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Malaria Infection in Thapangthong District, Savannakhet Province, Lao PDR, 2025: Bed Net Use and Forest Visit

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Abstract

On 19 Mar 2025, four *Plasmodium vivax* cases were reported in Thapangthong District, Savannakhet Province—an area previously considered malaria-free in Lao People's Democratic Republic (Lao PDR). The investigation was conducted from 20–28 Apr 2025. We aimed to confirm the outbreak, describe characteristics of the cases, identify associated factors, and recommend containment measures. We reviewed District Health Information Software Version 2 (DHIS2)—a national surveillance system for public facilities of Lao PDR. An active case finding was conducted in three villages in Thapangthong District. Univariable and multivariable logistic regression models were performed. Qualitative phone interviews with key stakeholders were conducted. From January to April 2025, eight confirmed malaria cases were detected based on DHIS2. Of the 294 screened individuals, 20 *P. vivax* cases (12 suspected and 8 confirmed) were identified. Multivariable analysis showed that prior malaria infection and recent travel history to endemic areas were significantly associated with increased odds of infection. Use of long-lasting insecticide-treated nets (LLIN) was associated with a non-significant but lower odds of infection. All participants with a history of forest visits were cases. The interviews revealed that a malaria control barrier included low usage of LLIN by the villagers. Rapid interventions, including a mass drug campaign, were implemented. As of 31 May 2025, no new cases had been detected. To advance malaria elimination, we recommend strengthening campaigns that promote LLIN usage, particularly among forest-goers, providing refresher courses on malaria-related knowledge for villagers and health volunteers, and maintaining active vigilance for new cases.

Keywords: malaria, Lao PDR, long-lasting insecticide-treated net (LLIN), forest-related malaria

Introduction

Malaria transmission remains an important public health challenge in countries in the Greater Mekong Subregion, including Lao People's Democratic Republic (Lao PDR).[1,2,3] The Lao PDR National Strategic Plan 2021–2025 focused on universal access to long-lasting insecticide-treated nets (LLIN), early diagnosis and rapid diagnostic tests (RDT), and early provision of artemisinin-based combination therapy (ACT).[4] The strategy aimed to eliminate *Plasmodium falciparum (P. falciparum)* malaria by 2025.[5] The number of

malaria cases declined from over 200,000 cases in 2018 to fewer than 700 cases in 2023.

However, outbreaks have continued to occur in low-burden areas, reflecting persistent challenges, such as importation of cases across provinces and *Plasmodium vivax (P. vivax)* relapse. Savannakhet is a province in the southern region of Lao PDR. Of 15 districts in the province, 13 are labeled as malaria elimination areas. However, in 2024, malaria cases were found in some districts.[6,7] Thapangthong District, located in Southern Savannakhet and predominantly covered by dry forests and highlands, is home to about 50,600 people living in 42 villages.

On 19 Mar 2025, four *P. vivax* cases were reported from two villages (Kengsakou and Naphanet) in Thapangthong District. This prompted a joint investigation from the Ministry of Health (MOH), Lao PDR, from 20–28 Apr 2025, aiming to (1) confirm the outbreak, (2) describe the characteristics of the cases, (3) explore factors associated with malaria infection, and (4) identify barriers to prevention and provide recommendations for further containment.

Methods

Study Design and Study Period

We conducted an analytical cross-sectional study, complemented by qualitative interviews from 20–28 Apr 2025.

Study Site

The study was conducted in three villages: Kengsakou and Naphanet—two villages where the initial cases were reported, and Lawang Yai—a nearby village in the elimination target area.

Operational Definitions

We defined LLIN usage as a reported history of sleeping under a bed net every night. A forest visit was defined as a history of staying overnight or spending at least eight consecutive hours in a forested area in the past two weeks. A forest-goer was defined as a person who earned a living by seeking goods from the forest.

Case Definitions

We defined a suspected case as a resident of Thapangthong District who developed fever within 14 days before the investigation; had at least two of the following symptoms: headache, chills, sweating, muscle aches, body aches, or diarrhea; and reported at least one risk factor: malaria infection within the past 28 days, travel to another malaria-endemic area, or forest-going. A confirmed case was any suspected case with malaria detected by RDT or microscopy.

Data Collection

Data collection involved three steps. First, we examined records from the district health information software version 2 (DHIS2), the national surveillance system for public hospitals in the Lao MOH, from January 2023 to April 2025, along with the 5-year median. Second, we implemented an active case finding (ACF) in the three villages using convenience sampling. Participants were recruited through public announcements. Structured paper-based questionnaires were administered via verbal interviews to gather information on demographics, symptoms, forest-going history, LLIN usage, travel history to endemic areas, and prior malaria infection. All suspected cases were confirmed by RDT or blood smear microscopy. RDT screening was also performed on family members of confirmed cases, symptomatic individuals, and forest-goers. Third, qualitative phone interviews were conducted with two respondents responsible for malaria elimination programs: the Deputy Director of Savannakhet Provincial Health Department and the Chief of the Epidemiology Division of Malaria Parasitology and Entomology. The interview questions focused on operational barriers and recommendations for malaria prevention and control.

Sample Size Calculation for Analytic Study

The two independent proportions formula was used. We assumed a 95% confidence interval, 80% power, with key parameters drawn from previous literature.[8] Noor et al. found malaria infection rates of 7% for bed net users and 17% for non-users.[9] By allowing for 10% rate of incomplete data, we needed approximately 200 participants per group.

Data Analysis

For quantitative data, we used descriptive statistics to determine the magnitude of the outbreak. Crude and specific attack rates were calculated. We fit univariable and multivariable logistic regression models in which the dependent variable was malaria infection (either a suspected case or a confirmed case). The independent variables were gender, age group (<5, 5–14, 15–49, and ≥50 years), occupation (forest-goer, farmer, student), reported LLIN usage, previous infection history, forest visit, and travel history to endemic areas. Variables with a p-value <0.1 in the univariable analysis were included in the multivariable analysis. To avoid model overfitting, multivariable analysis was conducted following standard events-per-variable (EPV) considerations, with priority given to LLIN use.[10] Crude odds ratios (COR), adjusted odds ratios (AOR), and 95% confidence intervals (CI) were presented. STATA version 16 was used. For qualitative data, thematic description was applied.

Results

Situation Review

From 1 Jan 2025 to 30 Apr 2025, data from the DHIS2 indicated that 4,137 individuals were tested for malaria in Thapangthong District. The number of cases in 2025 was higher than that in 2023 and 2024, and was close to the 5-year median. Eight cases were positive for *P.vivax*. All cases received outpatient care. There were neither reported deaths nor hospitalizations. The crude attack rate was 0.24 per 1,000 population. The median age of the cases was 24 years (range 22–39 years). All cases were male. *P. falciparum* infections presented in 2022, and since 2023, all cases were *P. vivax* infections (Figure 1).

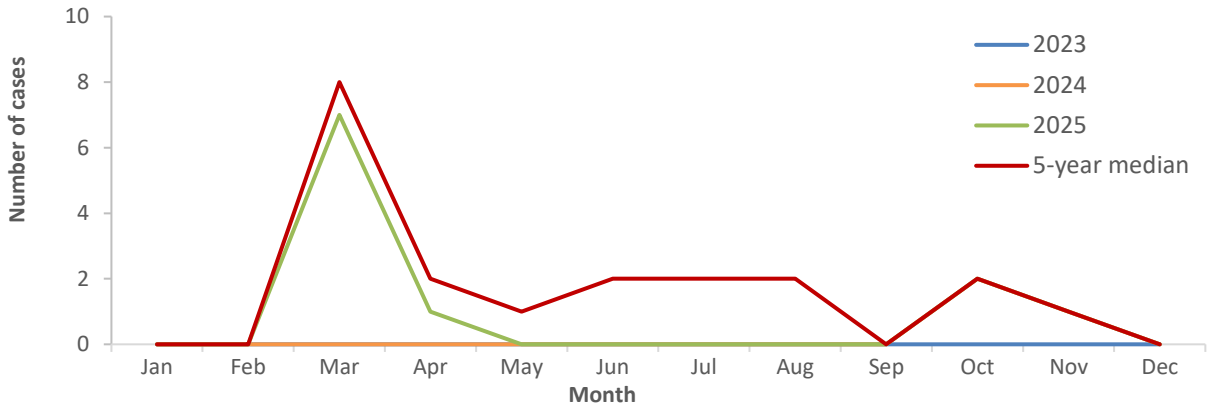

Figure 1. Malaria cases reported in the national surveillance system of Lao PDR, 2023–2025

Active Case Finding

A total of 294 individuals were screened across the three villages: Kengsakou (109, 37.1%), Naphanet (152, 51.7%), and Lawang Yai (33, 11.2%). Most participants were farmers (48.3%) and forest goers (46.6%). The samples were predominantly male (57.8%) and aged 15–49 years (79.9%).

Twenty individuals met the suspected case definition, and none developed severe symptoms. Subsequent blood testing confirmed *P. vivax* infection in eight individuals, who were then classified as confirmed cases, leaving 12 as suspected cases. All confirmed cases showed positive results for *P. vivax* and were treated by ACT. The male-to-female ratio was 4:1, and the median age was 26.5 years (range 14–65 years). We performed blood tests on 121 non-cases who were family members of the confirmed cases, or reported a history of visiting a forest, or being symptomatic during the investigation period. All of these individuals demonstrated negative results (Figure 2).

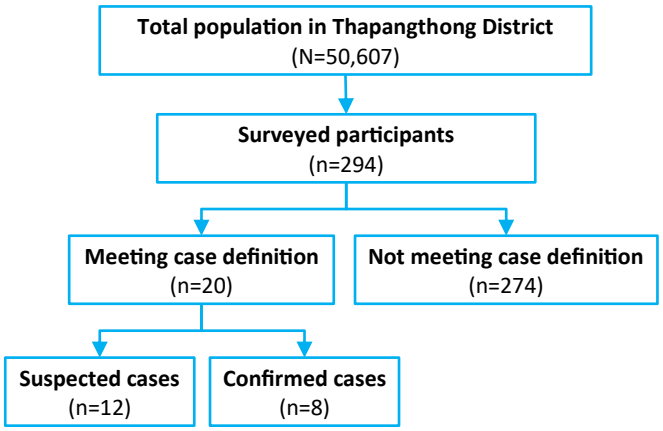

Figure 2. Active case finding in Thapangthong District, 20-28 Apr 2025

Regarding the specific attack rate by village, most (n=15) were residents of Kengsakou (specific attack rate 13.8% among screened samples), Naphanet recorded four cases, and Lawang Yai reported one case. Most (n=18) were aged 15–49 years, and males predominated (n=16) (Table 1).

Table 1. Specific attack rate by villages, age groups, and gender, Thapangthong District, 20–28 Apr 2025

Classification	Detail	Cases	Screened	Total population	Attack rate* (%)	Attack rate† (%)
Village	Kengsakou	15	109	663	13.76	2.26
	Naphanet	4	152	634	2.63	0.63
	Lawang Yai	1	33	1,264	3.03	0.08
Age group	<5	0	1	307	0.00	0.00
	5–14	1	22	666	4.55	0.15
	15–49	18	235	1,229	7.66	1.46
	≥50	1	36	359	2.78	0.28
Gender	Male	16	170	1,332	9.41	1.20
	Female	4	124	1,229	3.23	0.33

**Among screened. †Among total population.*

The first case occurred in mid-March, with sporadic cases continuing through late April. The cumulative case volume gradually increased until the end of April 2025. We further followed up on the situation in these three villages until May 31, 2025, by which time no additional cases were identified (Figure 3).

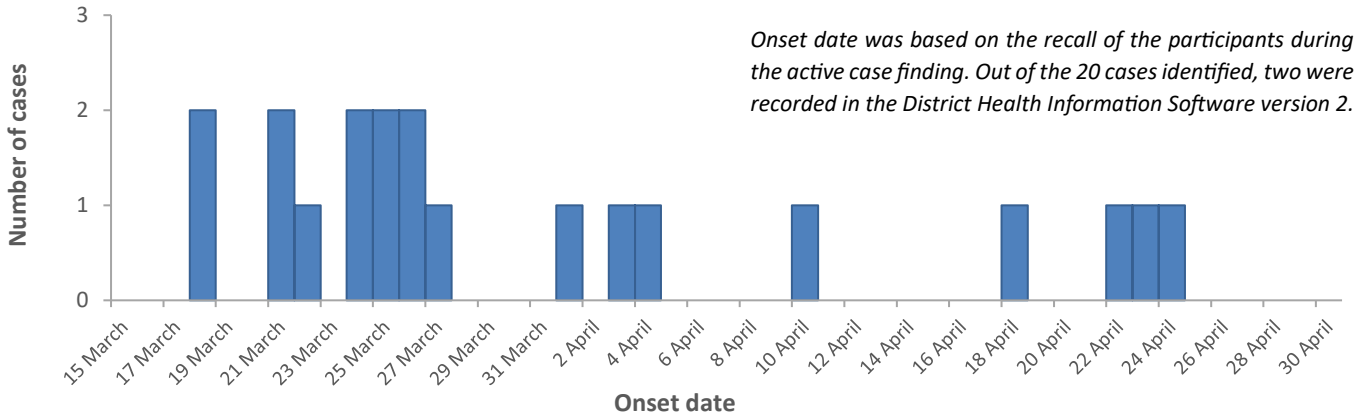

Figure 3. Cases identified by active case finding (n=20) in Thapangthong District, 15 Mar–30 Apr 2025

Fever occurred in all cases, with headaches (90%) and sweating (60%) the next most common symptoms.

Factors associated with malaria infection

Approximately two-thirds of the cases (14/20) reported using LLIN, compared to 86% (237/ 274) of non-cases. As shown in Table 2, LLIN usage exhibited borderline statistical significance, with a COR of 0.36 (*p*-value 0.052). All individuals with a history of forest visits were classified as cases. Both prior malaria infection (COR 22.2) and reported travel history to endemic areas (COR 12.3) demonstrated a strong association with malaria infection (*p*-value ≤0.001), while male gender (*p*-value 0.047) was moderately significant.

Table 2. Factors associated with malaria infection by univariable analysis, Thapangthong District, 20–28 Apr 2025

Factor	Case (n=20)	Non-case (n=274)	COR	95% CI	*P*-value
Gender					
Female	4	120	Ref.		
Male	16	154	3.12	1.01–9.56	0.047
Age group (years)					
<5	0	1	Ref.		
5–14	1	21	1.71	0.10–28.86	0.708
15–49	18	217	2.99	0.39–23.70	0.294
≥50	1	36	Omitted	Omitted	-
LLIN use					
No	6	37	Ref.		
Yes	14	237	0.36	0.13–1.01	0.052
Forest visit					
No	0	148	Ref.		
Yes	20	126	Omitted	Omitted	-
Prior malaria infection					
No	12	266	Ref.		
Yes	8	8	22.16	7.10–69.17	<0.001
Travel history to endemic areas					
No	7	238	Ref.		
Yes	13	36	12.27	4.59–38. 83	<0.001
Occupation					
Student	0	15	Ref.		
Farmer	0	142	Omitted	Omitted	-
Forest-goer	20	117	Omitted	Omitted	-

LLIN: long-lasting insecticide-treated net. COR: crude odds ratio. CI: confidence interval. Ref: reference.

As only 20 suspected cases were identified, we included only two independent variables in the multivariable models. Three candidate models were proposed for the multivariable analysis: (i) LLIN usage and gender, (ii) LLIN usage and prior malaria infection, and (iii) LLIN usage and travel history to endemic areas. In all three models, LLIN usage was non-significant but protective for malaria infection (AOR varying from 0.37 to 0.41). As shown in Table 3, prior malaria infection (AOR 21.3) and travel history to endemic areas (AOR 12.2) showed positive associations with malaria infection (*p*-value <0.001).

Table 3. Factors associated with malaria infection, Thapangthong District on multivariable analysis, 20–28 Apr 2025

	Model 1		Model 2		Model 3	
	AOR (95% CI)	*P*-value	AOR (95% CI)	*P*-value	AOR (95% CI)	*P*-value
LLIN use (Ref: no)	0.41 (0.51–1.14)	0.087	0.40 (0.13–1.27)	0.119	0.37 (0.12–1.15)	0.085
Male (Ref: female)	2.90 (0.94–8.95)	0.065				
Prior malaria infection (Ref: no)			21.29 (6.70–67.64)	<0.001		
Travel to a malaria risk area (Ref: no)					12.18 (4.51–32.89)	<0.001

LLIN: long-lasting insecticide-treated net. AOR: adjusted odds ratio.CI: confidence interval. Ref: reference.

Barriers to Malaria Control and Recommendations for Further Containment and Prevention

From the two respondents' perspectives, barriers of malaria control included: (i) importing of cases from neighboring provinces, (ii) low LLIN usage despite most villagers being provided with LLIN, (iii) presence of unregistered or hidden populations, such as migrants and mobile workers involved with forest working, and (iv) insufficient community engagement and support from local authorities.

To address these barriers, the respondents suggested targeting interventions toward hidden populations in the villages and identifying strategies to motivate the villagers to utilize LLIN. Community engagement and local authority involvement should also be strengthened.

Control and Prevention Response

A mass drug campaign (Pyramax®) was held for forest-goers and their families as preventive therapy to reduce the parasite reservoir and interrupt transmission. We also distributed LLIN to all forest-goers and encouraged them to use them during forest activities. Health education sessions were conducted to raise awareness and emphasize early care-seeking behaviors. In addition, the district malaria team carried out daily monitoring of new cases. No new cases were detected until the end of May 2025.

Discussion

Our situational review of the national surveillance system for public facilities of Lao PDR identified eight *P. vivax* cases (8/4,137, 0.2%) in Thapangthong District, with no deaths. From the active case finding, 20 cases were identified. The epidemic curve demonstrated continuous transmission from mid March 2025 until the investigation, indicating ongoing exposure rather than a single point-source outbreak.

Evidence in many countries suggests that forest work is strongly correlated with malaria transmission.[11,12] A scoping review suggested that rural and forested areas have been consistently identified as high-risk areas for malaria infection.[13]

Reported use of LLIN was associated with a 60% reduction in the odds of malaria infection. However, statistical significance was not established. Prior meta-analysis suggested that LLIN usage reduced the incidence of uncomplicated episodes of *P. vivax* by 39%.[14] Nevertheless, Kabeya et al. indicated that LLIN distribution briefly lowered malaria rates, but without statistical significance, suggesting the campaign alone was insufficient unless other prevention methods are in place.[15] This notion is supported by the interviewees' viewpoints, highlighting that while LLIN were widely distributed, their consistent usage could not be guaranteed.

Prior malaria infection is strongly associated with being a case as *P. vivax* parasites may relapse if not completely treated.[16,17] Reported symptoms—fever, headaches, and body aches—were consistent with those seen in typical malaria cases.[18,19]

Being male was significantly correlated with higher rates of infection. Numerous studies have documented this difference in case profiles across genders.[20,21] A survey in Tanzania found that being male was associated with a 32% increase in the odds of malaria

infection.[22] In our context, males are typically the main breadwinners of the families and are more at risk of mosquito bites due to outdoor activities.

Limitations

There were certain limitations in our study. First, the small sample size limited the statistical power of the analysis. We were unable to obtain the number of participants required by the sample size calculation, which may explain why bed net use was not statistically significant. The small number of interviewees in the qualitative study may have undermined the validity of the findings. Second, the cross-sectional design and short investigation period restricted our ability to make causal inferences. Third, the convenience sampling in our study design may have underestimated the actual number of cases and reduced generalizability to other settings. Fourth, self-reported responses are subject to recall bias, where cases may be more likely than non-cases to report past risk factors, and to social desirability bias, as some participants may have been reluctant to disclose sensitive behaviors or circumstances (such as belonging to a hidden population) due to fear of social judgement. Fifth, the lack of information on key behaviors, such as medication use from prior malaria infection, and detailed bed net use, limited the comparability of our study with others.

Recommendations

Key strategies should be introduced. First, interventions should be specifically tailored for forest-goers. These interventions include providing comprehensive prevention packages, such as LLIN and repellents and ensuring proper net use in forest settings. Novel strategies, such as adding small incentives or launching short reminder messages via smartphones, have shown promise in encouraging LLIN usage and reinforcing protective behaviors.[23,24] Second, ensuring radical treatment for *P. vivax* infections is critical to prevent relapses, including strengthening treatment capacity at the district level. Third, intensive education programs to raise malaria awareness among villagers are essential and should be continued. A refresher course to update malaria-related knowledge among frontline health volunteers would also be beneficial. Fourth, efforts should be made to strengthen the registration and monitoring of hidden forest workers to ensure that no case is left untreated and remains a reservoir of malarial parasites.

Conclusion

This *P. vivax* outbreak in Thapangthong District shows that even in elimination areas, malaria transmission can re-emerge through forest-related exposure. Prior malaria infection and travel to malaria-risk areas were found to be strong risk factors, highlighting the importance of addressing relapses and cross-border exposure. The observed effect of LLIN on lowering the odds of infection supports their continued promotion. To achieve malaria elimination, collective efforts, including mass drug administration and tailored strategies targeting forest-goers, are warranted.

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Contribution of Authors

Nouannipha Simmalavong: Conceptualization, data collection, formal analysis, methodology, project administration, validation, writing—original draft. **Rapeepong Suphanchaimat:** Conceptualization, formal analysis, methodology, supervision, validation, writing—review & editing. **Waraluk Tangkanakul:** Conceptualization, supervision, writing—review & editing. **Phoutnalong Vilay:** Project administration. **Tiengkham Pongvongsa:** Project administration. All authors have read and agreed to the published version of the manuscript.

Ethical Approval

As this study was part of the routine disease investigation by the MOH, Lao PDR, ethics approval was not required. However, all results are presented anonymously. No individual information has been disclosed.

Informed Consent

Not applicable.

Data Availability

The datasets analyzed in the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the authors used Copilot and ChatGPT to enhance clarity in some parts of the text. The content produced by this tool was reviewed and re-edited by the authors, who accept full responsibility for the final text.

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