

Caregivers' experience in pediatric malaria treatment acceptability and cost: a mixed methods study in South Ethiopia

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Abstract

Background

Malaria remains a major cause of childhood morbidity and mortality, particularly in Africa, which accounts for 95% of global malaria death, with 75% occurring in children under five years of age. As primary decision-makers, caregivers play a pivotal role in healthcare-seeking and treatment-adherence for children with malaria. However, the influence of caregivers' knowledge, attitudes, lived experiences, and economic burden on treatment behaviors remains poorly understood. This study examined how these factors shape healthcare-seeking, treatment acceptability, and adherence among caregivers of children with malaria.

Methods

A concurrent mixed-methods design was embedded within a clinical trial of pediatric *P. vivax*, which assessed the efficacy of a radical cure regimen of flavored pediatric primaquine formulations. Knowledge, attitude, and practice (KAP), and household costs of pediatric malaria data were collected from 120 caregivers using structured questionnaires and analyzed descriptively. Qualitative data were generated through focus group discussions with 29 caregivers, to explore lived experiences related to medication taste, packaging, dosing, and adherence. Quantitative and qualitative findings were triangulated and integrated during interpretation to develop a comprehensive understanding of caregivers' knowledge, attitudes, practices, experiences, and treatment behaviors.

Results

Overall, there was high knowledge-practice gap. Caregivers possessed high awareness of malaria transmission and prevention; most recognized it as preventable (97%) and potentially fatal if untreated (95%). However, this failed to translate into preventive practices: only 48.3% reported good prevention behaviors and 13.3% sought timely healthcare. The critical knowledge-practice gap is influenced by systemic and socioeconomic barriers. Self-medication and traditional remedies were common, and some households experienced catastrophic expenditure. Although caregivers emphasized the importance of completing treatment, adherence was influenced by challenges related to drug taste, dosing, and packaging. The flavored pediatric primaquine formulation was well accepted because of its improved palatability and supportive communication from healthcare workers.

Conclusion

The study revealed a critical knowledge–practice gap whereby high caregiver awareness did not consistently translate into appropriate actions because of systemic and socioeconomic barriers, as well

as challenges related to medication palatability and lack of fit-for-purpose packaging. Tailored community education, child-friendly drug formulations, and appropriately designed packaging were seen as positive steps to strengthening radical cure implementation.

Introduction

Malaria remains a major global public health challenge, disproportionately affecting children under five in Sub-Saharan Africa. In 2024, approximately 282 million malaria cases and 610,000 deaths occurred worldwide, with the WHO African region accounting for about 95% of cases and deaths [1]. Children under the age of five years accounted for nearly three-quarters of the malaria-related deaths in the region [1, 2]. During the same reporting period, Ethiopia was among the top ten nations carrying 66% of the global malaria burden with over 7.3 million cases and 1,157 deaths: children under five accounted for up to 20% of these deaths. *P. falciparum* and *P. vivax* contributed to the burden, with *P. vivax* recognized for its role in recurrent infections and sustained transmission [3]. A systematic review and meta-analysis of 12 Ethiopian studies, published between 2010 and 2021, including 34,842 children under-five, reported a pooled malaria prevalence of 22.0% [4].

Malaria elimination strategies relay on drug combinations targeting the symptomatic asexual blood stage, the transmission-capable gametocytes, and the dormant liver-stage hypnozoites. In line with global malaria elimination strategies, Ethiopia's National Malaria Elimination Program recommends a single low dose Primaquine (PQ) administered with Artemether-Lumefantrine (AL) for *P. falciparum* malaria to block transmission, and 14 days (0.25 mg/kg/day) of PQ combined with Chloroquine (CQ) for *P. vivax* malaria or with AL for mixed *P. vivax/P. falciparum* infections [5]. For decades, the global endeavor for malaria elimination have been hindered by lack of quality assured, child appropriate PQ formulations. Until recently, only 15mg and 7.5mg tablets were available, requiring caregivers or healthcare providers to crush tablets to achieve pediatric doses, thereby compromising dosing accuracy and palatability. Dispersible PQ tablets (2.5 & 5 mg) were not WHO prequalified until November 2025.

Evidence from sub-Saharan Africa documented that caregivers' knowledge, attitudes, and practices (KAP) strongly influence malaria prevention behaviors, timing of healthcare utilization, and treatment completion [6–11]. While general awareness of malaria transmission and prevention is often high, misconceptions about causes, delays due to home remedies or self-medication, and structural barriers such as treatment and care seeking cost and access continue to affect outcomes [10, 12–15]. Moreover, the economic cost of pediatric malaria on households was not well explored in Ethiopia [6, 7]. Caregivers' biomedical understanding of malaria, combined with their lived caregiving experiences, and associated cost are essential factors in the prompt initiation and ensuring completion for children under five [16–18].

This study was nested within an efficacy and acceptability trial of flavored PQ tablet strengths (7.5mg, 5mg, 3.75mg and 2.5mg) in vivax-infected children aged 6 months to < 16 years. We aimed to assess caregivers' KAPs regarding malaria, household costs associated with care and care-seeking, and their

lived experiences with pediatric malaria treatment, including perceptions of drug flavor, treatment acceptability, and packaging design.

Methods

Study setting and context

This study was conducted at Dil Fana Primary Hospital (DFPH), Arba Minch town, South Ethiopia Regional State (Fig. 1). DFPH serves as a key healthcare provider for a catchment population living within a 20-kilometer radius. Arba Minch is an urban center with a population of 210, 255. The local economy is highly diversified, with a mix of civil service, academia, trade, traditional textile weaving, tourism and fishing. According to Ketema et al, (2021), the Southern Ethiopia region is one of the high *P. vivax* burdened regions of Ethiopia: prevalence rates of 16–30% compared to around 9% for Ethiopia as a whole [3].

Study design and period

This study was nested within a clinical trial, entitled, *Assessing Pediatric Primaquine in Ethiopia (APPE)*, which evaluated new, flavored pediatric formulations of PQ. The APPE study was a phase IIb trial comprising three components: a field study (open label, single arm trial), and acceptability and qualitative studies (PACTR202110493521020) [19]. A concurrent mixed methods design was used to allow triangulation of quantitative findings with qualitative insights.

Data for this sub-study were collected between October 2024 and December 2025. The quantitative component consisted of an institutional-based cross-sectional survey designed to describe caregivers' socio-demographic characteristics and assess their KAPs, economic burden, and care-seeking of caregivers. KAP and a contextually-adapted version of the Study of global Aging and Adult Health (SAGE) household cost questionnaires were administered to all caregivers (n = 120) on the day of enrolment. During follow-up visits, a sub-set of caregivers (n = 29) participated in Focus Group Discussions (FGD)s to explore their beliefs, practices, experiences, and preferences related to the management of malaria, particularly of their children.

Study population and sampling

The study population consisted of caregivers (parents or guardians) of children aged 6 months to < 16 years and diagnosed by microscopy with uncomplicated *P. vivax* mono-infection or *P. vivax* and *P. falciparum* mixed infection. .

Operational definitions

Good prevention practice

Participants who scored greater than or equal to the mean score on the 11-item prevention practice measurement questions [9].

Poor prevention practice

Participants who scored less than the mean score on the 11-item prevention practice measurement questions [9].

Good healthcare seeking behaviors

Caregivers who scored greater than or equal to the mean score on the two healthcare-seeking behavior items and who sought care from a governmental health facility or private clinic within 24 hours of the onset of signs and symptoms requiring medical attention [20].

Out-of-pocket health expenditures (OOPHE)

are those made by households at the point of receiving health services and payments related to seeking care.

Catastrophic OOPHE

defined in relation to a household's consumption expenditures, when such expenditures exceed 5% or 10 of total household consumption or $\geq 40\%$ of non-food consumption expenditures (capacity-to-pay) [21, 22].

Data collection tools and procedures

The quantitative, structured, and interviewer-administered questionnaires were used to capture data on socio-demographic characteristics and KAP. Data on care seeking and pediatric malaria related costs incurred over the past one-year period before the day of the interview, including household economic status, consumption, asset possession, and direct medical cost, direct non-medical cost, in-direct cost of pediatric malaria care, were collected. Data on household water source, sanitation, and housing conditions were collected, including type of drinking water source, cooking location, toilet facility access and type, and toilet-sharing practices.

Qualitative data were collected through four FGDs, each consisting of 6 to 8 caregivers. A semi-structured guide with open-ended questions was used. The guide was initially developed in English and then translated into Amharic, the language with which participants were most comfortable, and all discussions were conducted in Amharic. FGDs lasted between 114 and 173 minutes. The discussions focused on the understandings of malaria symptoms, causes, transmission, prevention and treatment as well as caregivers' lived experiences with administering antimalarial drugs for children during previous

treatment, and their views and preferences on drugs formulation, instruction leaflet and packaging in the current study.

Data management and analysis

The data were collected using the research electronic data capture (REDCap) mobile application and uploaded to the REDCap server immediately after collection. Real-time data quality checks were performed, after which the finalized dataset was exported and analyzed using Stata version 17. Descriptive statistics (frequencies, percentages) were used to summarize socio-demographic characteristics and KAP. Open-ended responses in the surveys were reviewed and grouped thematically to identify common patterns. Tape-recorded FGDs were transcribed verbatim and translated to English by trained research assistants. The transcripts were checked for quality by the research team, imported to a computer assisted qualitative data management software, MAXQDA 2020 [23]. Thematic coding was performed through which recurring patterns were identified, followed by thematic analysis resulting in categories presented in this study.

Household income was computed using all sources of income that were summed and converted to their annual equivalents. The household's asset index was constructed based on a multiple correspondence analysis (MCA) using binary indicators on items that included ownership of a range of durable assets, household amenities and livestock. A household's asset index score was derived to categorize households into five wealth quintiles. Food expenditure was estimated by summing consumed own products and expenditure on food items over the last 7 days preceding the survey, non-food expenditure was calculated by summing expenditure on rent, electricity, transport, clothes and health care for the 30 days preceding the survey, and expenditure on education, durable goods, agriculture in puts, ceremonies and vehicle maintenance for the 12 months preceding the survey. To obtain comparable time periods, all consumption expenditures data were converted into annual consumption. Household consumption expenditure was calculated as a summation of food, non-food and health expenditure and then ranked into five quintiles.

We estimated OOPHE for direct medical and direct non-medical costs and expressed them in Ethiopian Birr (1US\$=140 ETB, average exchange rate for 2025). We measured catastrophic OOPHE for malaria care and care seeking using $\geq 5\%$, $\geq 10\%$ of households total consumption expenditure and $\geq 40\%$ of non-food consumption expenditures (capacity to pay). Coping strategies were measured by six items (using current income, use of savings, selling asset, taking out loans from a bank or money lender, payment or reimbursement from a health insurance plan, and asking friends and relatives for help) by the household to mitigate health care payments using a "Yes" or "No" response, if the HH has implemented a particular coping mechanism. Descriptive statistics (mean and median) were used to estimate direct, indirect medical costs, productivity costs, and OOPHE.

Quantitative and qualitative findings were triangulated and integrated during interpretation to develop a comprehensive understanding of caregivers' knowledge, attitudes, practices, experiences, and treatment

behaviors.

Quality assurance

All data collection tools, including questionnaires and FGD guide, were reviewed by experts. Data collectors received training prior to data collection. FGDs moderators carefully planned sessions, defined objectives, and captured both verbal and non-verbal communications using voice recorder and field notes, respectively. Probing questions were used to strengthen the rigor and depth of discussions. Transcription and translation were performed by trained experts.

Results

Sociodemographic, water, sanitation and housing conditions of study participants

All the 120 caregivers participated in KAP and costing studies. The majority were males (64.2%), mean age of 33 years ($SD \pm 8.0$). The mean household size was 5.6 ($SD \pm 1.8$), comprising an average of 3.0 adults ($SD \pm 1.3$) and 2.6 children under 15 years ($SD \pm 1.0$). Most households relied on public taps for drinking water ($n = 93$, 77.5%), while nearly one-third (28.3%) accessed water piped to the yard or directly into the dwelling (2.5%). Cooking most commonly took place in the living or sleeping room ($n = 52$, 43.3%), with one household (0.8%) cooking outdoors. Nearly all households had access to a toilet facility ($n = 119$, 99.2%). Among those with toilets facilities, the majority used a pit latrine with a slab ($n = 78$, 65.6%). Toilet sharing was common, with ($n = 94$, 79.0%) of households sharing facilities with other households. Of the 29 FGD participants most were female ($n = 22$). Socio-demographic characteristics; and housing, water and sanitation facilities of study participants is presented in Table 1.

Table 1
Socio-demographic characteristics, housing, water, and sanitation
facilities of study participants (n = 120)

Categories	Frequency (%)
Gender	
Male	77 (64.2)
Female	43 (35.8)
Educational level	
No formal education	8 (6.7)
Primary school (grade 1–8)	36 (30.0)
High school (9–12)	43 (35.8)
College and above	33 (27.5)
Source of drinking water (multiple responses)	
Piped water to dwelling	3 (2.5)
Piped water to yard	34 (28.3)
Public tap	93 (77.5)
Unprotected spring	1 (0.8)
Cooking places	
Living or sleeping room	52 (43.3)
Separate room used as kitchen	45 (37.5)
Separate building used as kitchen	22 (18.3)
Outdoors	1 (0.8)
Have a toilet facility	
Yes	119 (99.2)
No	1 (0.8)
Type of toilet facility (n = 119)	
Pit latrine with slab	78 (65.5)
Pit latrine without slab/open pit	41 (34.5)
Shared toilet with other HH (n = 119)	
Yes	94 (79.0)

Categories	Frequency (%)
No	25 (21.0)

Economic characteristics of study participants

The mean annual household income was 88,144 ETB (US\$630) (SD $\pm$ 46,838) and the mean annual consumption expenditure was 89,388 ETB (US\$639) (SD $\pm$ 37,939). Consumption and asset-based wealth quintiles showed relatively even distribution across categories but not for income (Table 2).

Table 2
Economic characteristics of study participants (n = 120)

Variables	Frequency (%)	
Wealth quintile (Q1–Q5)		
Lowest Quintile	24 (20.0)	
Second Quintile	24 (20.0)	
Third Quintile	31 (25.8)	
Fourth Quintile	17 (14.2)	
Fifth Quintile	24 (20.0)	
Income quintile (Q1– Q5) ($\bar{x}$ = 88,145, SD = 46,838)	Mean (SD) in ETB	
Lowest Quintile	45,450 (17,994)	36 (30.0)
Second Quintile	71,040 (2,834)	24 (20.0)
Third Quintile	84,000 (4,950)	13 (10.8)
Fourth Quintile	99,552 (5,343)	24 (20.0)
Fifth Quintile	167,143 (43,833)	23 (19.2)
Consumption quintile (Q1–Q5) ($\bar{x}$ = 89389, SD = 37939)	Mean (SD) in Birr	
Lowest Quintile	48,938 (13,810)	25 (20.8)
Second Quintile	66,600 (3,135)	25 (20.8)
Third Quintile	82,908 (5,420)	22 (18.3)
Fourth Quintile	104,442 (8,852)	24 (20.0)
Fifth Quintile	146,184 (33,846)	24 (20.0)
1US\$= 140 ETB (2025 average exchange rate)		

Community discourse on malaria

Recognizing malaria

Participants commonly referred to malaria as “*Shekere*” in the local language (Gamotho). Nearly all caregivers (95.8%) had heard of *Shekere*; the primary information sources were mass media (Television (96, 80.0%), radio (83, 69.2%)), health facilities (55, 45.8%), and other sources of information (32, 26.7%).

One participant explained:

“Health extension workers go from house to house to raise awareness. At the hospital, health professionals educate us about ‘Shekere’ before we receive treatment. (FGD 02)

However, FGDs also revealed gaps and uneven access to information, with some participants reporting limited awareness until they or a family member became ill. One participant reflected, *“I didn’t have awareness of ‘Shekere’ until my son got sick”* (FGD 04),

Symptoms most frequently recognized were chills (94.2%), fever (93.3%), and headache (90.8%). In addition, discussants described “*Shekere*” further as presenting with vomiting, loss of appetite, joint and back pain, fatigue or weakness, sweating, and occasionally pallor, swelling, dry mouth, bitter taste, and yellowish urine.

“The symptoms of ‘Shekere’ include fever, chills, back pain, and headache” (FGD 03)

Causes & transmission routes

Across the FGDs, “*Shekere*” was primarily attributed to mosquito, linked to stagnant water and poor environmental hygiene; hunger, and sun or rain exposure were also widely perceived as associated to “*Shekere*”.

“Shekere” is associated with not using bed nets, stagnant water, hunger, and exposure to the sun.” (FGD 04)

Only 41.7% the participants correctly identified the role of mosquitoes in malaria transmission, with most describing the process as direct pathogen transfer from an infected to a healthy individual (Table 3). As one caregiver explained:

“A mosquito bites an infected person and then bites a healthy person, transmitting the disease [Shekere].” (FGD 02)

Table 3
Knowledge about malaria among study participants (n = 120)

Variables	Frequency (%)
Ever heard about malaria	
No	5 (4.2)
Yes	115 (95.8)
Know about the cause and mode of transmission	
Insect bite only	50 (41.7)
Do not know*	70 (58.3)
Know signs and symptoms of malaria†	
One symptom	2 (1.6%)
Two to three symptoms	5 (4.2)
Four or more symptoms	108 (90.0)
Do not know	5 (4.2)
*Do not know options include drinking unclean water, contact with malaria patients and any combination of these options	

†Cited signs and symptoms of malaria include fever, chills, headache, joint pain, loss of appetite, bitterness in the mouth, nausea/vomiting, and dizziness

Focus group data further revealed community misconceptions regarding transmission, with participants incorrectly implicating sweat, breathing, breastfeeding, or sexual intercourse. As one caregiver stated:

“What makes malaria different is that if you sleep near someone who is infected, you can also become ill, as it is transmitted through sweat.” (FGD 03)

Concurrently, these discussions highlighted a domain of contested knowledge wherein some caregivers actively refuted contagious transmission routes based on personal experiential evidence. One participant clarified:

“When my child gets [Shekere] and has a fever, he sleeps with me but I do not get malaria from him. So, malaria is not transmitted by body contact or fever.” (FGD 04)

Risk factors for malaria

Participants widely associated malaria risk with environmental or behavioral factors that increase exposure to mosquitoes, particularly not using bed nets and living near dirt, stagnant water, or mosquito-breeding sites. As one participant explained:

“Mosquitoes breed in dirt and stagnant water and spread “Shekere” when they bite.” (FGD 01).

While there was broad agreement that children were the most affected group, the perceived causes of this vulnerability varied by the caregivers' educational backgrounds. A small subset of participants with higher levels of education attributed pediatric vulnerability to underdeveloped or weaker immunity. Conversely, the broader community more frequently blamed environmental factors and behavioral habits, such as frequent exposure to dirt, sun, cold weather, and irregular eating schedules. Older adults and pregnant women were also recognized as high-risk groups, though primarily by more educated caregivers who cited reduced immune function. One of these educated participants noted:

“I believe children and pregnant mothers are more vulnerable to [Shekere] because they have weaker immunity.” (FGD 02)

Attitude

Quantitative results revealed a strong consensus that malaria is both preventable (83.3%) and curable (95.0%) when interventions are sought promptly, with formal health facilities viewed as critical to clinical recovery (Table 4). During focus group discussions, participants emphasized the combination of personal, household and environmental prevention measures. Bed net utilization and environmental cleanliness were highlighted as primary strategies, as illustrated by one participant:

“So we need to keep our surroundings and ourselves clean and use bed nets.” (FGD 02).

Furthermore, the vast majority of participants (91.7%) perceived malaria as a severe and potentially fatal disease, particularly if therapeutic intervention is delayed (Table 4). Caregivers acutely understood the high stakes of untreated infection, with one stating:

“What I know is that if it [malaria] is not treated soon, it could kill people.” (FGD 01)

This acute awareness of mortality risk directly drove the shared understanding that survival depends heavily on early clinical care, as summarized by another caregiver:

“I know if you go to the health facility quickly, you will get better. Otherwise, you may die.” (FGD 01)

Table 4
Attitude towards malaria among study participants (n = 120)

Variables	Frequency (%)
I believe malaria causes severe health problems	
No	10 (8.3)
Yes	110 (91.7)
I believed malaria can be prevented	
No	20 (16.7)
Yes	100 (83.3)
I believe malaria can be treated.	
No	6 (5.0)
Yes	114 (95.0)

Malaria prevention practices

Regarding malaria prevention practices, less than half of the surveyed caregivers (n = 57, 48.3%) demonstrated good prevention practices (Table 5). Although insecticide-treated bed net ownership was relatively high at 72.3% (n = 86), consistent and targeted utilization varied across household members. Among households reporting bed net use, parents were the most frequent users 35.0%, followed by children under five years of age (33.3), and pregnant women(16.7%) (Table 5).

Coverage of indoor residual spraying (IRS) was low, with only 17.5% of households reporting that their home had been sprayed during the preceding 12 months. Among these households, most (80.9%) indicated that all rooms had been sprayed. However, nearly half (47.6%) reported that walls had subsequently been painted, replastered, or otherwise physically modified following the most recent spraying campaign (Table 5).

Table 5
Prevention practice for malaria among study participants (n = 120)

Variables	Frequency (%)
Protective measures used against malaria infection (n = 105)*	
Use repellent only	4 (3.8)
Use a bed net only	24 (22.9)
Use indoor residual spraying only	0
Use environmental management only	0
Use both a bed net and repellent	10 (9.5)
Multiple methods	62 (59.0)
No prevention measure used	5 (4.8)
Have a bed net in the household (n = 119)†	
No	33 (27.7)
Yes	86 (72.3)
Do all household members have their own bed net (n = 83)‡	
No	31 (37.3)
Yes	52 (62.6)
Household members who use a bed net§	
Parents (mother and father)	42 (35.0)
Pregnant household member	20 (16.6)
Children	40 (33.3)
Others	1 (0.8)
Indoor insecticide sprayed within the past 12 months (n = 120)	
Yes	21 (17.5)
No	99 (82.5)
Indoor residual spraying in all rooms (n = 21)	
Yes	17 (80.9)
No	4 (19.1)
*Protective measures used against malaria infection information were missing for 15 participants	

Variables	Frequency (%)
House wall painted or changed after the last spray (n = 21)	
Yes	10 (47.6)
No	11 (52.4)
Malaria prevention practice (n = 118)¶	
Good	57 (48.3)
Poor	61 (51.7)
*Protective measures used against malaria infection information were missing for 15 participants	

†Have a bed net in the household (n = 119) information was missing for one participant

‡Do all household members have their own bed net information were missing for three participants

¶Respondents were able to provide more than one response to this question

¶Malaria prevention practices were not assessed for two participants

Treatment practices for malaria

Regarding healthcare utilization, the vast majority of caregivers (n = 112, 93.3%) reported seeking treatment for their child at public health facilities. Despite this high preference for formal healthcare, less than half (n = 48, 40.3%) sought medical care immediately following the onset of fever. Before attending a health facility, more than half of caregivers (n = 62, 52.1%) reported using home remedies (Table 6).

Table 6
Treatment practices for malaria

Variables	Frequency (%)
Where do you get your child treated for malaria(n = 120)	
Government health facility	112 (93.3)
Private clinic	6 (5.0)
Other*	2 (1.7)
Time to seek care following illness (n = 119)	
Immediately after fever onset	48 (40.3)
1 day	26 (21.9)
2–3 days	33 (27.7)
4–6 days	12 (10.1)
Type of Treatment sought before visiting health facilities (n = 119)	
Home remedies	62 (52.1)
No action taken	44 (37.0)
Other†	13 (10.9)
*Traditional healer 1 (0.8%), and religious healing places 1(0.8%)	

†Religious activities 5 (4.2%), and Traditional medicine 8 (6.7%)

Focus group discussions contextualized these delays, revealing that initial self-medication prior to visiting a health facility was a widespread practice. This behavior typically involved administering over-the-counter analgesics, such as paracetamol, or utilizing leftover antimalarial medications saved from prior illnesses. Caregivers explained that professional clinical care was generally viewed as a secondary option, sought only when symptoms persisted or failed to resolve. As one participant detailed:

“We take painkillers like paracetamol or leftover drugs from previous treatments [...]. If we don’t feel better after that, we go to the health center. We don’t usually go [to health facilities] immediately.” (FGD 01)

Home or traditional remedies

Focus group discussion revealed widespread use of home and traditional remedies prepared from local plants including Moringa (*Moringa stenopetala*), Girawa (*Vernonia amygdalina*), coffee (*Coffea arabica*), and Artemisia (*Artemisia annua*). However, caregivers specified that these traditional phytotherapies were strictly reserved for adults and older children (> 10 years). For younger pediatric cohorts, caregivers

strongly preferred allopathic clinical care, explicitly citing that traditional extracts were too intensely bitter for small children to tolerate compared to standard antimalarials like Coartem:

“We take [young children] to the health facility. We don’t give them traditional medicines because they are bitter and children can’t handle the taste.” (FGD 01)

Preference for Drug formulation

Caregivers consistently emphasized the need for age-appropriate, child-friendly formulations to facilitate swallowing and optimize adherence. They favored liquid syrups or dispersible powders for younger cohorts and solid tablets for older pediatric groups:

“I think syrup is better for children under five years old, and tablets are suitable for those older than five.” (FGD 02)

Palatability

The organoleptic properties of conventional Coartem—specifically its intense bitterness and unpalatable odor—were frequently reported as significant barriers to treatment adherence. Caregivers reported that these sensory traits induced distress, resistance, and vomiting in children, which sometimes led to premature treatment cessation by the caregivers themselves:

“Coartem is difficult to give [to children] because it tastes bitter. Even adults struggle to swallow Coartem. So, I mix it with sugar and water or Mirinda.” (FGD 01)

“He [my son] refused it [Coartem] because it has a bad odor and bitter taste. Sometimes he even vomited.” (FGD 04)

“Personally, I never took the full dose because it was disgusting. Once I felt better, I stopped taking it and gave the remaining medicine to someone else.” (FGD 04)

To mitigate these palatability barriers and prevent emesis, caregivers routinely resorted to mixing crushed tablets with sweet vehicles, such as concentrated sugar solutions, honey, or commercial carbonated sodas (e.g., Mirinda):

“We mix it with sugar or Mirinda to make it easier for children.” (FGD 01)

“I mixed the medicine with sugar and water, encouraging him to drink it to avoid vomiting.” (FGD 04)

Packaging

Caregivers strongly agreed that clear instructions, localized language translation, and intuitive visual cues are essential to prevent dosing errors, particularly for non-literate users. Reviewing a prototype pediatric package design developed by the Developing Paediatric Primaquine (DPP) consortium [24], participants highlighted how visual aids democratize treatment comprehension:

"I'm illiterate, but I can understand this one." (FGD 01)

Packaging layouts that incorporate structural behavioral nudges—such as marked chronological tracking, pictorial frequency indicators, and explicit completion warnings—were highly valued. Caregivers noted that these design features serve as critical reminders that prevent missed doses and premature treatment discontinuation:

"This [package design] says if all tablets are not taken, malaria cannot be cured. [...] It includes the dosage and has pictorial explanations." (FGD 01)

"Since this packaging suggests the timing of doses, it helps us give the medication on time without discontinuation." (FGD 02)

Caregivers expressed a strong preference for secure, moisture-resistant, individually sealed blister packaging to protect against ambient contamination. Furthermore, they heavily favored packaging architectures displaying explicit, age- or weight-stratified pediatric dosing tiers over generic adult guidelines:

"Individually sealed tablets are more hygienic." (FGD 01)

"I prefer the orange one because it shows weight and amount of medicine to be taken." (FGD 04)

Out- of- Pocket expenditure and productivity losses

Among the subset of households reporting economic data for a pediatric malaria episode ($n = 55$), the mean direct medical cost was 864 ETB (US\$6.2) ($SD = 1,832$), with drug procurement accounting for the largest share of expenditures (mean = 712 ETB (US\$5.1)). The mean direct non-medical cost was 198 ETB (US\$1.4) ($SD = 743$), driven predominantly by patient and caregiver transportation.

Cumulatively, the mean household OOPHE was 1,062 ETB (US\$7.6) ($SD = 2,235$). In addition to direct expenditures, 9 households sustained substantial indirect productivity losses due to caregiving responsibilities, with a mean income loss of 409 ETB (US\$2.9) ($SD = 444$). Education was also disrupted: among the 26 children forced to miss school, the average absenteeism was 5.5 days ($SD = 3.6$); range: 2 to 15 days. When direct expenditures and indirect income losses were combined, the mean total economic cost per household was 1,129 ETB (US\$8.1) ($SD = 2,385$).

At a $\geq 5\%$ threshold of total annual household consumption expenditure, 9.1% ($n = 5$) of households experienced catastrophic health expenditure (CHE). Similarly, when applying the more stringent ($\geq 40\%$) threshold of non-food consumption expenditure (reflecting a household's true capacity-to-pay), 5.5% ($n = 3$) of households faced CHE.

Discussion

This study provides comprehensive evidence that caregivers' KAP, together with treatment related factors including drug formulation, palatability, and packaging, and the cost of care substantially influence pediatric malaria treatment acceptability and adherence in Ethiopia.

Although most caregivers correctly identified malaria symptoms, mosquito transmission, and preventive measures, this knowledge did not consistently translate into appropriate preventive and healthcare seeking practices. Fewer than half of caregivers demonstrated good malaria prevention practices, and only two-fifths sought care immediately after the onset of fever, despite strong recognition that malaria is preventable, serious, and treatable. These findings reveal a critical gap between knowledge and practice, highlighting how structural, practical, and experiential factors mediate translation of knowledge into action. Rather, behavior appears to be shaped by a combination of socioeconomic constraints, entrenched community practices, and barriers to accessing healthcare. Furthermore, the variation in household income and consumption across quintiles indicates substantial socioeconomic heterogeneity among study participants. Such disparities may influence care-seeking behavior, and the risk of catastrophic out-of-pocket expenditures, particularly among lower-income households. Importantly, acceptability of pediatric PQ was strongly influenced by caregivers' lived experiences of administering medication, particularly taste, dosing, and packaging design.

Our findings align with prior research demonstrating that malaria knowledge alone does not guarantee optimal prevention or adherence behaviors [25–28]. Similar to studies across sub-Saharan Africa, misconceptions coexist with biomedical understanding, and preventive practices such as consistent bed net use remain suboptimal despite high awareness [6, 8, 9, 29]. The widespread use of home remedies and initial self-medication further reflects pluralistic health practices common in malaria-endemic settings [16, 17, 30–32]. Importantly, this study extends existing literature by linking care-seeking or adherence not only to KAP but also to drug formulation and packaging. Caregivers' negative experiences with bitter antimalarials such as Coartem, often mitigated by mixing with sweet liquids, illustrate how formulation challenges directly influence adherence behaviors. In contrast, the new pediatric primaquine formulations were perceived as more acceptable due to improved palatability and user-friendly design.

There is ample evidence for poor primaquine adherence [33–37] but few data on the role of user-friendly packaging to improve adherence. The expressed need of our participants for simple packaging in the local language and visual cues to aid adherence echoes findings for primaquine radical cure from Cambodia and Thailand South East Asia and for artemether lumefantrine from Uganda [38]. Moreover, one old Chinese study showed significantly improved adherence with blister-packed PQ and pictorial instructions compared to standard packaging, namely, primaquine in envelopes [39].

The burden of OOPHE payment for a pediatric malaria episode is substantial. Overall, the OOPHE is about Birr 1,062 (US\$7.6) In a study from sub-Saharan Africa the household cost of treating uncomplicated malaria varies from US\$3.56, in Tanzania to US\$5.70 in Ghana and US\$8.68 in Kenya [40]. In a systematic review by Gunda *et al*, the total treatment cost for simple (uncomplicated) malaria per case ranged from US\$4.03 to US\$31.23 [41]. Similarly, in another study from The Gambia the total

treatment cost per household ranged from US\$5.1 to US\$19 [42]. *P. vivax* is associated with recurrence and therefore predisposes households for ongoing medical care and productivity loss. Thus, households had to sacrifice other essential spending to pay for medical treatment. In Ethiopia, despite malaria diagnosis and treatment being exempted services, our findings demonstrated that households of children with malaria experienced catastrophic health expenditure irrespective of threshold levels used. Thus, where financial risk protection is weak and payment for health care relies on OOPHE payments, catastrophic payment is to be expected. Previous studies on economic cost of malaria reported similar findings [43, 44]. Strengthening the government run community-based health insurance (CBHI) which enrolls millions of households paying annual premiums may protect the financial catastrophe among household experiencing malaria illness.

The study's mixed-methods design strengthened the credibility of findings by integrating quantitative KAP measures with qualitative insights into caregiving realities. While the number of FGDs was limited and may not capture all contextual variation in the study population, purposive sampling ensured diversity in participant characteristics and facility contexts, and thematic saturation was achieved within the study site. Participants were recruited from a health facility, which may introduce selection bias and limit generalizability. Restricted inclusion to caregivers within a 20 km radius from the study hospital, intended to minimize loss to follow-up, may further limit representativeness and underestimate indirect costs such as transportation. The relatively small sample size limited subgroup analysis, and self-reported practices and expenditures over a one-year period are subject to recall and social desirability bias. These limitations were mitigated through a mixed-methods design with triangulation, purposive sampling to capture diverse experiences, trained independent facilitators, and the use of standardized tools and careful probing to enhance data reliability.

Although conducted at a selected Ethiopian setting, the mechanisms identified are likely transferable to other malaria-endemic contexts. Caregivers across similar settings serve as primary decision-makers for children's treatment, navigate competing health beliefs, and manage practical constraints in administering medication. The interplay between KAP, drug preferences in terms of formulation, palatability and packaging, and costs of care likely represents a broader pattern beyond Ethiopia. However, sociocultural norms, health system access, and literacy levels may influence the magnitude and expression of these determinants, warranting contextual adaptation of findings.

Conclusion

Caregivers are central to pediatric malaria prevention and treatment, but knowledge alone does not ensure optimal practices. Persistent misconceptions, practical challenges in administering medicines, and the economic burden on households highlight the need for policies that go beyond information provision. Integrating targeted community education with caregiver-informed, child-friendly, dose-adapted drugs in easy-to-understand packaging and stronger financial risk protection can improve adherence, strengthen radical cure implementation, and enhance child health outcomes in endemic settings.

Abbreviations

AL	
Artemether/Lumefantrine	
APPE	
Assessing Pediatric Primaquine in Ethiopia	
CBHI	
Community-Based Health Insurance	
CHE	
catastrophic health expenditure	
CQ	
Chloroquine	
DFPH	
Dil Fana Primary Hospital	
DPP	
Developing Pediatric Primaquine	
EDCTP2	
European-Developing Countries Clinical Trial Partnership	
EFDA	
Ethiopian Food and Drug Authority	
FGD	
Focus Group Discussions	
HH	
Household	
IRS	
Indoor Residual Spraying	
KAP	
Knowledge, Attitude, And Practice	
MCA	
Multiple Correspondence Analysis	
OOPHE	
Out-of-Pocket Health Expenditures	
P. Falciparum	
plasmodium falciparum	
P. Vivax	
Plasmodium Vivax	
PQ	
Primaquine	
REDCap	
Research Electronic Data Capture	

SAGE
Study of Global Aging and Adult Health
SD
Standard Deviation
US\$
United States Dolar
WHO
World Health Organization
WHO-AFRO
World Health Organization, the African region.

Declarations

Declaration of Competing Interests

The authors have declared that no competing interests exist.

Ethics approval and consent to participate

The protocol was approved by the AHRI/ALERT (PO/24/21) and National (712 – 513/m254/35) Research Ethics Review Committees, and implementation was authorized by the Ethiopian Food and Drug Authority (EFDA) (ET-CT-0033). Written informed consent was sought from the participants, and privacy and confidentiality were ensured through secured storage and anonymization of data in the process of the study.

Consent to publication

Consent for publication was obtained from all participants for the use of anonymized data; no identifying images or personal or clinical details that could compromise anonymity are included in this manuscript.

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Author Contribution

TC, DEW and AA performed formal analysis, drafted the original manuscript, and addressed comments from reviewers. TC, DEW, AA, AA, GS, GMA, BD, ME, IM, NA, SG, FAK, KA, SC, DHY, JN, TK, EM, and YH were responsible for conceptualization, data collection, curation, study coordination and supervision. EG and WRT acquired funding for the study and provided overall supervision. All authors contributed to reviewing and editing the manuscript and approved the final version.

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Data Availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

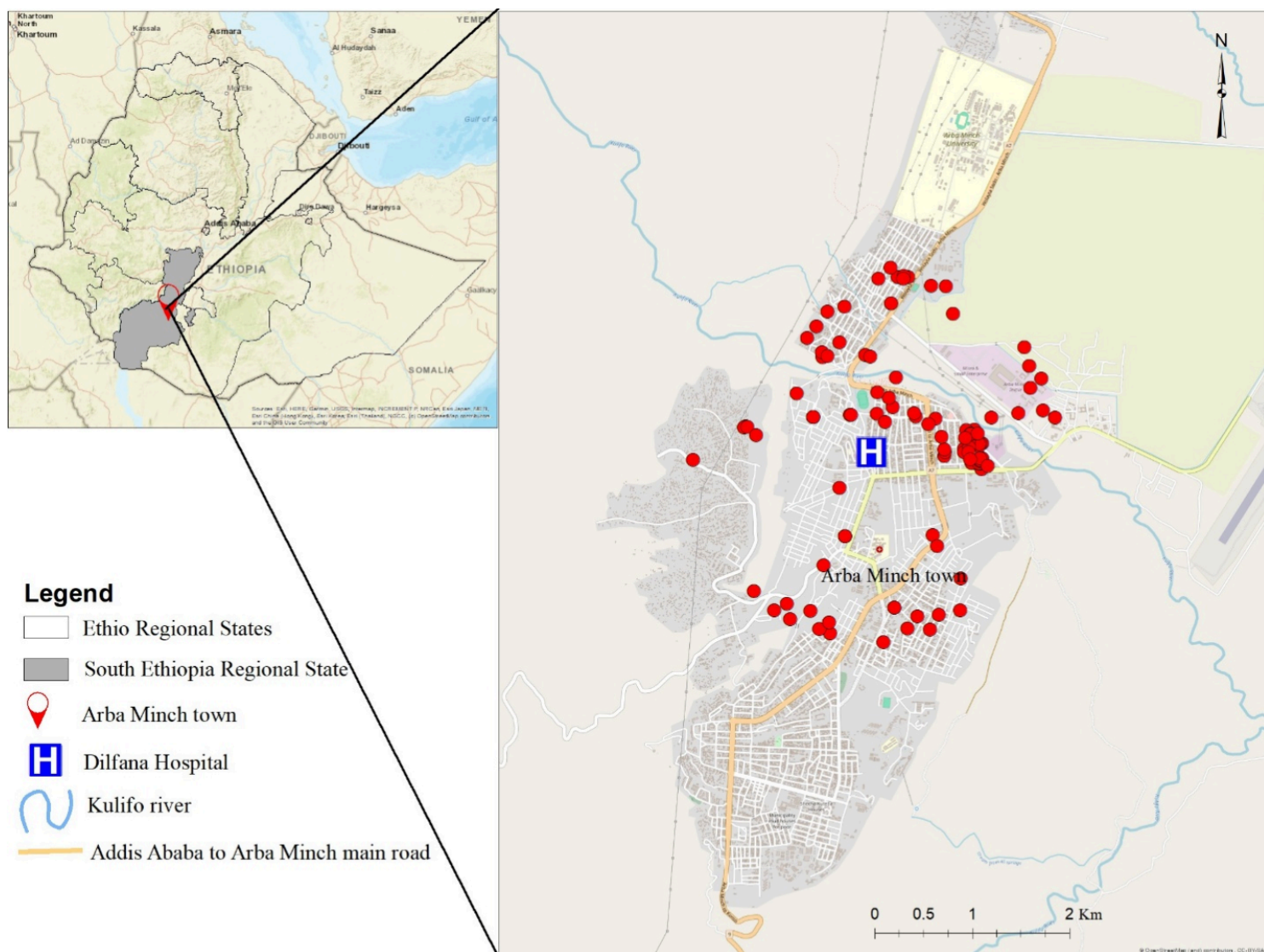


Figure 1

Map of the study area