

## Potential Vector Shelter for Malaria in South Central Timor Regency in Indonesia

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### Abstract

More than half of the areas in East Nusa Tenggara province, a province in the eastern part of Indonesia, are planned to be free from malaria by the end of 2030. However, one of the critical indicators for malaria elimination is still lacking, i.e. vectors' environment and breeding place indicators. South Central Timor (SCT) District is one of the areas with the highest Annual Parasite Incidence (API) >2% with the majority of the population works as farmers. The purpose of this study was to capture the relationship between environmental factors and the prevalence of malaria. This study was a cross-sectional analytic retrospective study using data from a previous malaria study conducted in August 2013 to September 2014 in 5 sub-districts of SCT district. All respondents were selected using the systematic random sampling approach from the population of healthy people. Data were collected using a standard questionnaire and an observation environment form. Malaria was confirmed through microscopic and Polymerase Chain Reaction (PCR) examinations. Data were then analyzed using the bivariate and multivariate analysis with 95% CI and  $\alpha:0.05$ . Of 357 data collected, 35% (125/357) were malaria positive based on PCR examination. Two variables (living nearby lagoon and nearby rice field) were significant ( $p\text{-value}<0.05$ ) as vector shelters for *Anopheles* sp. Thus, these have to be included as inputs to formulate effective and efficient malaria elimination strategies and programs in 2030.

**Keywords:** Malaria prevalence, South Central Timor Regency, vector shelter

## Lokasi Potensial Perkembangbiakan Vektor Malaria di Kabupaten Timor Tengah Selatan, Indonesia

### Abstrak

Lebih dari setengah Provinsi Nusa Tenggara Timur di Indonesia timur akan menghadapi bebas malaria pada akhir tahun 2030. Namun, salah satu indikator penting untuk eliminasi malaria adalah pengukuran lingkungan dan tempat berkembang biak vektor masih kurang. Kabupaten Timor Tengah Selatan adalah daerah dengan salah satu Insidensi Parasit Tahunan tertinggi di Indonesia dan mayoritas penduduknya bekerja sebagai petani. Tujuan dari penelitian ini adalah mencari hubungan antara faktor lingkungan dengan prevalensi malaria. Penelitian ini menggunakan studi potong lintang metode analitik, menggunakan data retrospektif dari penelitian sebelumnya yang dilakukan pada Agustus 2013 hingga September 2014 di 5 kecamatan di Kabupaten Timor Tengah Selatan. Responden dipilih secara acak sistematis dari orang sehat. Pengumpulan data dengan kuesioner standar dan formulir observasi lingkungan. Konfirmasi malaria dengan menggunakan metode mikroskopis dan PCR. Data dianalisis dengan bivariat dan multivariate dengan 95% CI dan  $\alpha: 0,05$ . Total 357 data dikumpulkan, 35% (125/357) positif malaria dengan pemeriksaan PCR. Dua variabel (dekat dengan laguna dan dekat dengan sawah) signifikan (nilai- $p <0,05$ ) sebagai tempat perlindungan vektor untuk *Anopheles* sp. Penelitian ini diharapkan dapat memberikan informasi rinci untuk merumuskan strategi dan program eliminasi malaria pada tahun 2030 yang efektif dan efisien.

**Kata kunci:** Kabupaten Timor Tengah Selatan, prevalensi malaria, perkembangbiakan vektor

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## Introduction

Malaria is transmitted through the bite of female *Anopheles sp.* mosquitoes that contain malaria parasites. In Indonesia, 72% of the population live in areas that are free from malaria. However, there are still 10.7% of Indonesian people who live in medium and high endemic areas, such as Papua, West Papua, and East Nusa Tenggara. These three provinces are the ones that contribute the most to malaria cases in the country.<sup>1</sup>

Malaria elimination has been announced by the Ministry of Health, Republic of Indonesia in a formal regulation since 2009. Currently, the targets for elimination are, chronologically, Jakarta and Bali in 2010; Java, Aceh, and Riau in 2015; Sumatera, Kalimantan, Sulawesi, and West Nusa Tenggara in 2020, and Papua, West Papua, Maluku, East Nusa Tenggara and North Maluku in 2030.<sup>2</sup> Some of the most critical indicators for malaria elimination is the measurement of the environment and breeding place of the vectors. Both of these assessments are important for reducing the source of the vector by applying environmental management.<sup>3</sup> Given the archipelago geography of Indonesia, unique challenges are to be expected for source reduction program.<sup>4</sup>

East Nusa Tenggara province, which is located in the eastern part of Indonesia, has 22 districts with 5,203,514 population in 2017.<sup>5</sup> According to the Annual Parasite Incidence (API) in 2017, East Nusa Tenggara province is the 3<sup>rd</sup> province with the highest malaria cases in Indonesia (API=5.76‰).<sup>4</sup>

South Central Timor District is one of the districts in East Nusa Tenggara province that consists of 32 sub-districts that lie on a 3,995.56 km<sup>2</sup> area with 461,681 population.<sup>5</sup> The district has the highest API value, with a total of 12,527 malaria cases.<sup>4</sup>

More than 60% of South Central Timor District is dominated by hills and valleys, surrounded by highlands or hills of the island. There are 40 rivers with a length of ranging from ±25 up to 118 km. The area have two seasons: the dry season in June-September and the rainy season in October-March. The wind currents from Australia and the Pacific Ocean do not contain a lot of water vapor, resulting in the dry climate of the area.<sup>5</sup>

Eastern Indonesia environment, with the vegetation and temperature ranging from 30-31°C, supports the breeding of *Anopheles sp.* mosquitoes.<sup>5</sup> Temperature affects the level of dissolved oxygen in water essential for the

survival of this mosquito larvae.<sup>6,7</sup>

Reliable information is required regarding the relationship between malaria and environmental factors to maximize public benefits and help the District Health Office (DHO) in developing the 2030 malaria-free program. Unfortunately, the environmental assessment related to the malaria prevalence, especially in eastern Indonesia, is still lacking. The purpose of this study was to capture the relationship between the environmental factors related to shelter vectors and the prevalence of malaria. This study was expected to provide detailed information to formulate effective and efficient malaria elimination strategies and programs in facing the year of 2030.

## Methods

This was a cross-sectional analytic retrospective study using secondary data from the previous malaria study conducted in August 2013 to September 2014.<sup>8</sup> This study was conducted in 5 sub-districts in South Central Timor District, East Nusa Tenggara Province, Indonesia based on their API, i.e. South Amanatun (API >5‰), Central Amanuban (API >5‰), South Amanuban (API 1-5‰), Batu Putih (API 1-5‰), and Oenino (API <1‰).

Respondents were recruited through a systematic random sampling based on households from each sub-district in South Central Timor District, East Nusa Tenggara Province. A total of 357 subjects were recruited based on the inclusion criteria of >14 years old, healthy based on the assessment local health practitioner before the study, and no fever (>38°C). The sample size was calculated using a formula for analytic comparative study with a categorical scale ( $\alpha=5\%$  and  $\beta=20\%$ ) with a significant difference in the minimum proportion of malaria ( $p_1-p_2$ ) of 0.2. Based on the calculation, the minimum representative sample size of this study was 212. Eleven environment variables were analyzed in this study: living nearby river, lagoon, rice fields, garden, swamp edge, and water spring; water source from plumbing; water source from wells or springs; family owns lands or rice fields; family owns livestock; and livestock nearby house. To reduce bias in the environmental assessment, a standard questionnaire, i.e. malaria observation form, and double assessment (local and main investigator team members) were applied. Malaria was confirmed using results from microscopic

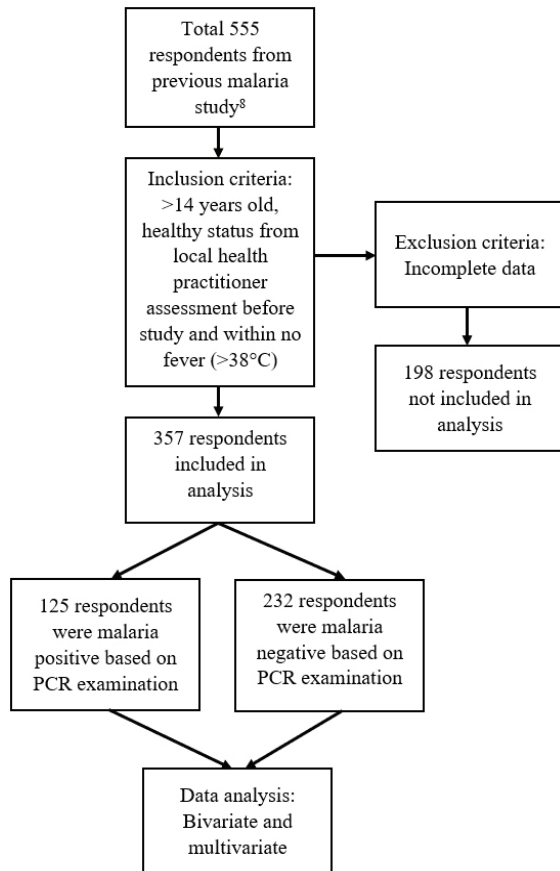


Figure Study Flowchart

examination and Polymerase Chain Reaction (PCR).

The predetermined variables were analyzed using the 25th version IBM® SPSS® software application. The obtained variables were then processed using chi-square and multivariate analysis with a confidence interval of 95%, with a p-value of 0.05 considered significant. Results were then presented in table form, with a p-value of >0.05 represented the lack of significance while a p-value <0.05 indicated significance. This study received ethical approval from the Health Research Ethics Committee, Faculty of Medicine, Universitas Padjadjaran, under the issuance of the ethical clearance number 1100/UN6.KEP/EC/2019. All respondent data were analyzed anonymously.

Results

A total of 357 subjects were recruited based on the inclusion criteria and exclusion criteria in this study. Of these, 35% (125/357) were malaria positive based on PCR examination.

Table 1 shows that there were more female respondents than male respondents in the positive PCR results group and the negative PCR results group. From the perspective of age, the group with the highest positive cases in PCR results was >50 years old group respondents

Table 1 Respondent Characteristics (N=357)

Characteristics	PCR examination		Total (%)
	Positive (%)	Negative (%)	
Gender			
Male	51 (40.8)	91 (39.2)	142 (39.8)
Female	74 (59.2)	141 (60.8)	215 (60.2)
Age Groups			
14–15 years	1 (0.8)	6 (2.6)	7 (2.0)
16–20 years	4 (3.2)	6 (2.6)	10 (2.8)
21–30 years	13 (10.4)	36 (15.5)	49 (13.7)
31–40 years	34 (27.2)	67 (28.9)	101 (28.3)
41–50 years	27 (21.6)	56 (24.1)	83 (23.2)
>50 years	46 (36.8)	61 (26.3)	107 (30.0)
Districts			
South Amanatun	21 (16.8)	61 (26.3)	82 (23.0)
Central Amanuban	36 (28.8)	41 (17.7)	77 (21.6)
South Amanuban	5 (4.0)	19 (8.2)	24 (6.7)
BatuPutih	30 (24.0)	46 (19.8)	76 (21.3)
Oenino	33 (26.4)	65 (28.0)	98 (27.5)

Note: PCR= Polymerase Chain Reaction

**Table 2 Bivariate Analysis on Effect of Mosquito Breeding Types on Malaria Prevalence (n=375)**

Variables	Malaria Status		Total (%)	P-value (OR)	95% CI	
	Positive (%)	Negative (%)			Lower	Upper
Nearby river (<50 m)						
Yes	19 (15.2)	36 (15.5)	55 (15.4)	0.937		
No	106 (84.8)	196 (84.5)	302 (84.6)	(0.976)	0.533	1.785
Nearby lagoon (<50 m)						
Yes	1 (0.8)	19 (8.2)	20 (5.6)	0.004		
No	124 (99.2)	213 (91.8)	337 (94.4)	(0.09)	0.012	0.684
Nearby rice field (<50 m)						
Yes	18 (14.4)	16 (6.9)	34 (9.5)	0.021		
No	107 (85.6)	216 (93.1)	323 (90.5)	(2.271)	1.114	4.629
Nearby garden (<50 m)						
Yes	62 (49.6)	118 (50.9)	180 (50.4)	0.820		
No	63 (50.4)	114 (49.1)	177 (49.6)	(0.951)	0.615	1.469
Nearby swamp edge (<50 m)						
Yes	18 (14.4)	28 (12.1)	46 (12.9)	0.531		
No	107 (85.6)	204 (87.9)	311 (87.1)	(1.226)	0.648	2.317
Nearby water spring (<50 m)						
Yes	2 (1.6)	6 (2.6)	8 (2.2)	0.548		
No	123 (98.4)	226 (97.4)	349 (97.8)	(0.612)	0.122	3.080
Water source from plumbing						
Yes	9 (7.2)	22 (9.5)	31 (8.7)	0.465		
No	116 (92.8)	210 (90.5)	326 (91.3)	(0.741)	0.330	1.661
Water source from wells/springs						
Yes	94 (75.2)	172 (74.1)	266 (74.5)	0.826		
No	31(24.8)	60 (25.9)	91 (25.5)	(1.058)	0.641	1.746
Family owns land/rice fields						
Yes	95 (76.0)	177 (76.3)	272 (76.2)	0.951		
No	30 (24.0)	55 (23.7)	85 (23.8)	(0.984)	0.591	1.639
Family owns livestock						
Yes	97 (77.6)	188 (81.0)	285 (79.8)	0.440		
No	28 (22.4)	44 (19.0)	72 (20.2)	(0.811)	0.476	1.382
Livestock nearby house						
Yes	94 (75.2)	181 (78.0)	275 (77.0)	0.546		
No	31 (24.8)	51 (22.0)	82 (23.0)	(0.854)	0.512	1.425

Note: PCR= Polymerase Chain Reaction; OR= Odd Ratio;, 95% CI= 95% Confidence Interval

**Table 3 Multivariate Analysis of Influence of Mosquito Breeding Type on Malaria Prevalence**

Variable	$\beta$	P-value	OR	95% CI	
				Lower	Upper
Nearby Lagoon (<50m)	-2.325	0.024	0.098	0.013	0.741
Nearby Rice Field (<50m)	0.738	0.043	2.091	1.024	4.268

Note: OR= Odd Ratio; 95% CI= 95% Confidence Interval

while the group of <15 years old had the least positive cases. On the other hand, the highest negative case group was seen in the 31–40 age group while the group with the least negative cases was the <15 year and the 16–20 year groups. Based on the sub-district area, the Central Amanuban sub-district had the highest positive malaria cases with 36 cases and the Oenino sub-district was the sub-district with the least malaria cases.

Table 2 shows the results of data analysis using the chi-square test from the eleven variables studied. The nearby lagoon variable and nearby rice field variable showed a p-value of <0.05, meaning that there was a significant relationship between these variables and the prevalence of malaria.

Table 3 explains the results of the multivariate analysis. Two significant variables had p-values below 0.025. It showed that the nearby lagoon variable (<50m) had a p-value of 0.024, lower than the nearby rice field variable (<50m) with a p-value of 0.043. However, the odds ratio showed that the nearby lagoon variable (<50m) is not significant, only with an odds ratio of 0.098. This result is the opposite of the variable of a nearby rice field (<50m), which significantly increased the risk to two times higher, with an odds ratio of 2.091.

## Discussion

This study discovered that the rice field is the vector shelter, which is significant for malaria transmission in South Central Timor District when compared to other conditions. A survey conducted in Nunukan District, East Kalimantan, reveal a significant effect of the proximity between houses and breeding places of malaria vectors (rice fields) with malaria prevalence with a p-value of 0.002.<sup>9</sup> This is in contrast with a study conducted by Hasyimi, stating that the proximity between houses and breeding places (rice field) has no significant effect on malaria prevalence, with a p-value of 0.766.<sup>10</sup>

The presence of rice fields around the home environment will increase the potential for malaria as the fields will be inundated with water, which is a very good breeding site for *Anopheles* sp.<sup>11</sup> Furthermore, wide areas will provide a wide media for *Anopheles* sp. breeding. It will make it easier to increase the population and will be more challenging to control. One of the control efforts that can be applied by the surrounding community is to add mosquito larvae fish-eaters such as mujair fish in rice fields and plant rice simultaneously so that the removal of breeding sites can be more manageable.<sup>12</sup>

The potential *Anopheles* sp. breeding places are also found in coastal areas, such as lagoons, rivers, and rice paddies near the coastal line. It further proves that *Anopheles vagus* is the most potential malaria vector in these sites. *Anopheles vagus* is one of the most frequently captured mosquitos which may be due to the fact that it is found in almost all types of breeding places including lagoons, rice fields, rivers, and stagnant water.<sup>13</sup>

A study in Africa also supports these findings. The study proves the close link between malaria vectors and agriculture by discovering that gravid *Anopheles arabiensis* are attracted and oviposit in response to the odor in the air around rice fields.<sup>14</sup> A study conducted by Widawati in East Nusa Tenggara had discovered that *Anopheles annularis* is the most commonly found Anopheles in the lowlands whereas *Anopheles vagus* is more commonly found in the highlands of East Nusa Tenggara Province.<sup>15</sup>

The environmental conditions are different for each endemic area, and it becomes locally unique for local governments to intervene in dealing with malaria. A study conducted in Nunukan District, East Kalimantan, found that the presence of livestock near homes does not have a significant effect on malaria prevalence with a p-value of 0.217.<sup>9</sup> This is similar to the finding in this study, with a p-value of 0.44 for livestock near home. In a study in the Toho Village, Pontianak District, the p-value identified is 0.004.<sup>16</sup> However, other studies in Kei Besar

Sub-District, Southeast Maluku District, Maluku Province show that the livestock presence near the house significantly affect malaria prevalence with a p-value of 0.021.<sup>17</sup>

The fact is that most of the population in South Central Timor are farmers, and the study findings emphasizes the reasons why this area is endemic for malaria.<sup>5</sup> Women suffer more from malaria than men because apart from being a farmer, women do their household activities since morning. This situation puts women at greater risk of malaria infection than men because *Anopheles* bites human from dusk to dawn. Meanwhile, the socio-economic condition also takes part in the prevalence. The contradictory belief that women are responsible for their children's health but the men control the funds has been emphasized. In this case, delays in decision making may happen when the spouse (or other male decision-makers) is absent.<sup>18,19</sup>

This study uses secondary data. Therefore, the variables for analysis are limited. Additional variables are needed so that the results obtained are more varied and to be able to better prove the effect of environmental conditions on malaria prevalence. Also, this study did not collect mosquitoes. As a result, this no link can be identified between topography and the species of *Anopheles*.

In conclusion, the rice fields are used as the shelter by malaria vector and is a variable that is significant for malaria transmission in South Central Timor District, compared to other conditions. Since women suffer more than men, health officials must look at ways of addressing women's relative lack of power and financial resources. Equally important is the need to target women for malaria control education and sensitization. Subsequently, a collaboration among health practitioners, local institutions, and the community is required for preventing malaria infection. The local institutions should focus on this matter and help develop more convincing recommendations for preventing malaria infection. The community also needs to increase their knowledge and proactiveness in efforts to prevent malaria, such as getting used to using mosquito nets and anti-mosquito repellent; minimizing outdoor activities at night; wearing clothes with long sleeves, etc.<sup>20</sup>

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