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ORIGINAL RESEARCH

Traditional Medicine Practice and Its Role in the Management of Malaria in Jimma Town, Oromia, Ethiopia

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Background: Traditional medicines have been used to treat malaria for thousands of years and are the source of the two main groups (artemisinin and quinine derivatives) of modern anti-malarial drugs.

Objective: To assess the preference, practice, and factors associated with the practice of traditional medicine for malaria management.

Methods: A community-based cross-sectional study was conducted among 403 residents of Jimma town, Southwest Ethiopia. The data were collected by interviewing selected households. A simple random sampling technique was used to select the households. The data were analyzed using SPSS version 26, and descriptive statistics were used for describing and summarizing the data. A multivariable logistic regression model was used to identify factors associated with the practice of traditional medicine. The medicinal plants were tabulated in excel 2010 with their parts used, route of administration and side effects reported. The relative frequency of citation (RFC) was calculated, and the commonly used traditional medicines were reported.

Results: More than half (64.1%) of the participants practiced traditional medicine. Age [AOR (95% CI) = 1.04 (1.01, 1.07)], family size [AOR (95% CI) = 1.78(1.42, 2.23)] and not having information on traditional medicine use for malaria [AOR (95% CI) = 0.95 (0.03, 0.31)] were factors associated with the practice of traditional medicine. However, only 10.6% of the participants preferred to use traditional medicine. *Lepidium sativum* (RFC= 0.016), *Allium sativum* (RFC= 0.014), and *Zingiber officinale* (RFC= 0.012) were the commonly used herbal products.

Conclusions and Recommendations: Even though the preference to use traditional medicine was low, the community practiced traditional medicine for malaria management. Age, family size and information about traditional medicine use for malaria management were associated with the practice of traditional medicine. *Lepidium sativum, Sativum allium* and *Zingiber officinale* were the commonly used traditional medicines. The stakeholders are advised to act accordingly.

Keywords: traditional medicine, malaria, complementary and alternative medicine, Jimma, preference, herbal medicine

Background

Traditional medicine is defined by the World Health Organization (WHO) as the sum of knowledge, skills, and practices based on theories, beliefs, and experiences indigenous to various cultures that are used to maintain health as well as to prevent, diagnose, improve, or treat physical and mental illnesses.[1] The technique comprises plant, animal, and mineral-based medicines, massage, spiritual treatments, and other regional and culturally specific practices.[2] Traditional medicines are still highly underutilized as a health resource. Traditional medicine can also give insights and creative techniques that may have a direct influence on public health and the economy.[3] Traditional medicine serves the main healthcare requirements of around 65–80% of the world population.[4] Traditional, complementary, and alternative medicine of demonstrated quality, safety, and efficacy provide many benefits, according to the World Health Organization (WHO).[5]

Traditional medicine and practitioners have a long history in Africa. And they are essential in delivering treatment to communities.[6,7] The primary reasons for using TM were accessibility, cost, money, educational level, efficacy, and inaccessibility to modern health services.[8] Ethiopian traditional medicinal practices represent the richness of Ethiopian cultures. The Ethiopian community utilized traditional medicine for disease prevention, treatment, and well-being promotion. Ethiopia's health and drug regulations recognize the importance of traditional medicines in healthcare.[9]

Malaria is a risk to worldwide public health. In the year 2020, there were an estimated 241 million malaria cases worldwide, with around 627,000 deaths.

Malaria is one of the leading causes of illness and mortality in the country. Approximately 60% of the population lived in malaria-risk zones. *Plasmodium falciparum* and *Plasmodium vivax* are the most common parasites in Ethiopia, accounting for the vast majority of malaria cases.[10]

Five *Plasmodium* species are capable of infecting humans. The recognized parasites that infect humans include *Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale, Plasmodium malariae*, and *Plasmodium knowlesi*.[11] The rise of drug-resistant *Plasmodium* species has intensified the health and economic consequences of malaria. During the last two decades, research on alternative anti-malarial treatments has increased. Malaria is becoming more common, necessitating the identification of new therapeutic targets for both prevention and treatment. *Plasmodium* proteases, which play an important part in the parasite's life cycle, could be potential therapeutic targets.[12]

Medicinal herbs have traditionally been utilized to create an effective anti-malarial drug. Quinines, triterpenes, sesquiterpenoids, quassinoids, limonoids, alkaloids, lignans, and coumarins have been identified.[13] Traditional medicines have been used to treat malaria for thousands of years and are the source of the two main modern anti-malarial drugs.[14] In 1971, *Artemisia annua* was isolated by Chinese scientists and confirmed to have anti-malarial potency, developed an effective extraction process, and The active ingredient identified in 1972.[15–17]

Terpenoidal, indole, bisindole, quinolone, and isoquinoline alkaloids were discovered to have promising antimalarial action.[18]

For the treatment of malaria, medicinal herbs were used traditionally. Proper documenting of traditional medicine and flora used in malaria prevention and treatment is critical not just for maintaining valuable indigenous knowledge and biodiversity. But also to provide opportunities for pharmaceutical companies and researchers to seek more viable alternatives. In Ethiopia, ethnobotanical and ethnopharmacological research on anti-malarial herbs is in the early stages.[10] Furthermore, scientific literature on indigenous anti-malarial plants is exceedingly limited, underscoring the crucial need for careful compilation and synthesis., the current study aimed to assess the preference, practice, and factors associated with traditional medicine practice for the management of malaria.

Material and Methods

Setting and Period

The study was conducted in Jimma town. Jimma town is located 350 km southwest of Addis Ababa, the capital city of Ethiopia. The town lies in the climatic zone ideal for agriculture and human settlement.[19] As per the Central Statistical Agency (CSA, 2007) report, the total population is 120,960, of whom 60,824 are males, and 32,191 households are present in the town.[20] Jimma town has five public health centers, one medical center, and two general hospitals. The study was conducted from August-September 2021. The study area is reached in anti-malarial plants.[13]

Study Design and Population

A community-based cross-sectional study design was employed.

The study participants were selected households. Adults older than 18 years and who lived for at least six (6) months were included. However, Priority was given to the head of the household. Because they are expected to have more knowledge about traditional medicine used in the community than adults, and if they are unavailable during data collection, individual older than 18 years was included. Individuals who were unable to give the required information due to any reason (unwillingness, mental problem etc.) were excluded from the study.

Sample Size and Sampling Technique

The sample size was determined using the single population proportion formula for the cross-sectional study, $n = Z^2 P (1-P)/d^2$. Where $P = 50\%$ (prevalence of traditional medicine practice for malaria prevention and treatment) and $Z = 1.96$ is the value under the standard normal table for the confidence level of 95%, the margin of error 5%, and nonresponse rate of 5%. Finally, 403 households were used as a sample size.

The list of all households was obtained from the Jimma Town Administration Office. The list is arranged in ascending order according to their registration number. Finally, a simple random sampling technique was used to select the required number of households using computer system. Trained graduating Pharmacy students collected the data.

Data Collection Tools

A pretested, structured questionnaire was adopted from a previously conducted study with modifications based on the local context.[21,22] The questionnaire was prepared in English. The pretest was conducted on 5% of non-sampled households to check the reliability and clarity of the questionnaires.

The questionnaires consist of the following parts: Sociodemographic characteristics (age, sex, ethnicity, religion, marital status, occupation, educational level, family size and monthly income in Ethiopian birr).

The practice of traditional medicine (ever heard of traditional medicine before, current use of TM for the prevention and treatment of malaria, frequency of use, do you mix TM with modern medicine for the treatment of malaria, how do you rate the outcome of using traditional medicine for the prevention and treatment of malaria, source of information on the use of TM for the prevention and treatment of malaria, by whom traditional medicine was practiced), commonly used herbal medicines for the treatment of malaria (vernacular name, parts used, route of administration, and side effects of the medicinal product).

Preference: preference between traditional medicine, modern medicine and both traditional and modern medicine for the prevention and treatment of malaria, the reason for the preference of traditional medicine for the management of malaria.

Data Processing and Analysis

The data were entered and cleaned using Epi Info 3.1 software and exported to IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA) for further analysis. Descriptive statistics were used for describing and summarizing the data. Bivariable logistic regression was performed to determine factors associated with the practice of traditional medicine. A variable with a p-value of less than 0.25 in binary logistic regression was eligible for multi-variable logistic regression. P-value <0.05 was used to declare the significant association.

The medicinal plants were recorded in Microsoft excel 2010 and tabulated with their parts used, route of administration and side effects. The Relative Frequency of Citation (RFC was calculated using the following equation below.

$$RFC = \frac{FC}{N} \tag{1}$$

Where FC is the number of respondents who mentioned the plant and N is the number of respondents who participated in the study. The results of the RFC and the top mostly used medicinal plants were presented in the radar diagram.

Ethical Consideration

Permission letter was obtained from Jimma University School of Pharmacy with reference number of pharm 697/2011. Additionally, permission letter was also obtained from Jimma town Administration office. Verbal informed consent was obtained from the participants after the purpose and methods of the study had been explained. Since the participants had only asked to describe traditional medicine practice they know, we used verbal informed consent.

Results

Sociodemographic Characteristics

The response rate of the study was 98.01 (395/403). The remaining questionnaires were excluded from the analysis because of incomplete and did not have the required information about traditional medicine practice. The participants

were also unwilling to disclose whether they use TM or not. In addition, they were not willing to express their preference, and participants were reluctant to tell their herbal or non-herbal medicines they practice.

More than half (54.2%) of the participants were male. The age in years (mean ± SD) of the participants was 35.99 ± 11.99. Around 70% of them were married. 38% of the participants were followers of the Orthodox religion. More than half (56.2%) of the participants were of Oromo ethnicity, and 48.9% had an educational level of > 12 grade complete. Around 37.2% of participants were government employed. The monthly income in Ethiopian Birr (mean ± SD) and the family size (mean ± SD) of the participants were 7955.58 ± 3768.50 and 3.91 ± 1.42, respectively (Table 1).

Traditional Medicine Practice for the Management of Malaria

The majority, 91% of the participants, heard of traditional medicine used for malaria management. The majority of participants (64.1%) used traditional medicine for the management of malaria. Less than half (49%) of the participants practiced traditional medicine whenever they had malaria-like symptoms, and 68.4% experienced symptomatic relief

Table 1 Sociodemographic Characteristics of Participants

Characteristics	Category	Frequency (%)
Sex	Male	214 (54.2)
	Female	181 (45.8)
Mean age in years (mean ± SD)		35.99 ± 11.99
Marital status	Single	111 (28.1)
	Married	279 (70.6)
	Divorced	1 (0.3)
	Widowed	4 (1.0)
Religion	Orthodox	150 (38.0)
	Muslims	124 (31.4)
	Protestant	104 (26.3)
	Catholic	11 (2.8)
	Others$	6 (1.5)
Ethnicity	Oromo	222 (56.2)
	Amhara	98 (24.8)
	Gurage	29 (7.3)
	Tigre	6 (1.5)
	Others@	40 (10.1)
Educational status	No formal education	3 (0.8)
	Grade 1–6	33 (8.4)
	Grade 7–12	117 (29.6)
	Read and write	49 (12.4)
	Above grade 12	193 (48. 9)
Occupation	Government employee	129 (32.7)
	Housewife/husband	53 (13.4)
	Private business owner	96 (24.3)
	Students	60 (15.2)
	Daily worker	45 (11.4)
	Others*	12 (3.0)
Number of family (mean ± SD)		3.91 ± 1.42
Monthly income in Ethiopian birr (mean ± SD)		7955.58 ± 3768.50

Notes: $Waqeefta, Adventist and Jehovah witness; @Yem, Dawro; *Merchant and tailor.

after traditional medicine use. More than half (68.4%) of the participants did not mix prescription drugs with traditional medicines they practiced. Almost half of the participants responded the practice was practiced by the elderly (Table 2).

Preference of Community for the Management of Malaria

The majority (76.5%) of the participants preferred to use modern medicine. Cultural influence (83.3%) and therapeutic effectiveness of traditional medicine (54.8%) were the common reasons for the preference of traditional medicine (Table 3).

Table 2 Traditional Medicine Practice for the Management of Malaria

Traditional Medicine Practice	Frequency (%)
Do you heard of traditional medicine use for the prevention and treatment of malaria like symptom?	
Yes	360 (91.1)
No	35 (8.9)
Do you used any type of traditional medicine for the prevention and treatment of malaria previously?	
Yes	253 (64.1)
No	142 (35.9)
When do you use traditional medicine for the prevention and treatment of malaria? (n=253)	
When I have malaria like symptoms	124 (49.0)
Sometimes	66 (26.1)
When unwell	35 (13.8)
Daily	17 (6.7)
Often	10 (3.9)
When confirmed by physicians	1 (0.4)
Do you mix traditional medicine with the modern medicine? (n=253)	
Yes	80 (31.6)
No	173 (68.4)
What is the outcome of using traditional medicine for the prevention and treatment of malaria? (n=253)	
Symptomatic relief	173 (68.4)
Permanent cure	61 (24.1)
No change	19 (7.5)
Your source of information about traditional medicine use for prevention and treatment of malaria? (n=253)	
Family	182 (71.9)
Friends	50 (19.7)
Healthcare professionals	13 (5.1)
Others*	8 (3.1)
By whom traditional medicine is practiced? Who recommends?	
Elderly	126 (49.8)
Traditional medicine practitioners	63 (24.9)
Family (mother and father)	55 (21.7)
Others[@]	9 (3.6)

Note: [@]Care giver and friends, *TM healers and elder people.

Table 3 Preference of Community for the Management of Malaria

Preference of Community	Frequency (%)
Preference of community for the prevention and treatment of malaria (n=395)	
Modern medicine	302 (76.5)
Traditional medicine	42 (10.6)
Both	51 (12.9)
Reasons for preferring traditional medicine (n=42)	
Cultural influence	35 (83.3)
Therapeutic effectiveness of traditional medicine	23 (54.8)
Affordability of traditional medicine	21 (50.0)
Religious affiliation	8 (19.05)
Others	10 (25.0)

Reported Route of Administration for the Management of Malaria

The oral route (82.86%) was the most used route of administration of traditional medicine, followed by the nasal route (14.29%) (Figure 1).

## Part of Plants Used for the Management of Malaria

Seed (40.0%), leaves (31.43%), rout (25.71%) and bulb (25.71%) was the commonly used parts of plants (Figure 2).

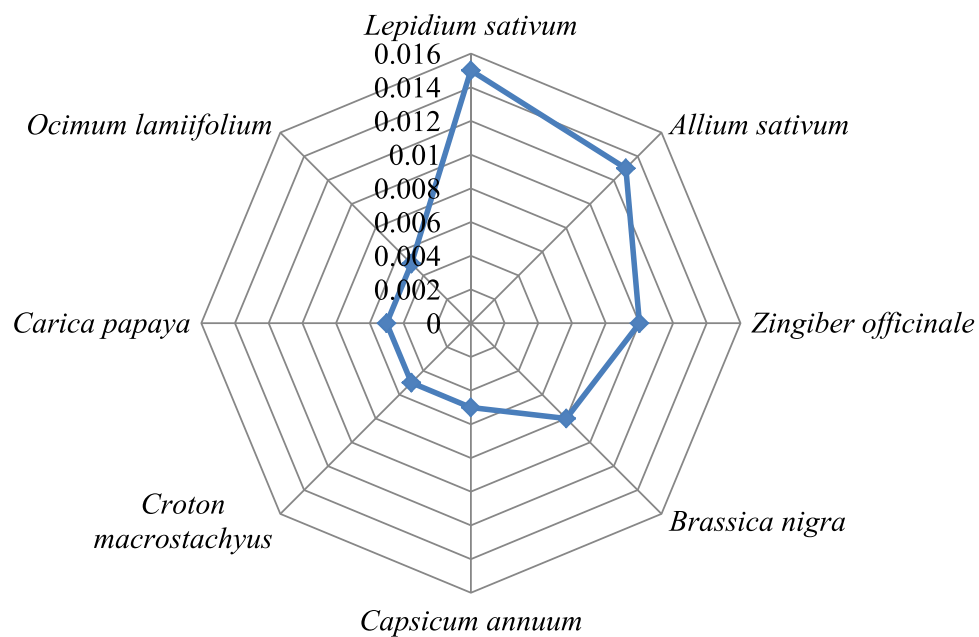## Commonly Used Herbal Products for the Management of Malaria

Lepidium sativum (RFC= 0.015), *Allium sativum* (RFC= 0.013), *Zingiber officinale* (RFC= 0.01), *Brassica nigra* (RFC= 0.008) were the commonly used herbal products by the community for the management of malaria (Figure 3).
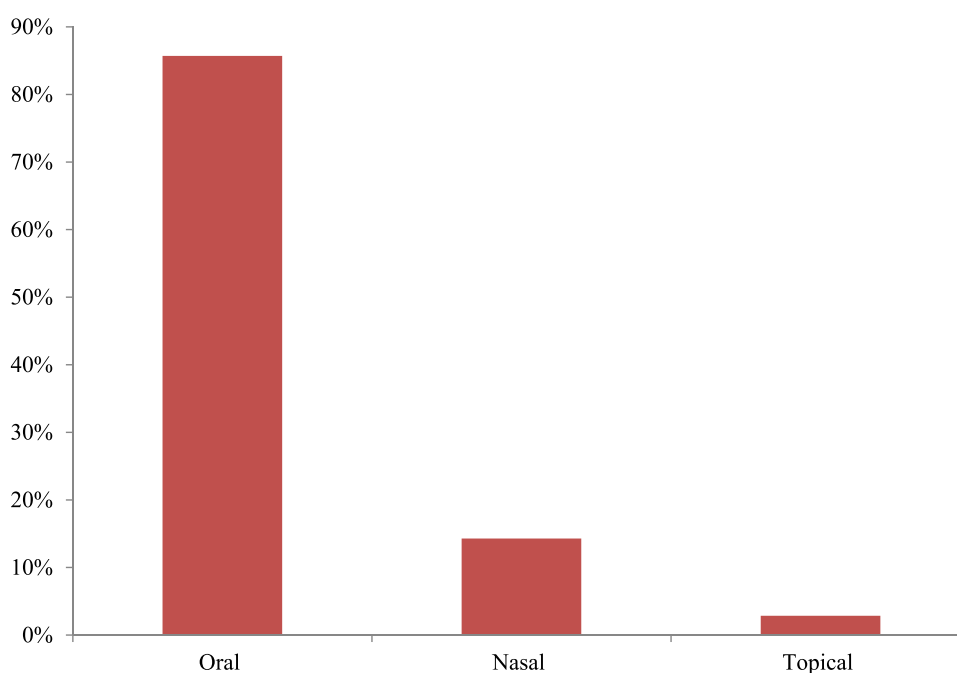
Figure 1 Reported route of administration by the community for the management of malaria.
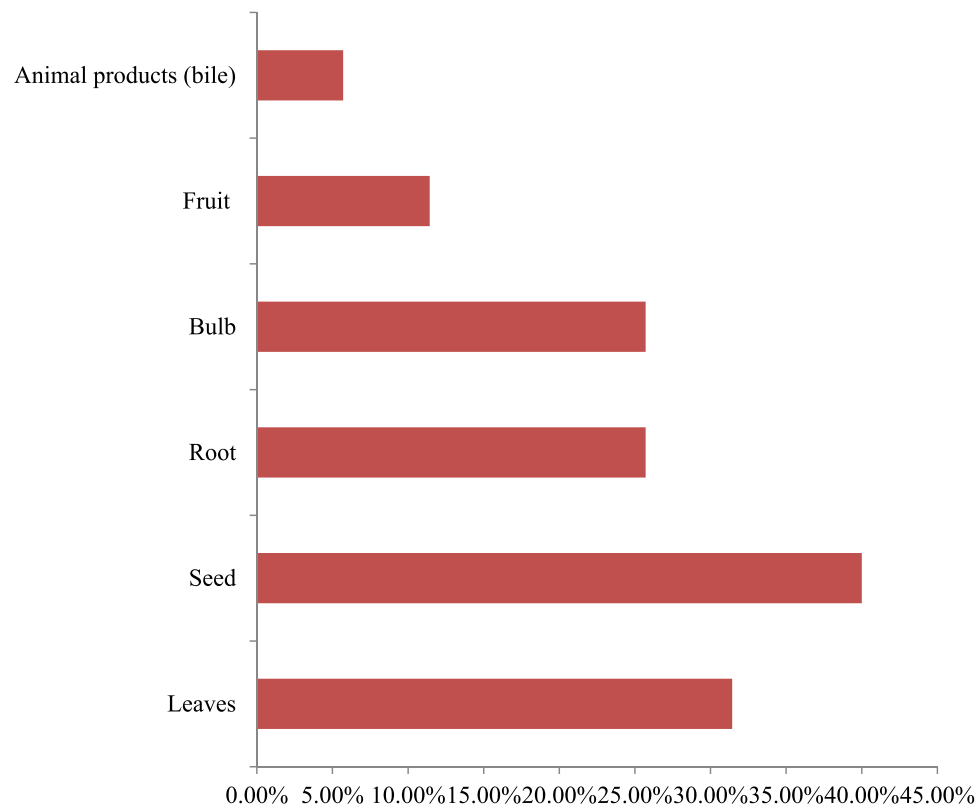
Figure 2 Part of plants commonly used by the community for the prevention and treatment of malaria.

Figure 3 Commonly Used Herbal Products by the Community for the Prevention and Treatment of Malaria.

Reported Side Effects of Traditional Medicine Used for the Management of Malaria

Twenty-one herbal and non-herbal medicinal practices were reported. Gastritis, heartburn, and constipation were the common side effect reported by the participants (Table 4).

Table 4 Reported Traditional Medicines Practice and Side Effects

No.	Local Name (Scientific Name)	Parts Used	Methods of Preparation	Route Administration	Source	Reported Side Effects
1	Shinfaa¶ (*Lepidium sativum* L.) and qullubbii adii¶ (*Allium sativum*)	Seed and bulb	Grinded and mixed uniformly, then eaten as it is or with food	Oral	Market	gastritis
2	Shinfaa (*Lepidium sativum* L.), qullubbii adii¶ (*Allium sativum*)	Seed, bulb, root	Grinded and mixed uniformly, then eaten as it is or with food	Oral	Market	Gastritis
3	Papaye* (*Carica papaya* L.)	Leaves/ seed	Boiled with water	oral	Market and home	Not reported
4	Qullubbii adii¶ (*Allium sativum*)	Bulb	Eaten as it is or with food	Oral	Market	Gastritis, heartburn
5	Qullubbii adii¶ (*Allium sativum*) and senafic* (*Brassica nigra*)	Bulb, seed	Grinded and mixed uniformly, then eaten as it is or with food	Oral	Market	Gastritis
6	Senafic* (*Brassica nigra* (L.)	Seed	Grinded and mixed with water and salt, then eaten as it is or with food	Oral	Market	Not reported
7	Shiferaw* (*Moringa stenopetala*)	Leaves	Boiled with water	Oral	Home	Not reported
9	Girawa* (*Vernonia amygdalina*)	Leaves	Grinded or squeezed to get the liquid part	Oral	Home and wild	Vomiting
10	Qullubbii adii¶ (*Allium sativum*), qullubbi diimaa¶ (*Allium Cepa*), kariya* (*Capsicum annuum* L.)	Bulb, root, fruit	Grinded and mixed uniformly, then eaten as it is or with food	Oral	Market	Gastritis
11	Jinjiibila¶ (*zingiber officinale*)	Root	Boiled with water or grinded	Oral	Market	Not reported
12	Shinfaa¶ (*Lepidium sativum* L.)	Seed	Grinded and mixed with salt, then eaten as it is or with food	Oral	Market	Not reported
13	Buna¶ (*Coffee arabica*), honey	Seed	Grinded and mixed uniformly with honey, then eaten as it is	Oral	Home and market	Constipation
14	Bakkanniisa¶ (*Croton macrostachyus*)	Leaves/ stem	Dried and grinded in to powder form, then put it on fire to get the fog or boiled with water	Nasal/oral	Home and market	Headache
15	Yemidir enbuay* (*Cucumis ficifolius* A.)	Root	Dried and grinded and mixed with honey, then eaten as it is or with food	Oral	Market	Not reported
16	Tikur azmud* (*Solanum incanum* L.)	Seed	Grinded, then eaten as it is or with food	Oral	Market	Not reported
17	Geeshoo¶ (*Rhamnus prinoides*)	Fruit	Grinded to let the liquid out	Topical	Market and home	Not reported
18	Baargamoo adii¶ (*Eucalyptus globulus*)	Leaves	Put it on fire to produce fog	Nasal	Market	Not reported
19	Damakese (*Ocimum lamiifolium*)	Leaves	Squeezing to let the juice out	Oral	Home and market	Not reported
20	Duboo Hoolaa¶	Duboo	In soup form	Oral	Market/ home	Diarrhea
21	Rajiijii re'ee/ hoolaa¶ (Goat/sheep bile)	Bile	Drink as it is	Oral	Market/ home	Bitter taste

Note: ¶Afaan Oromo, *Amharic.

Table 5 Factors Associated with Traditional Medicine Use for the Management of Malaria

Variables	Practice of Traditional Medicine COR (95% CI)	p-value	Practice of Traditional Medicine AOR (95% CI)
Sex			
Male	1		
Female	1.146 (0.76, 1.73)	0.519	
Age	1.04 (1.02, 1.06)	<0.001	1.04 (1.01, 1.07)*
Monthly income	1.000 (0.9996, 0.9997)	<0.001	1.00 (0.999, 1.000)*
Marital status			
Single	1		
Married at least once	1.061 (0.67, 1.67)	0.798	
Religion			
Christians	1		1
Others	0.54 (0.35, 0.83)	0.005	0.62 (0.35, 1.09)
Ethnicity			
Oromo	1		1
Amhara	0.70 (0.43, 1.13)	0.148	0.82 (0.45, 1.49)
Gurage	2.38 (0.93, 6.08)	0.070	1.93 (0.68, 5.53)
Tigre	3.10 (0.36, 27.00)	0.305	2.13 (0.21, 22.03)
Others	5.58 (1.92, 16.24)	0.002	3.61 (1.15, 11.26)*
Family size	1.24 (1.06, 1.45)	0.007	1.78 (1.42, 2.23)*
Heard of traditional medicine use for malaria before?			
Yes	1		1
No	0.06 (0.02, 0.17)	<0.001	0.95 (0.03, 0.31)*

Note: *Statistically significant at p<0.05.

Determinants of Traditional Medicine Practice for the Management of Malaria

The practice of traditional medicine was associated with monthly income [(AOR: 95% CI): 1.00 (0.999, 1.000)], age [(AOR: 95% CI): 1.04 (1.01, 1.07)] and participants who heard of traditional medicine use for the management of malaria practice more than their respective friend who did not have information about traditional medicine use for malaria (Table 5).

Discussion

Traditional medicines (TM) have been utilized for thousands of years to treat malaria and are the basis of current antimalarial drugs. Over 1200 plant species from 160 families are used to treat malaria and fever. Traditional herbal remedies are utilized for malaria management by one-fifth of patients in endemic areas.[23] Herbs and herbal extracts are used in malaria therapy in several regions of the world because they are inexpensive and widely available, and there is evidence that they are effective.[24]

Majority 91.1% of the respondents heard traditional medicine used for the management of malaria. An earlier study from the same area reported, 54.4% of the households had adequate had information.[25] The difference might be related to the difference in the year of data collection.

Traditional medicine was practiced by 64.1%. A similar result was reported from Mali, where traditional medicines were utilized by 50% of children with severe malaria.[26] However, studies conducted in different regions of Ethiopia and Indonesia (Northwest, Southern, and Southwest) reported that 22.2%, 8%, 43.0%, and 18.77% were used medicinal plants for malaria-like symptoms (fever and flu-like illness, including shaking chills, headache, muscle aches, and

tiredness), respectively.[27–30] The increased use of TMs for malaria may be attributable to the diversity of indigenous anti-malarial medicinal plants, the geographical variance in malaria distribution,[13] and the community inability to buy contemporary medicine.

Less than half (49.0%) of the community used traditional medicine when they had malaria-like symptoms. However, in a study by Suswardan et al, 75.2% of the respondents who used TMs for malaria had malaria-like symptoms in the last month.[30]

For almost half (49.8%) of the participants, the medicines were delivered by the elderly. Around 25% of the participants had the medicines from traditional medicine practitioners. A similar finding was reported in Ethiopia, in which family members (13.5%) provided traditional medicines more than traditional healers (8.5%).[25] More than two-thirds (68.4%) of the participants experienced only symptom relief after traditional medicine use. A comparable finding was reported in which 69.0% of the children with malaria who used herbal medicines got a cure.[27]

Regarding the preference of the community, 10.6% and 12.9% of the respondents preferred to use traditional medicine alone and both TMs and modern medicine, respectively. The reasons for preferring traditional medicine were cultural influence (83.3%), therapeutic effectiveness (54.8%), and affordability issues (50.0%). A comparable finding was reported from the Southern part of Ethiopia, where 27.9% of the households went to traditional healers, and 13.2% used homemade remedies when they were ill. The main reasons for this preference were effectiveness, low cost, and ease of availability. The discrepancy between traditional medicine preference (10.6%) and practice (64.1%) might be due to cultural influence and affordability to the use of modern medicine. Malaria was the top-treated illness with herbal remedies in households and by traditional healers.[31]

Lepidium sativum, Allium sativum, Zingiber officinale, and *Brassica nigra* were the herbal products used for malaria. The commonly used route of administration for the management of malaria was the oral and nasal route. Gastritis, heartburn, headache, constipation and diarrhea were the reported side effects of traditional medicines used for malaria management.

Traditional medicine practice for malaria was linked to monthly income, ethnicity, the number of households, and information on malaria management using traditional medicine. Several studies have linked the use of traditional medicine for malaria to factors such as accessibility, cheap cost, ethnicity, lack of knowledge about contemporary treatment, and the idea that traditional medicine is superior.[25,29,30]

Limitation of the Study

The study did not test (in vitro and in vivo) the efficacy, safety and quality of the medicinal plants reported. Therefore, it is not recommended to practice by the community.

Conclusions and Recommendations

For the treatment of malaria, the majority of the participants used traditional medicine. Traditional medicine was preferred by only one-tenth of the participants. Cultural influence, therapeutic effectiveness, price, and religious influence were reasons for traditional medicine preference. Age, family size, and information on traditional medicine for management of malaria were factors associated with the practice.

Weakness and Strength of the Study

The study includes large sample size and reported the non-herbal products used by the community.

Abbreviations

AOR, adjusted odd ratio; CI, confidence interval; COR, crude odd ratio; CSA, Central Statistical Agency; RFC, relative frequency of citation; SD, standard deviation; TM, traditional medicine; WHO, World Health Organization.

Data Sharing Statement

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

Ethical Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and permission letter was obtained from Jimma University School of Pharmacy with reference number Phar 697/2011. Additionally, permission letter was also obtained from Jimma town Administration office. Verbal informed consent was obtained from the participants after the purpose and methods of the study had been explained. Since the participants were only asked to describe traditional medicine practice they know, we used verbal informed consent.

Disclosure

The authors disclosed that they have no conflicts of interest for this work.

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