risk	203	0 (0.0)	0.005	1.049	1.006-1.093
Risk	108	5 (4.6)			

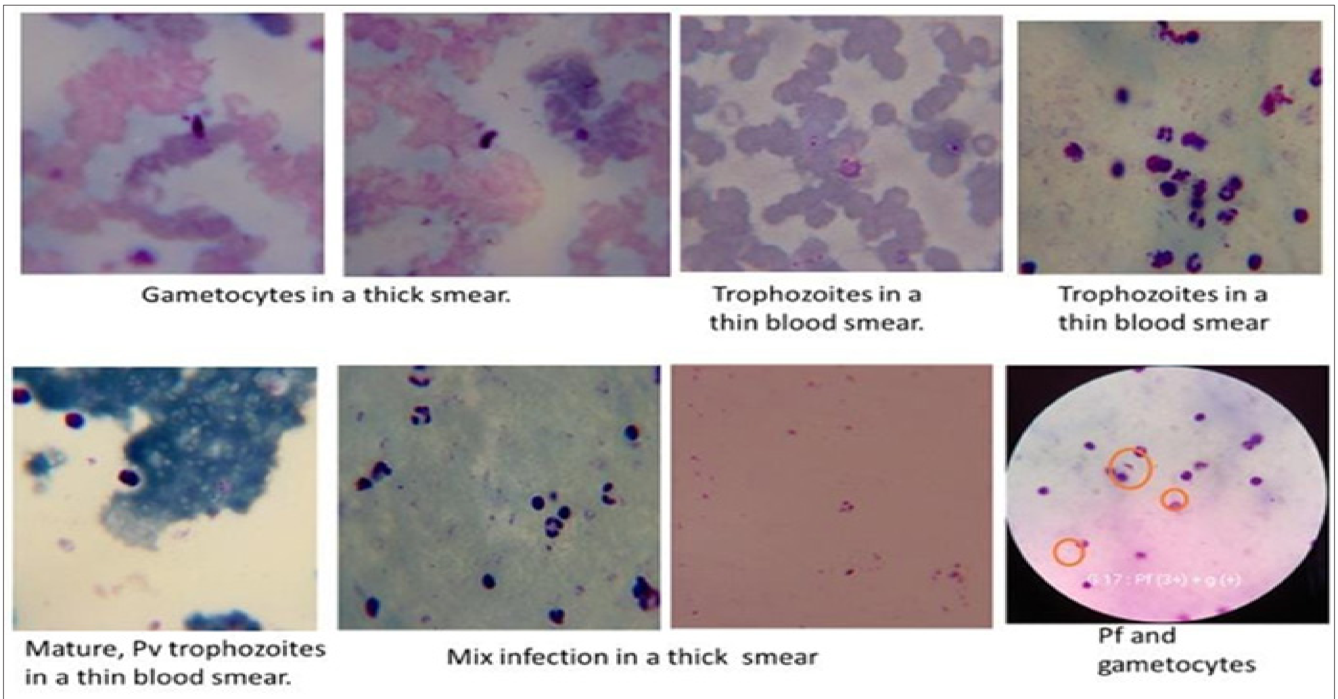

Figure 2.Positive Malaria Specimens in Tabalong

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Discussion

Cases of malaria are more common among males than females. This is due to work activities and habits carried out by the community in Tabalong District, Jaro Health Center, particularly in Solan, Temperak, and Garagata villages, such as working in the forest on top of a mountain to look for birds and wood. Previous research also found that infections were more common in men than in women.[2] Another study discovered that malaria was more prevalent in the productive age group of 18-47 years old.[15]

Malaria was found to have a prevalence of 1.6%, with *Plasmodium falciparum* being the most common cause (Figure 2). According to the Ministry of Health's annual profile 2020, malaria has been eliminated in 53.8% of the districts of South Kalimantan.[5] Malaria cases are still contagious in the community because we discovered the gametocyte stage, which is involved in malaria and the transmission is well known to be assisted by forest ecosystems.[16] Indriyati et al. discovered three species of Anopheles as malaria vectors in Siayuh Village, Bungkukan District, South Kalimantan.[17]

Forests are one of the ecosystems that can support the establishment of a breeding ground for malaria vectors.[13] Malaria cases in Paser Regency reached 59.4%, with 58.1% confirmed through laboratory testing. Microscopy has been reported to detect approximately 145 malaria infections and 89 cases were examined using a Rapid Diagnostic Test (RDT).[18] Through informal communication with health personnel, it was found that they suspect that people infected with malaria seek treatment at health centres. It is possible that they are infected somewhere outside of Tabalong. Tabalong is bounded by the malaria-endemic Paser Regency. According to the district health officer, the forest where people make a living is located in the Paser Regency area and the positive cases of malaria are the people who are employed in that forest. Five people tested positive for malaria, three from the Jaro sub-district and two from the Muara Uya sub-district, both villages bordering the Paser district's mountains and forests. Malaria has also been reported in Muara Uya District, where residents make their living by working in the border forest. This district is in Category 1 of malaria elimination. Epidemiological details of local malaria, which is transmitted mainly by Anopheles, have not been confirmed by previous surveys. During interviews, the community admitted that they frequently contracted malaria and were treated at the health centre after returning from the forest. The infected people were workers who had spent the night in the forest for an extended period of time (> 7 days).

Despite the fact that there were no indigenous malaria cases in Tabalong, the study revealed that infected persons in Tabalong are cross-border cases due to the area's proximity to Paser District and the people who work in the border forests. More than 3500 malaria cases have been discovered across the district's boundaries in the past 11 years. Although the API rate has decreased between 2005 and 2010, malaria outbreaks continue to occur in a number of villages. Outbreaks were mostly concentrated in the Magelang and Kulonprogo regency. This demonstrates that the Menoreh cross-border area contributes to the greatest number of imported malaria cases in two districts, namely Kulonprogo and Purworejo (39-47% between 2011 and 2015). Malaria cases in the Purworejo cross-border area have increased significantly in the last five years. This occurs because most local residents visit one another, trade, work, socialise, attend religious events, and engage in recreational activities, but migration supervision is insufficient, enabling malaria transmission to continue.[19]

Imported cases can occur as a result of international travel and immigration from malaria-endemic areas.[20] This finding is critical for malaria programmes in malaria-endemic districts/ cities, particularly in terms of achieving elimination. As Wangdi et al. suggested, cross-border populations in hotspot districts or municipalities will require targeted intervention strategies tailored to occupation, age, and mobility status in order to achieve malaria elimination.[21] Penajam Paser Utara is a district in East Kalimantan that has high malaria prevalence. Suryadi et al. discovered 310 cases of malaria, 60.3% of which were caused by *Plasmodium falciparum* and 39.7% by *Plasmodium vivax* in a hospital-based study.[22]

The findings revealed that the communities' malaria knowledge was quite good. This is consistent with Lumolo et al.'s findings that public awareness of malaria is high (55.8%).[23] In Tabalong District, South Kalimantan, there was no significant relationship between gender and malaria incidence ($p < 0.05$). This is consistent with Manumpa findings that gender does not play a role in malaria risk.[24] In terms of mosquito net use and malaria incidence, the findings revealed that there was no significant relationship between the two. This is consistent with the findings of Anjasmoro, who revealed that there is no significant relationship between the use of mosquito nets and the incidence of malaria.[25] This can happen if the mosquito nets used are non-insecticide nets, respondents who stay at work until night to look for wood only use mosquito nets when sleeping, the mosquito net is damaged (inappropriate or torn condition), and due to opening and closing the mosquito net, making the mosquito bites still possible.[26]

About 87.1% of the 271 respondents did not use wire gauze in the house, and the odds ratio was 4,702. According to Anjasmoro, the use of wire gauze in the house has not become a cultural practice and is not valued by the community. It has been seen that people who do not use

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wire gauze in their houses are four times more likely to get malaria.[25]

Furthermore, according to the reference to the behaviour of the exophagic Anopheles mosquito, respondents were positive for malaria because they worked outside the house. This is in contrast to Sepriyani et al's study, which found that using mosquito wire mesh at home prevents respondents from being bitten by Anopheles mosquitoes.[26] There is a relationship between staying in the forest and the occurrence of malaria. This is consistent with Herdiana et al.'s findings that staying in the forest increases the risk of malaria.[27] For occupational factors, there is a significant relationship between respondents' work in the forest and the incidence of malaria. The five positive cases were all employed in the forest.

Prior to transitioning from a control to an elimination programme, a malaria programme should reduce annual parasite incidence to less than one per 1,000 person-years.[28] Inadequate or outdated scientific knowledge about malaria transmission exists, especially in border areas, which will contribute to the slowing of malaria control efforts. Even though China has eliminated malaria, re-establishing transmission in border areas remains a challenge.[29] Saldanha et al. address the cross-border data integration and visualisation system that was applied between French Guiana and Brazil. The cross-border monitoring tool could aid in the generation of new scientific evidence on cross-border malaria dynamics, as well as the strengthening of malaria control and elimination cooperation.[30] To achieve the best preparedness for the malaria epidemic, districts must identify areas and situations prone to the epidemics, such as districts (regions) with initially high malaria potential, and movement of people from non-endemic and low-lying areas to areas that are highly malaria endemic.

Conclusion

The study found that the tight relationship between malaria epidemiology and worker mobility in border areas is a major factor in the district's malaria incidence. More importantly, cross-border transmission is thought to be responsible for the majority of confirmed malaria cases in Tabalong; no original cases were reported. We suggest that potential malaria risk factors should be monitored at all times, particularly in areas where malaria elimination is a priority. Although the fact that the malaria elimination programme is currently under way, it is critical to anticipate epidemics in districts that are nearing elimination indicators, and it is critical to consider re-establishing transmission in border areas.

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Conflict of Interest: None

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