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Treatment outcomes of patients with uncomplicated malaria and associated factors in Northwest Ethiopia: a prospective follow-up study, 2024

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Abstract

Background Malaria is the major public health problem in low-income countries like Ethiopia. Despite extensive interventional studies being conducted to attain the 2030 malaria elimination goals, there is limited data on the treatment outcomes of uncomplicated malaria in Ethiopia. Thus, this study aimed to assess the treatment outcomes and associated factors of uncomplicated malaria in Northwest Ethiopia.

Methods This study was conducted in two health centers, Kolla Diba and Forhe-Sankira, located in Dembia and North Achefer Districts, from April to June 2024. Data was collected from 460 study participants who presented with signs and symptoms and from parasitologically confirmed patients. Malaria was confirmed using microscopy and rapid diagnostic tests (RDT). The parasitologically confirmed patients were appointed on the 3rd, 7th, 14th, and 28th days to determine treatment outcomes for those who were parasitemic on the preceding visit or symptomatic at each visit. The collected longitudinal data was entered and cleaned by Epi-data 4.1 and then analyzed using SPSS 25 software. Descriptive statistics were computed. A binary logistic regression model was fitted to identify factors associated with unsuccessful treatment outcomes at a 95% CI, and a *p*-value < 0.05 was considered significant.

Results Of the 460 study participants, 234 (50.9%) were parasitologically confirmed. Treatment outcomes were determined for 224 (95.7%) patients. Ten patients were lost to follow-up. The overall unsuccessful treatment rate was 18.8%. No previous malaria attack (AOR = 18.62, 95% CI: 5.15, 67.25), being infected by *Plasmodium vivax* (AOR = 8.58; 95% CI: 2.85, 25.83), and coartem two times for 3 days plus primaquine for 14 days (AOR = 4.84; 95% CI: 1.83, 12.79) were the identified factors for unsuccessful treatment outcomes.

Conclusions and recommendations This study revealed that a higher proportion of patients had an unsuccessful treatment outcome. No previous malarial attack, being infected by *Plasmodium vivax*, and coartem plus primaquine were the identified factors for unsuccessful treatment outcomes. We recommend that healthcare providers prescribe

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first-line antimalarial therapy and appoint patients for follow-up evaluation according to the national guidelines to identify treatment failure early.

Keywords Treatment outcome, Factors, Uncomplicated malaria, Cure, Failure, Lost to follow-up

Introduction

Malaria is a major public health problem caused by *Plasmodium* parasites, and infected patients usually present with fever, chills, headache, joint pain, vomiting, and other symptoms [1, 2]. In 2022 globally, there were 249 million malaria cases in 85 endemic countries, of which African countries Ethiopia (1.3 million), Nigeria (1.3 million), Uganda (597,000), and Papua New Guinea (423,000) had the highest malaria burden [3]. Moreover, the World Health Organization (WHO) reported that 94% of malaria cases and 95% of deaths occurred in the African regions, of which the higher burden was observed in pregnant mothers and children [4–6]. WHO reported that 75 million Ethiopians were at risk of contracting malaria, and the peak transmission period was from September to December and from March to May [7, 8]. In Ethiopia, the number of malaria-confirmed cases increased by one-third while it doubled in the Amhara region between 2021 and 2022 [9].

The treatment failure rate of uncomplicated malaria was 32.6% at the global level [10]. An indigenous systematic review showed that the overall unsuccessful treatment rate for malaria was 7.1% [11]. However, another indigenous study depicted that the therapeutic efficacy of uncomplicated malaria was 100% [12]. The WHO recommended malaria treatment outcome evaluation should be done on the 3rd, 7th, 14th, and 28th days' visits [6]. Despite this recommendation, there was limited evidence in Ethiopia in general and the Amhara region in particular in this regard. Thus, this study aimed to assess the treatment outcomes of patients with uncomplicated malaria and associated factors in northwest Ethiopia.

Methods and materials

Study setting, study design, and period

This facility-based prospective follow-up study was conducted at Kolla Diba and Forhe-Sankira health centers located in Central Gondar and West Gojjam Zones, Amhara region, Ethiopia, respectively. Kolla Diba Health Center is 729 km away, while Forhe-Sankira Health Center is 591 km away from Addis Ababa, the capital city of Ethiopia. Both districts are bounded by Lake Tana (the largest lake in Ethiopia). These health centers were selected due to their high malaria prevalence rate in the region [13, 14]. In both districts, the peak malaria transmission season was between October and December [15]. Both *P. vivax* and *P. falciparum* exist in these areas, with *P. falciparum* dominating all the year [16, 17]. The study was conducted from April 1 to June 30, 2024.

Population

All patients presented with signs and symptoms of malaria both at Kolla Diba and Forhe-Sankira health centers, were the source population, while all parasitologically confirmed patients were the study population.

Eligibility criteria

All adult patients (≥18 years) who were parasitologically confirmed and clinically diagnosed uncomplicated malaria patients were included, while pregnant mothers, children, and lactating women within the first 6 months of postpartum were excluded.

Sample size and sampling procedures

The sample size of this study was calculated using a single population proportion formula. To yield the maximum sample size, we used a 50% proportion, a 95% confidence interval, and a 20% non-response rate, $N = 460$. A consecutive sampling technique was employed to recruit study participants until the required sample size was obtained. As the study period was on the second peak malaria season following minor rains of spring, the consecutive sampling method was appropriate to recruit adequate participants before the winter falls.

Operational definitions

Uncomplicated malaria Confirmed malaria cases without any features of complicated or severe malaria, such as diminished consciousness, respiratory distress, prostration, severe anemia, hypoglycemia, jaundice, or shock.

Early treatment failure (ETF) Danger signs or severe malaria on day 1, 2, or 3, in the presence of parasitemia; parasitemia on day 2 higher than on day 0, irrespective of axillary temperature; parasitemia on day 3 with axillary temperature ≥ 37.5 °C; and parasitemia on day 3 ≥ 25% of count on day 0.

Late clinical failure (LCF) Danger signs or severe malaria in the presence of parasitemia on any day between day 4 and day 28 (day 42) in patients who did not previously meet any of the criteria of early treatment failure; and presence of parasitemia on any day between day 4 and day 28 (day 42) with axillary temperature ≥ 37.5 °C in patients who did not previously meet any of the criteria of early treatment failure. Presence of parasitemia on any day between day 7 and day 28 (day 42) with axillary temperature < 37.5 °C in patients who did not previously meet

any of the criteria of early treatment failure or late clinical failure.

Adequate clinical and parasitological response (ACPR) Absence of parasitemia on day 28, irrespective of axillary temperature, in patients who did not previously meet any of the criteria of early treatment failure, late clinical failure, or late parasitological failure [6].

Lost to follow-up (LTFU) When patients were not returned back to health centers for evaluation during the 3rd, 7th, 14th, and 28th days of treatment follow-up evaluation as their treatment outcomes were unknown.

Unsuccessful treatment outcome patients whose treatment was either with early treatment failure, late treatment failure, danger signs, and symptoms identified during the treatment course or then after during their post-treatment follow-up evaluation time.

Parasite load Low parasite load (< 1,000 parasites/μl blood), moderate (1,000–4,999 parasites/μl), high (5,000–99,999 parasites/μl), and hyper parasitemia (≥ 100,000 parasites/μl) [18–20].

Data collection tools and procedures

Data was collected using semi-structured questionnaires containing demographic and clinical variables that were developed after reviewing literature and treatment guidelines (supplementary file). Baseline data was collected from the 460 patients at the time of registration and then during the follow-up periods for 234 parasitologically confirmed patients.

Thin and thick blood films were prepared on the same slide for each blood sample by experienced laboratory personnel. Two drops of blood were placed on a clean, labeled glass slide about 1 cm apart. For the thick blood film, the larger blood spot was stirred in a circular motion with the corner edge of another slide. The thin blood film was prepared by placing the smooth edge of the spreader slide on the drop of blood at an angle of 45° and quickly smeared forward on the slide surface. The blood smears were allowed to air dry, and the thin films were fixed with methanol. The slides were then stained with 10% Giemsa for 10 min, after which the stain was washed off and air-dried. Slides were examined using a light microscope with 100x oil immersion, and 100 fields were scanned before a particular smear was declared negative. Parasitemia was calculated for positive blood smears by counting the number of parasites observed per 200 leukocytes and assuming a total of 8,000 leukocytes/μl. Species identification and parasite grading were on thin and thick blood films, respectively. Assuming an average white cell count of 8,000/μl, parasitemia can be estimated from a thick smear by counting the number of parasites until 200 white cells have also been counted. This count, when multiplied by 40, gives an indication of the number of parasites per microliter of blood. The parasitemia percentage can then be calculated by dividing the parasite density by 4,000,000 (the average number of erythrocytes per microliter in blood) and multiplying by 100. The quality of prepared slides was regularly checked by researchers using WHO blood film quality standards, posted at each study site along with SOPs.

Patients were appointed on the 3rd, 7th, 14th, and 28th days; blood film was repeated for those who were parasitemic in the preceding visit or symptomatic at each visit, but RDT was not repeated due to its intrinsic characteristics of remaining positive for 5–7 weeks after treatment.

Patients were treated with anti-malarial drugs as per the national malaria guideline 2022: *Plasmodium falciparum* cases: artemether-lumefantrine (AL) (coartem) two times for three days + primaquine single dose (0.25 mg/kg); *Plasmodium vivax*: Chloroquine (weight based) for three days + primaquine (0.25 mg/kg) daily for 14 days; mixed cases (*Plasmodium falciparum* and *Plasmodium vivax*): AL (coartem) two times for 3 days + primaquine (0.25 mg/kg) daily for 14 days; alternatively, *P. vivax* can be treated with coartem alone or coartem plus primaquine.

Data quality assurance

The data collection tools were prepared in English considering the available literature. The tools were then translated into the local language, Amharic, and then back to English to maintain consistency. The tools were pre-tested in the Gondar health center before the actual data collection was started. A one-day training was provided for data collectors and supervisors before the data collection commenced. Data was collected by data collectors and was checked by the supervisors on a daily basis.

Data processing and analysis

The collected data was entered using EpiData version 4.1 and analyzed by SPSS version 25 software. Descriptive statistics were computed and presented by tables and graphs. The association between the predictor variables and treatment outcomes was determined using a binary logistic regression model. Binary logistic regression with the adjusted odds ratio (AOR) and 95% confidence interval (CI) was employed. Hosmer and Lemeshow's goodness of fit ($P > 0.05$) was used to assess the model's fitness. Variables were deemed eligible for inclusion in multivariate analysis if their univariate p-value was less than 0.2. The binary logistic regression analysis was performed on 224 patients whose treatment outcomes were known. Patients who lost from follow-up monitoring visits were excluded from the regression analysis. A p-value of less

than 0.05 indicated that a variable was statistically significant in predicting an unsuccessful treatment outcome.

Results

Socio-demographic characteristics of the patients

A total of 460 patients took part in the study. Of these, 260 (56.5%) were females. The median age of participants was 28 (± 26 IQR) years, and the majority (52.5%) of the respondents were under 25 years. Almost three-fourths (74.8%) of study participants were residing in rural areas, and about 41% of them were students. About two-thirds of the patients were followed up at Kolla Diba health center.

Distribution of socio-demographic characteristics and treatment outcomes

The majority of male and female patients were cured of malaria. Females had a higher proportion of treatment failure than males. The higher proportion of unsuccessful treatment outcomes (71.4%) was observed in patients younger than 27 years and rural residents (73.8). Students had the highest rate (50%) of unsuccessful treatment outcomes. Ten patients were lost from follow-up on the 7th follow-up visit (Table 1).

Baseline and follow-up characteristics of malaria patients

From the total 460 screened patients, 234 (50.9%) of them were positive for malaria infection at baseline. The predominantly identified species was *P. falciparum*, 146 (62.4%). However, on the third day of follow-up, only 29 (12.4%) patients were positive for *Plasmodium* vivax; early treatment failure. These 29 patients were referred to the health facilities where chloroquine was available. Moreover, in the next follow-up period, about 13 patients developed late clinical failure, and these patients were referred to hospitals. Then after, adequate clinical improvements were observed among 182 patients on the 7th, 14th, and 28th days and declared cured (Fig. 1).

Table 1 Distribution of socio-demographic characteristics, follow-up visits, and treatment outcomes of uncomplicated malaria patients in Northwest Ethiopia, 2024 ($n = 224$)

Variables	Category	Treatment outcomes	
		Successful (%)	Unsuccessful (%)
Sex	Male	76 (41.8)	19 (45.3)
	Female	106 (58.2)	23 (54.7)
Age	≤ 27	94 (51.6)	30 (71.4)
	28–37	25 (13.8)	3 (7.2)
	38–47	29 (15.9)	4 (9.5)
	≥ 48	34 (18.7)	5 (11.9)
Residence	Rural	108 (59.3)	31(73.8)
	Urban	74 (40.7)	11 (26.2)
Occupation	Housewife	57 (31.3)	10 (23.8)
	Farmer	29 (15.9)	8 (19.1)
	Merchant	10 (5.5)	2 (4.8)
	Government employee	1 (0.6)	1 (2.3)
	Student	85 (46.7)	21 (50)
Bed net utilized	Yes	8 (4.4)	2 (4.8)
	No	174 (95.6)	40 (95.2)
3rd day follow-up visit			
Malaria symptoms	Yes	0 (0.0)	29 (100)
	No	205 (100)	0 (0.0)
Blood film	Positive	0 (0.0)	29 (100)
	Negative	205 (100)	0 (0.0)
7th day follow-up Visit	Develop a severe malaria sign	0 (0.0)	13 (100)
	Lost from follow-up	0 (0.0)	10 (100)
	No malaria symptoms	182 (100)	0 (0.0)
14th day follow-up visit	No malaria symptoms	182 (100)	0 (0.0)
	Lost from follow-up	0 (0.0)	0 (0.0)
	Danger/severe malaria sign	0 (0.0)	0 (0.0)
28th day follow-up visit	No malaria symptoms	182 (100)	0 (0.0)
	Lost from follow-up	0 (0.0)	0 (0.0)
	Danger/severe malaria sign	0 (0.0)	0 (0.0)

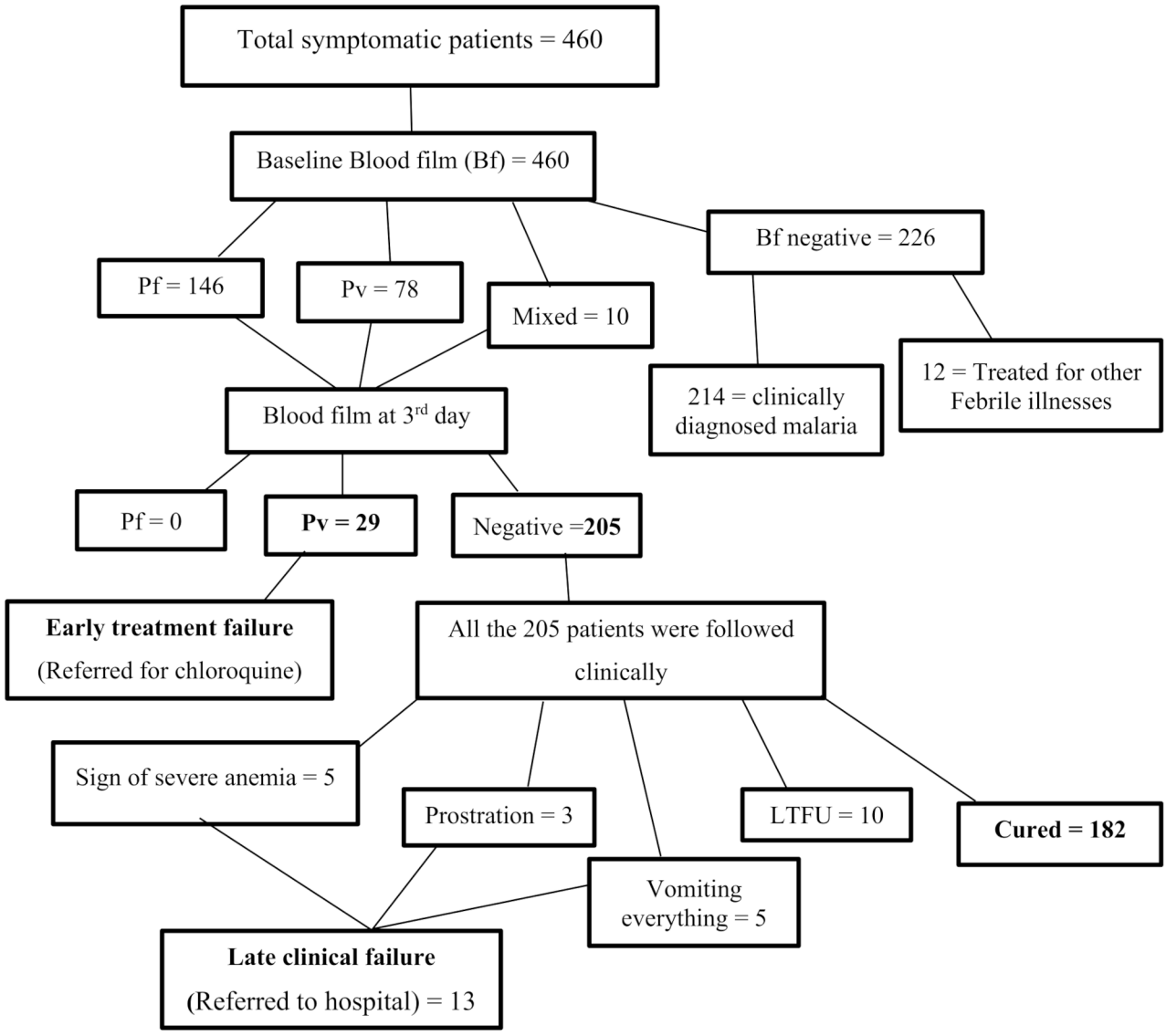

Fig. 1 Schematic presentation of malaria patients from diagnosis to treatment outcomes in northwest Ethiopia, 2024

Distribution of clinical characteristics and treatment outcomes

All study participants had all the classic symptoms (fever, headache, joint pain, chills, and rigors) of malaria. The mean temperature value was 38.02 °C (min = 38 °C and max = 39 °C). All patients were tachycardic. Among the identified *Plasmodium* species, patients infected with *Plasmodium vivax* had the largest proportion of unsuccessful treatment outcomes, 69%. Moreover, the majority of the patients (54.8%) infected with *Plasmodium vivax* and treated with coartem had developed an unsuccessful treatment outcome. In addition, patients who took antimalarial drugs alone had a 100% higher rate of unsuccessful treatment outcomes (Table 2).

The level of treatment outcomes of malaria patients

The highest number of overall unsuccessful treatment outcomes was observed among patients with *P. vivax*, while the highest number of successful treatment outcomes was observed among patients with P. falciparum (Fig. 2).

Factors associated with treatment outcomes

In the univariate logistic regression analysis, residence, age, previous malaria attack, blood film result at day "0" parasite density, and anti-malarial drugs were the determinants of unsuccessful treatment outcomes at a 20% level of significance. However, in the multivariable logistic regression analysis, a previous malaria attack, blood film result at day "0," and antimalarial drugs were the

Table 2 Distribution of clinical characteristics and treatment outcomes of malaria patients in the outpatient departments in Northwest Ethiopia, 2024 ($n = 224$)

Characteristics	Category	Treatment outcome	
		Successful (%)	Unsuccessful (%)
Respiratory rate	Tachypnea	3 (1.6)	0 (0)
	Normal	179 (98.4)	42 (100)
Blood pressure	≥140/90	2 (1.1)	0 (0)
	< 140/90	180 (98.9)	42 (100)
Comorbidities	Yes	2 (1.1)	0 (0)
	No	180 (98.9)	42 (100)
Blood film result at baseline	*Plasmodium vivax*	46 (25.3)	29 (69)
	Mixed infection	5 (2.7)	5 (11.9)
	Plasmodium falciparum	131 (72)	8 (19.1)
Parasite density	High	149 (81.9)	25 (59.5)
	Moderate	11 (6)	11 (26.2)
	Low	22 (12.1)	6 (14.3)
Types of antimalaria given	Coartem (two times for 3 days) + primaquine (single dose)	125 (68.7)	14 (33.3)
	Chloroquine for 3 days + primaquine (14 days)	18 (9.9)	5 (11.9)
	Coartem (two times for 3days) + primaquine (14 days)	39 (21.4)	23 (54.8)
Antimalaria with antibiotics	Yes	9 (4.9)	0.0 (0.0)
	No	173 (95.1)	42 (100)

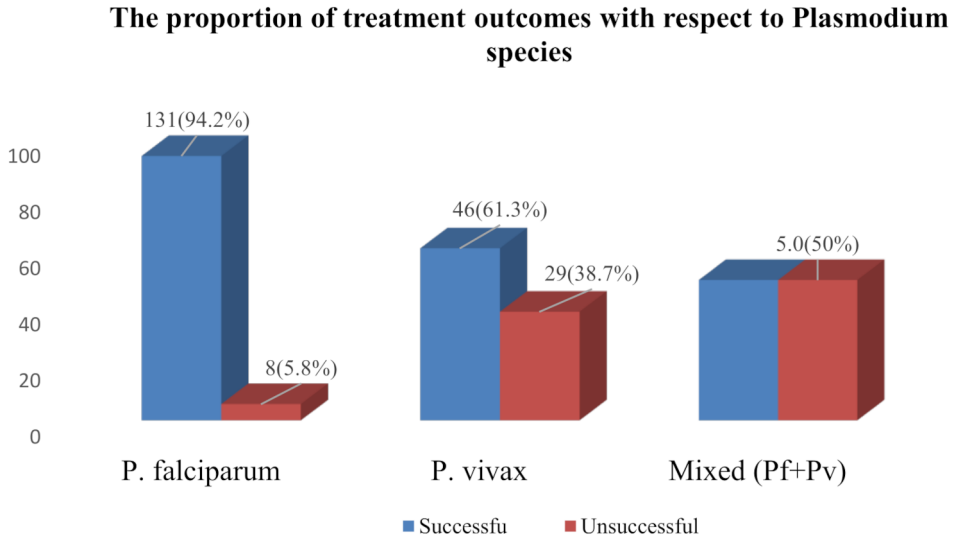

Fig. 2 The distribution of treatment outcomes of uncomplicated malaria with respect to P. species among patients in northwest Ethiopia, 2024 ($n = 224$)

determinants for unsuccessful treatment outcome at a p-value of < 0.05.

Patients who did not have previous malarial attack were nearly 19 times (AOR = 18.62, 95% CI: 5.15, 67.25) at higher risk of having unsuccessful treatment outcome as compared to their counterparts.

The odds of an unsuccessful treatment outcome was approximately ninefold (AOR = 8.58; 95% CI: 2.85, 25.83) higher among patients with *Plasmodium vivax* compared to those with *Plasmodium falciparum*. Patients who took Coartem two times daily for 3 days plus primaquine daily for 14 days had nearly five times (AOR = 4.84; 95% CI: 1.83, 12.79) higher unsuccessful treatment outcomes compared to those patients who took Coartem two times daily for 3 days plus primaquine single dose (Table 3).

Discussion

This study assessed the treatment outcomes of uncomplicated malaria and associated factors in Northwest Ethiopia. Both clinical and parasitological responses were used to determine the treatment outcomes. Previous malaria attacks, being infected by *Plasmodium vivax*, and coartem for three days plus primaquine (14 days) were the identified factors for unsuccessful treatment outcomes. Moreover, about 4.3% of patients were lost to follow-up

Table 3 Binary logistic regression analysis of malaria treatment outcome among patients in Northwest Ethiopia, 2024 ($n = 224$)

Variables	Category	Treatment outcome		COR (95%CI)	AOR (95%CI)	*P*-value
		Unsuccessful	Successful			
Residence	Rural	31	108	1.93 (0.91, 4.08)	1.69 (0.64, 4.43)	0.288
	Urban	11	74	1.00	1.00	
Age	≤ 27 years	30	94	2.34 (1.13, 4.86)	1.34 (0.52, 3.46)	0.544
	> 27 years	12	88	1.00	1.00	
Previous malaria attack	No	9	13	8.62 (3.38, 21.98)	**18.62 (5.15, 67.25)**	**0.0001**
	Yes	173	29	1.00	1.00	
Blood film at day "0"	*Plasmodium vivax* infection	29	46	10.32 (4.41, 24.19)	**8.58 (2.85, 25.83)**	**0.0001**
	Mixed infection	5	5	16.38 (3.92, 68.46)	5.95 (0.98, 36.25)	0.053
	Plasmodium falciparum infection	8	131	1.00	1.00	
Parasite density	High	25	149	0.62 (0.23, 1.67)	0.66 (0.19, 2.24)	0.509
	Moderate	11	11	3.67 (1.07, 12.55)	3.55 (0.83, 5.18)	0.088
	Low	6	22	1.00	1.00	
Anti-malaria drugs	Coartem (two times for 3 days) + Primaquine for 14 days	23	39	5.27 (2.47, 11.21)	**4.84 (1.83, 12.79)**	**0.001**
	Chloroquine for 3 days + Primaquine for 14 days	5	18	2.48 (0.79, 7.71)	2.10 (0.54, 8.22)	0.286
	Coartem (two times for 3 days) + Primaquine single dose	14	125	1.00	1.00	

(unknown treatment outcome) on the 7th day of the follow-up visit.

In this study, the overall unsuccessful treatment outcome was 18.8%. This finding was higher than the findings of other studies: a systematic review in Ethiopia 7.1% [21], Debrezeit 2% [22], Serbo 3.6% [23], Halaba Special District in Southern Ethiopia, 11.7% [24], and Vietnam 7.2% [25]. Findings in studies in Metehara [12] and Kenya [26] were in contrast to our finding. This might be due to a stockout of chloroquine in Kolla Diba health center during our study, leading to patients with *Plasmodium vivax* receiving coartem instead. This alternative treatment may have contributed to higher rates of unsuccessful treatment outcomes. Moreover, it could also be linked with variation in anti-malaria treatment regime selection, drug adherence, drug resistance, malabsorption, and other adverse drug events.

In this study, the proportion of early treatment failure was 12.4% at the 3rd day of their treatment follow-up time. Our finding was about twofold higher than the study finding in Vietnam, 7.2% [25]. However, it was lower than the finding in Kenya (54%), which was positive for the *Plasmodium* parasite on the 4th day of treatment [26]. Moreover, other studies in Uganda [27, 28] and Burkina Faso [29] also reported similar findings. A randomized clinical trial study also reported that 12% and 4% treatment failures were observed among patients with *Plasmodium vivax* who received solely coartem and chloroquine, respectively [30]. The possible justification for early treatment failure in our study could be the stockout of chloroquine in Kolla Diba health center during the study period, and patients infected with *Plasmodium vivax* were provided Coartem, which is the alternative treatment regimen in Ethiopia.

Patients who did not have a previous malarial attack were nearly 19 times (AOR = 18.62, 95%CI: 5.15, 67.25) at higher risk of having an unsuccessful treatment outcome as compared to their counterparts. This might be due to patients with no history of malaria attacks, having lack of innate immunity to the *Plasmodium* parasite [31].

The odds of an unsuccessful treatment outcome were approximately ninefold (AOR = 8.58; 95% CI: 2.85, 25.83) higher among patients with *Plasmodium vivax* compared to those with *Plasmodium falciparum*. This finding was in agreement with the study findings of a systemic review in six countries [32] and Myanmar [33]. But it was against the study finding of Arba Minch [34]. The possible justification could be Kolla Diba health center was stocked out of chloroquine. As a result, these patients with *Plasmodium vivax* were treated with coartem, which is the alternative anti-malarial agent of this *Plasmodium* species. In addition, inadequate drug exposure, impaired immunity, malnutrition, drug resistance, drug adverse effects [35], drugs might be taken with inadequate fat intake [6], and drug adherence might be attributed to this finding.

Patients who took Coartem two times daily for 3 days plus primaquine daily for 14 days had nearly five times (AOR = 4.84; 95% CI: 1.83, 12.79) higher unsuccessful treatment outcomes compared to those patients who took coartem two times daily for 3 days plus primaquine single dose. This finding could be challenged due to the fact that one of the two study health centers, Kolla Diba health center, was out of chloroquine during the study period to treat *P. vivax* patients; thus, patients were treated with coartem plus primaquine. Our finding was

in contrast with the finding in Guyana, which showed that treating *Plasmodium vivax* with artemether-lumefantrine combined with primaquine significantly reduced the rate of unsuccessful treatment outcomes [36]. This finding might be explained by the overuse of Coartem for the treatment of clinically diagnosed malaria cases and *P. falciparum*, the dominant species, in Ethiopia, which might result in further resistance to *P. vivax*.

Patients who took antimalarial drugs alone had a higher rate of unsuccessful treatment outcomes, 42 (18.8%). In support of our finding, macrolides were effective in treating P. falciparum [37, 38]. This finding was in agreement with a study finding in South Africa, as antibiotics had a synergistic effect with antimalaria drugs and also prevented concomitant bacterial infection [39].

Limitations of the study

The unavailability of chloroquine in Kolla Diba health center was one of the main challenges of this study. Moreover, the study solely included patients older than 18 years; this might be difficult to generate comprehensive evidence for the entire population.

Conclusions and recommendations

This study revealed a higher proportion of patients had unsuccessful treatment outcome, 18.8%. No previous malarial attack, baseline blood film with *Plasmodium vivax*, and coartem plus primaquine were the identified factors for unsuccessful treatment outcomes.

The findings of this study will have an enormous lesson for healthcare providers to appoint patients for treatment follow-up evaluation as per the national and the WHO recommendations. In addition, we recommend health care providers prescribe the first-line antimalarial drugs as per the national malaria treatment guidelines. Furthermore, we recommend healthcare managers, policymakers, and other stakeholders create strong platforms that can ensure the availability of the first-line anti-malarial drugs consistently.

Finally, we recommend researchers conduct further studies on antimalarial drug efficacy and drug resistance testing surveillances.

Abbreviations

ACPR	Adequate Clinical and Parasitological Response
ALT	Artemetherine-Lumefantrine
AOR	Adjusted Odds Ratio
COR	Crude Odds Ratio
ETF	Early Treatment Failure
IQR	Interquartile Range
IRB	Institutional Review Board
LCT	Late Clinical Failure
LTFU	Lost to Follow-Up
PF	*Plasmodium falciparum*
PV	*Plasmodium vivax*
RDT	Rapid Diagnostic Test
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12879-025-10791-z.

Supplementary Material 1

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Author contributions

TBD: Conceptualization, methodology, formal analysis, investigation, data curation, writing original draft, and visualization; MAB: Conceptualization, methodology, writing review & editing, and supervision; GMB: methodology, formal analysis, investigation, data curation, writing original draft, and visualization; BBB: methodology, formal analysis, investigation, writing original draft, and visualization; MT: methodology, formal analysis, investigation, data curation, writing original draft, and visualization; AAA: methodology, formal analysis, investigation, writing original draft, and visualization; AAB: methodology, formal analysis, investigation, writing original draft, and visualization; MY: methodology, formal analysis, investigation, writing original draft, and visualization; AAM: methodology, formal analysis, investigation, and writing original draft; WAD: Conceptualization, methodology, formal analysis, investigation, data curation, writing original draft, and visualization.

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Data availability

We do have data generated during this study. However, we didn't put in the repository as we agreed to the IRB not to share data for third party.

Declarations

Ethical approval and consent to participate

Ethical approval was obtained from the ethical review committee of the Addis Ababa University given, College of Health Science (with protocol number: 14/23). Written informed consent was obtained after providing adequate information on the purpose of the study. The data of study participants was kept confidential. This study was conducted according to the Declaration of Helsinki, Finland, 1964.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

It is not applicable, as it is a follow-up study solely to assess the outcomes of the patients, but not the effectiveness of the drugs.

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