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Original Research

Ethno-botanical survey of medicinal plants traditionally used for malaria prevention and treatment in Jor District, South Western Ethiopia

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Abstract

The objective of the study was to record and document the plant species used to prevent and treat malaria and identify the traditional practices of local people for medicinal plants and major threats against traditional plants and practices that have been used for malaria prevention and treatment in the jor district. Data were collected from 89 (55.09%) female and 78 (44.9%) male respondents. The informants were selected using systematic sampling, and traditional healers were obtained by the snowball sampling method by asking friends of friends. The traditional medicinal plants documented by this study were 22 plants that prevent and treat malaria in humans. The major plants used to prevent and treat malaria in the study were trees (40%), shrubs (31.2%), climbers, runners, and bulbs (4.5%), respectively. The dominant plants used by local people were Achekea momordica foetida (Cucurbitaceae), which was ranked first, followed by Jiiw Dodonea angustifolia (Sapindaceae) and Orotea (Cordia africana Lam (Boraginaceae), respectively. Therefore, further study to empower traditional healers and elders to change their attitude to work freely without any fear to transmit their indigenous knowledge not to lose out on exotic influence is needed to be prioritised.

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INTRODUCTION

In Ethiopia, about 60% of the population lives in malaria-risky areas, mainly areas that lie below 2000 m above sea level (FMOH, 2017). Malaria transmission is seasonal and epidemic in the country, mainly due to altitudinal and climatic variations (Abose et al., 1998; Abeku et al., 2003; Deribew et al., 2017). The disease transmission peaks from September to December, coinciding with the major rainy season, and a minor transmission season also occurs in April–May (Abeku et al., 2003; Deribew et al., 2017). The western part of the country, particularly western Oromia, Amhara, Tigray, and Southern Nation, Nationality, and Peoples' Region (SNNP), and most of the entire areas of Benishangul, Gumuz, and Gambella regions, represent the major malarial hotspots in the country (Sema & Waktola, 2022). Anopheles arabiensis, a member of An. gambiae s. l., is the sole primary vector of malaria in the country (Abose et al. 1998). Plasmodium falciparum

and Plasmodium vivax are the dominant malaria parasites, which account for around 60% and 40% of the overall malaria cases in the country, respectively (Abose et al., 1998). The high-transmission season coincides with the cultivation months; hence, malaria has a deleterious socioeconomic effect on productivity and development in the country (FMOH, 2017).

Malaria control relies on indoor residual house spraying (IRS) and long-lasting insecticidal nets (LLINs) as the key frontline malaria prevention with vector control in Ethiopia, plus prompt and effective treatment with anti-malarial drugs in the country (FMOH, 2017). However, the use of LLINs, IRS, and anti-malarial drugs has been threatened by increased insecticide resistance to the malaria vectors (Balkew et al., 2012; Massebo et al. 2013; Gari et al. 2016), difficulties in attaining adequate population coverage (Solomon et al. 2019), outdoor and early biting behaviour of the malaria vector (Yohannes and Boelee 2011; Degefa et al., 2015; Kenea et al. 2016), and the increased spread of drug resistance by the malaria parasites (Koche et al. 2016). Particularly, Plasmodium falciparum has developed resistance to all currently used anti-malarial drugs (Koche et al., 2016; Abera et al., 2019). The above-mentioned anti-malarial interventions have proven difficult to implement on a sustainable basis, cover household members in peripheral communities, and necessitate the search for alternative methods for malaria control in Ethiopia.

Medicinal plants are the focus of many scientists aimed at discovering optional anti-malarial drugs in many parts of the globe (Abera et al., 2022). Ethiopia is endowed with abundant medicinal plant resources and traditional medicinal practices. Alebie et al. (2017) reported that 80% of the Ethiopian population uses different varieties of medicinal plants. Another study also indicates that a total of 200 plant species have been used in traditional malaria prevention and treatment in Ethiopia, of which Allium sativum, Croton macrostachyus, and Carica papaya are the most frequently used plant species (Alebie et al. 2017; Abera et al. 2019). The traditional indigenous knowledge and practice of using anti-malarial plants in Ethiopia have been transferred from one generation to another, usually through word of mouth without proper documentation, just like in other parts of Africa (Alebie et al. 2017). As a result, there is a danger of losing knowledge and medicinal plants due to the passing away of knowledgeable people and the rapid degradation of the natural habitats of medicinal plants, respectively. Notwithstanding the recent reports of Megenase et al. (2019), ethnobotanical surveys of anti-malarial plants are lacking from the Gambella Region of Ethiopia in general and from Jor district in particular. The authors focused on the general indigenous knowledge and practices of medicinal plants used against human and animal ailments by local communities in the Gambella Region and did not address ethnobotanical knowledge and practices that have been used against malaria in the region, particularly in peripheral communities of the region, including Jor district. Thus, more investigations need to be carried out in the Gambella Region to come

up with more complete information about medicinal plants traditionally used against malaria. Therefore, the present study was undertaken to document information on plants traditionally used for the treatment of malaria in the Jor district of the Gambella Region in south-western Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Jor District (JD), Gambella Regional State, south-western Ethiopia (Figure 1). The district is located 891 km away from the Ethiopian capital, Addis Ababa. The total population of the district during the study period was 14,862, which comprised 7,580 males and 7,282 females (JD Health Office, 2021). The absolute location of JD ranges from 7^0 $30^{'}$ $0^{"}$ N to 8^0 $0^{'}$ $0^{"}$ N and 033° $30^{'}$ $0^{"}$ to 34° $10^{'}$ $0^{"}$ E. The district has 37 natural ponds that are useful for wetland crop production and are also suitable for mosquito breeding and malaria transmission. The district annual mean temperature ranges from 16.4°C to 29°C, with the mean annual average temperature being 24.40°C, the mean annual maximum temperature being 25°C to 35°C, and the mean annual minimum temperature being 11.8°C to 20.4°C. The district has a maximum mean annual rainfall of 2,272 mm and a minimum mean annual rainfall of 694 mm. It is characterised by heavy rain from June to September and high floods in the area since the district landscape is flat.

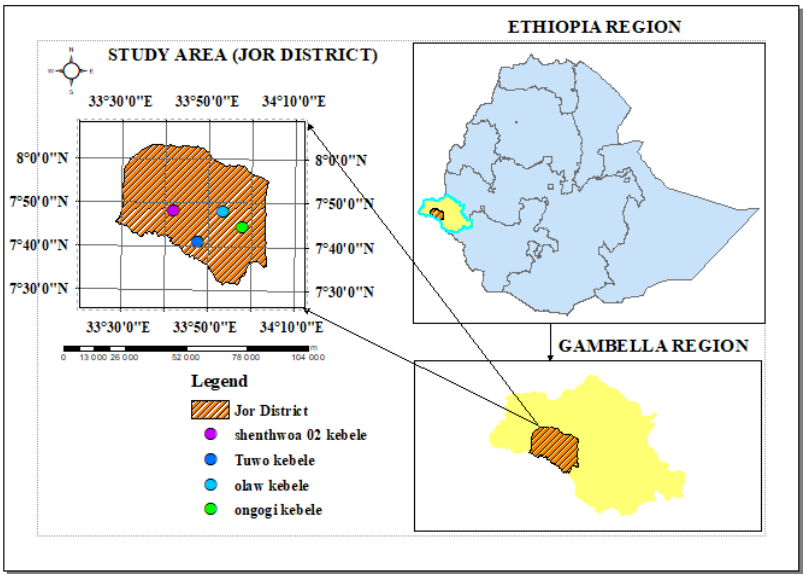

Figure 1 *Map of the study area and its location in Gambella Region and Ethiopia*

Study Design and period

A community-based cross-sectional study was carried out for the survey of medicinal plants and traditional practices used in malaria prevention and treatment and to identify threats against the plant species. The study was carried out from April to October 2021in four Kebeles of the district.

Sample size determination

The sample size was determined based on the Kothari, (2004) formula at a confidence interval of 95%.

$n= \frac{N}{1+N(e)2}$

Where

n= Sample size to be studied

N= population size

e= margin of error

From the above formula, the sample size of this study would be

$n= \frac{288}{1+288(0.05)2}$

$n= \frac{288}{1+11.4}$

n= 167

The sample size in this study is 167

Study population

Data were collected from residents of the four kebeles who were selected purposefully based on malaria prevalence, occurrence, and abundance of malaria mosquito breeding habitats such as ponds, rivers, and lakes.

The total study population of the kebeles was 4173 out of these 167 were selected by systematic sampling method K= $\frac{N}{n}$

Where k = interval size

N= the number of unit in the population

n= sample size work

Then K= $\frac{N}{n}$

K=$\frac{4173}{167}$; K= 24

Inclusion and exclusion criteria

The inclusion criteria included residents above 18 years of age who were household heads and who lived in the kebeles for more than three years, and all traditional healers living in the study kebeles who had more experience with traditional medicinal plants and practices to prevent and treat malaria.

Exclusion criteria include all people of the kebeles below 18 years of age, none household heads, who were not traditional healers, and who have no more experiences about medicinal plants and traditional practices used to prevent and treat malaria.

Sampling procedures

The systematic sampling method was used to select the interviewee from the four kebeles, and the second sampling method was the snowball sampling method by asking traditional healers using friends of friends. Therefore, household heads were selected by systematic sampling. The first household was selected from the list of household heads by the lottery method, and then every 24th household head was selected and interviewed about the local plant species that are used for malaria prevention and treatment and traditional practices used against malaria as well. In the absence of a household head adult who would take the highest responsibility for looking after family members, they were interviewed. In addition, traditional healers were selected by snowball or referral sampling, beginning with the initial respondents and going to friends of friends.

Data collection instruments

The data collection instruments were standardised questionnaires that were developed from Ethiopian demographic and health survey journals and prepared in

English. Data were collected from the household heads and traditional healers by asking them about the plant species that have been used for malaria prevention and treatment and the traditional practices used by local people. Information about traditional medicinal plants and sociodemographic features was collected from household heads and healers in the four kebeles, such as Olaw, Shenthwoa 02, Tuwo, and Ongogi, and information about coverage and medicinal plant use was collected from households randomly administered questionnaires**.**

Data Quality control

Quality control and assurance of data were put in place with the involvement of daily checking of the data for completeness, inconsistencies, inaccuracy, and validity, depending on how long ago it was collected. The data were organised and processed by categorising and coding them before being entered. Data were categorised into roots, leaves, bark, fruit, and herb coverage. The utilisation of medicinal plants and the number of people who got treatment were described according to the interview.

Data analysis

Data were checked for completeness and consistency, cleaned by the supervisor, entered into SPSS version 20.0 by the data clerk, and analysed by investigators. Results were then presented using descriptive frequencies with percentages in an appropriate bar chart and pie chart to display the descriptive part of the results. Yes-or-no questions were asked to each respondent regarding their knowledge, and other yes-or-no questions were also asked regarding attitude. The questions for which the respondents gave the correct answer were counted and scored, and then the scores were pooled together and the mean scores were interpreted in order to determine the overall knowledge of the respondents. The respondents who scored greater than or equal to the mean value were grouped as having good knowledge and attitude, and those who scored less than the mean values were considered to have poor knowledge and attitude.

Ethical considerations

Ethical clearance was obtained from the ethical review committee of Wollega University before the study was conducted. Permission was requested from the Jor district administration by formal letter. Oral consent was also asked from each participant in the study area, and participants were informed that they could discontinue at any stage of the interview. All the participants who declared their willingness to participate were included in the study, and the confidentiality of the data was maintained by omitting their names and house numbers.

RESULTS AND DISCUSSION

Results

Socio-demographic characteristics of respondents

Most respondents (55.09%) were female, followed by males (44.91%). The result of age categories shows that the respondents less than 25 years have (8.38%), or the least

percent, and 58.68%, 19.76%, and 13.17%, respectively, have enough years during the interview that show the key informants transferred accurate messages at the time of the interview. The result of this study showed that years are important in the practices of traditional medicinal plants that are used for malaria prevention and treatment because, with increasing years, there was an increase in the capacity of healing, great attention to the traditional medicinal plants used. Not only this, but when the years become above 50, there will be a preparation and selection body that healers or elders will use to transfer the knowledge because of secrecy. At this stage, the healers used to close the person he or she wanted in order to show every activity and procedure to document or record in his or her mind, knowing the practices for the coming responsibility.

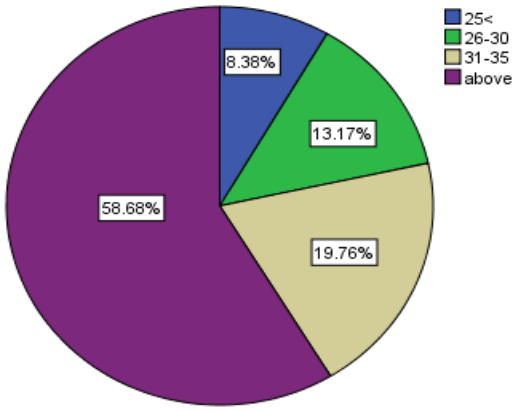

Figure 2 *Age categories of respondents*

In the study area, the majority of people living in the district were uniforms or of the same tribe, which means Anywaa in the local language (100%). As a result, there was no language barrier encountered by the researchers during the time of the interview. In addition to this, the researcher identified that there was a gap in experiences shared among the informants with other healers who practice traditional medicinal plants used to prevent and treat malaria from somewhere in the country because most of the healers and elders live in remote areas and have no chance to go somewhere in the region to get additional experiences. The study found consensus that living in uniformity in one area has an impact on scaling up the traditional medicinal plant knowledge and practices in sharing and modernization (Figure 2).

The community was living for a long period of time in practices of their indigenous knowledge to prevent and treat malaria in the district, but there was a smaller gap in the district in research to support the genuine knowledge of the community to bring into the modern health system. Therefore, even though local people have potential knowledge about traditional medicinal plants used to prevent and treat malaria, additional support is required.

In the study area, most of the interviewees—65.87%—were married, 17.37% were single, 11.38% were divorced, and 5.38% were widowed (Figure 3). These studies indicate that most marital statuses in the study area appeared in the study, which showed that there are strong social interactions among the local people of the study locality. The study identified that most of the traditional healers and elders were married because, during their practices of this knowledge, they needed either a wife or a close child to help them with their equipment when treating patients. Not only this, healers believe that natural wisdom or knowledge need not be practiced with somebody who has no blood relationship with them because of secrecy. So marriage and having children have a great value in the practices of traditional medicinal plants used for malaria prevention and treatment. Not only was this marriage by itself one of the criteria, but in the community, a mature man or woman has to get married when mature enough in order to get respect in the family as well as in the community. That is why the percentage of single people among the interviewees is countless in terms of marital status.

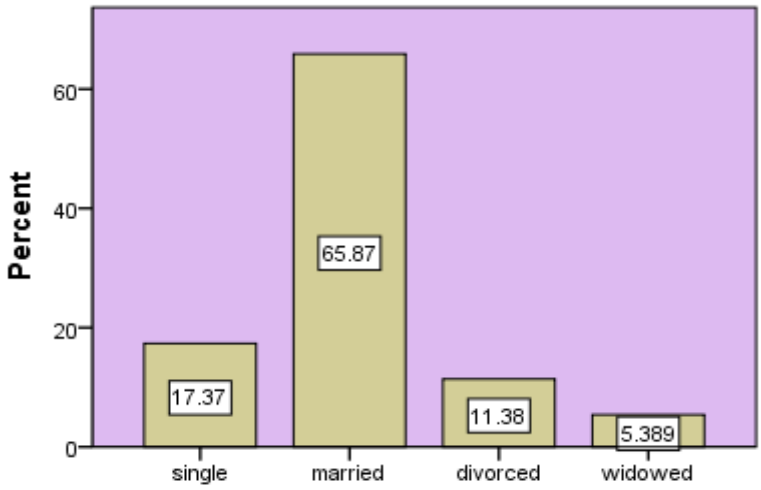

Figure 3 *Marital status of the respondents*

The result of this study evidenced that the majority of the four Kebeles religion followers (72.46%) were protestant, followed by 27.54% of Catholic followers. This showed that in the study area, there are only two religions that are dominant in the study district. The result of the survey also showed that the majority of people in the district were protestant, which means it was protestant missionaries' who arrived in the area for the first time travelling on foot because of access to the road. So after some road was constructed, the Catholic Church came and started its selection of members and established the church. So because of the late coming of Catholics, their members have become less than protestant. Therefore, the study realises that entering some area first for

religious followers has the value of having more members in that community. In addition to that, as the area is remote, the missionaries themselves need to commit to staying in the area to transmit their mission in order to change the people and gain more followers. In addition to the transmission of the spiritual, only humanitarian services were required to convert their minds and get more followers as they were still in the remote area. Not only was this respecting the culture of the local community not to react with the religion message another issue to have enough members or followers in the local community, but telling the true message of the religion also has a great value to having more members.

The majority of the respondents (53.29%) were illiterate, and 46.71% were literate. With this information, the study realised that most of the informants in the study area were unable to read, so they really used their own indigenous knowledge and practices to reply to the questionnaires. Not only this, they used their own knowledge to practice traditional medicinal plants to prevent and treat malaria without support from any educational body. Therefore, having this knowledge of the informants without any support from anywhere else is one of the strengths of the local people. Therefore, to support this unique knowledge, traditional healers and elders have to deliver adult education to them in order to compare their work and write down the names of the medicinal plant species on their own.

The study also investigated whether traditional healers had enough knowledge to prevent and treat on their own without asking for help from a literacy body. They record and name their medicinal plants based on their indigenous knowledge, verbally. So even though this is true for the future, in order to modernise indigenous knowledge and change traditional medicinal plants to their modern form, some support from stakeholders is required. In the case of literate people, although more of them were not involved in the healing system, it became a problem in the documentation of medicinal plants, so for the future, it is advisable to support the illiterate community to record the medicinal plant species and keep them for future researchers.

The study also identified that the majority of the respondents have incomes between 500 and 1000 (53.89%), while less than 500 (26.35%) flow from incomes above 1000 per month. This means that most of the informants have no income in the study locality. According to the discussion made with the informants, they agreed that traditional medicinal plants used to prevent and treat malaria need value addition to change income for the future. Therefore, additional studies that lead traditional healers and elders to generate income through traditional medicinal plants that are used to prevent and treat malaria are needed. This study investigates that most of the traditional medicinal plants used to prevent and treat malaria were not considered sources of income; rather, they were used to cure patients without any payment.

Although the study area has the potential of traditional medicinal plants, due to a lack of technology and frequency of research, it's become difficult to change the opportunity for income generation; therefore, giving attention is required to overcome the challenge further.

As the study investigated, most of the informants got their income from the properties of farmland, which was not enough to change their lives with medicinal plants.

This study found three types of occupation among the respondents, which means (58.68%) were farmers, (31.74%) were government employees, and only (9.58%) were self-employed. From this point of view, the survey identified that most of the informants have no occupation in their locality, which can support, promote, and advertise the use of traditional medicinal plants that prevent and treat malaria in some parts of the district.

Therefore, most of the traditional healers and elders stayed where they were. Not only was this, but there were also lacks of access or roads in the study area to solve problems that made healers not move here and there to promote their unique traditional medicinal skills. The survey showed that there was a lack of unemployment in the study localities due to the fact that traditional healers and elders depended on their farms for consumption purposes without taking medicinal plants as a means of occupation.

To legalise medicinal plants as a part of an occupation, there is a need for initial income, as indicated above, so linking the work with the government and other stakeholders' support from local administration is needed. Not only this, but empowering traditional healers from local administration by connecting them with credit agencies to get initial capital to value additions to medicinal plants and give them licenses is advisable for the Jor district.

Self-reported utilization of traditional medicinal plants in Jor district

This survey showed that all of the informants used different traditional medicinal plants to prevent and control malaria in different ways of preparation and mode of application. In this survey, prevention and control of malaria were carried out in different ways. For instance, local people agreed that smoking the house with the leaves of the plants and putting on some plant parts to repel mosquitoes is the major way of prevention and control. For example, smoking the house with neem leaves (baybay) in the Anuwaaa language and menh-nho leaves was the best prevention and control method in the community.

When the house is smoking with these two plants, there will not be any mosquitoes that land on the body of a human or on the wall. By doing this system, there would not be more mosquitoes in the area, and as a result, malaria incidents would be rare. This study also investigates the fact that the local community in the study area has more experience using traditional medicinal plants because they believe in them and have savoured them for a long time. Not only was this due to the lack of health facilities in the local area, but the community was also committed to relying on medicinal plants to prevent and treat malaria in the locality. Therefore, even though the local community used traditional medicinal plants to prevent and treat malaria, the way to change these medicinal plants into modern forms was found to be a great gap.

Medicinal plant used for prevention and treatment of malaria

Table 1 shows the different plant species that are used to prevent and treat malaria in Jor District with their various parts, including

their habitat, and the modes of remedy preparation and application recorded according to the informants in the study locality. As indicated in Table 1, most of the plant species were trees (40% followed by shrubs (31.2% species. The study also identified the least medicinal plants used to prevent and treat malaria in the locality, which were climbers, runners, and bulbs (4.5% followed by runners and herb species (9%).

Table 1

List of medicinal plant used for prevention and treatment of malaria based on the informants report in Jor District

Local name	Scientific name (family)	Habitat	Growth form	PU	Parts used	MRPA	RA
Achekea	*Momordica foetida* (*Cucurbitaceae*)	climber	climber	Antimalarial	Leaves /stem	boil	oral
Otit	*Aritimiza abyssimica* (*Asteraceae*)	Runner	runner	Antimalarial	WP	Crush and bath with cold water	oral
orotea	*Cordia africana* Lam (*Boraginaceae*)	Tree	Tree	Antimalarial	Leaves /bark	Boil	oral
Riedha	*Echinops kebericho* mesfin (*asteraceae*)	Shrub	shrub	Antimalarial	Root	Decoction	oral
Baybay	*Azadricah indica* (*Meliaceae*)	Tree	Tree	Antimalarial /repellents	Bark/ leave	Boil/smoke	oral
adegegn jur	*Melia azedarach* (*Meliaceae*)	Tree	Tree	Antimalarial /repellent	Leaves /Ba	Boil	oral
Jiiw	*Dodonea angustifolia* (*Sapindaceae*)	Tree	Tree	Antimalarial	Wp	Boil	oral
Kwolo	*Croton macrostachyus* Hochst.ex (*Euphora biaceae*)	Tree	Tree	Antimalarial	Fruit	Crush and bath with cold water	oral
Tippo	*Senna didymobotrya* (*Fabaceae*)	Tree	Tree	Antimalarial	L/B	Boil	oral
Dwong	*Gardina ternifolia* (*Rubiaceae*)	shrub	Shrub/ T	Antimalarial	Runner	Boil	oral
Ababa	*Rhus natalensis* Benth Hochst.ex (*Anacardiaceae*)	shrub	shrub	Antimalarial /repellent	Leaves	Boil	Oral
Albizia	*Albizia malacophylla* A.rich (*Fabaceacea*)	Tree	Tree	Antimalarial	Leaves	Boil	oral
Chewa	*Tamarindus indica* L. (*Fabaceacea*)	Tree	Tree	Antimalarial /repellents	Leaves /fruits	Boil	Oral/dd ermal
Menh-nho	*Cadia purpurae* (*Fabaceae*)	shrub	shrub	repellents	Leaves	Paint/smoke	dermal

Table 1 *continues…*

Okamo	*Echinops kebericho* (*Asteraceae*)	Runer	runner	Antimalarial	Root/leaves	Boil	oral
Atwachi	*Gnidia involucrata* steud.exA.Rich (*Thymealeaceae*)	Herb	herb	Antimalarial	Wp	Boil	oral
Tworo	*Aloe sp (aloaceae)*	Shrub	Shrub	repellents	leave	decoction	oral
Paypaya	*Carica papaya* (*Caricaceae*)	Tree	Tree	Antimalarial	Root/leaves	Boil	oral
obudo	*Asparangaus africanus* (*Asparagaceae*)	Shrub	shrub	Antimalarial	Root/leaves	Boil	oral
Abachal matar	*Alium sativum* L.(*Alliaceae*)	bulb	bulb	Antimalarial	Bulb	Boil/chew	oral
Adibuch	*Aloepirottoe Berger* (*Aloeceae*)	Shrub	shrub	Antimalarial	Leaves	Bath with cold water	oral
Atebi	*Nicotiana tabacum* (*solonaceae*)	Herb	herb	repellents	Stem/leaves	Smoke	inhale

The study also identified the route of remedy administration for the plant species in the locality, as indicated in the table. Most routes of remedy administration were oral, followed by dermal, and inhalation. This showed that the local community has established indigenous knowledge and practices to prevent and treat malaria in their locality. The study also investigated that the mode of remedy preparation and application was boiling parts of plants, cooling the decoction, then drinking by the patient, followed by cleaning and crushing the parts of the plants, and then bathing in pure cold water, filtrating it, and drinking. Most of the remedies described in this study were administered orally as water-based concoctions.

Habitats of the medicinal plants and their collection seasons

The survey found that the majority of the plant species (84.43%) were so wild that people collected them from the wild forest, and only 15.57% of species were harvested from home gardens or farmland. Therefore, the habitat of the medicinal plants where they were collected has value for using the plants and promoting them as a source of health care. Therefore, the study identified that cultivation of traditional medicinal plants used for the prevention and treatment of malaria near home gardens is needed in order to avoid collecting them in wild form because of the distance and conservation action of the habitat of the plants. Not only would this be the distance where the medicinal plants were found, but there were also problems for the sake of security and abduction because most of the collectors of these plants were women.

According to the results and season of maturity level, the key informants replied that 68.26% of the plants were higher plants that were available in all seasons and could be harvested at any season of the years, and some of the other plants matured in different seasons of the years (31.74%) from April to December. That means most of these plant species were shrubs and herbs, which were found in grassland, wetland, and the forest, and so these plants were venerable to wildfire, which is why they are not available all over the years. In this study, the researcher found that most of the medicinal plants used to

prevent and treat malaria were affected by natural hazards, including human factors.

Not only these problems, but there was also a lack of conservation of the plants to keep their maturity when used by traditional healers. On the other hand, the maturity season of the medicinal plants is also affected by the distance from where they are. In the case of traditional medicinal plants that grow near home gardens, they were also collected in different seasons of the year because most of the shrubs were annual plants that dried after three months, whereas biennial plants were collected in all seasons of the year. So healers and elders were taking care of the season of collection and storing some of the medicinal plants to use further.

Traditional practices against malaria prevention and treatment in Jor district

About 89.22% of respondents realised that there was no taboo in the plant collection that was used for the prevention and treatment of malaria, but only 10.78% had taboo in the collection, which indicates that there was a special body used to collect such kinds of plants in the community, which means that from the culture of the community, they have a belief that when such plants were collected by the body, which was not recommended to collect these medicinal plants, there would be a belief that medicinal plants did not work in the patient's body. Therefore, the informants also agreed that there were some species of plants collected by elders who have enough years and who have no relationship with the opposite sex in the community culture. From this study, the respondents realised that a few plants that were taboo in collection and mode of remedy preparation were also given to elders or healers who were 70 years of age or older because those people had no relationship with their opposite sex. According to the respondents, most of the plants used to prevent and treat malaria have no different doses (57.49%) among men, women, and elders, but since the community used local measurement, 42.51% reduced the amount of remedies in cases of children and pregnancy to avoid some side effects.

This survey also identified that traditional medicinal plants used to prevent and treat malaria were given in small amounts in the case of pregnancy under four months because there would be a possibility of abortion. Children also gave a small amount to avoid the weakness of their bodies through vomiting and diarrhoea due to the characteristics of medicinal plants. In the study area, the researcher identified a gap in the dose given to the patients, which means if the researcher gives the dose by guess, the patient may encounter some side effects, as mentioned above, that need additional antidotes to minimise the problems. Therefore, due to these problems, additional research is needed to modernise the system of healing and adjust the measurement equipment further. Plants doses and antidote use to give to the patients in age interval and health condition.

The survey identified that 66.47% of medicinal plants used to prevent and treat malaria have no noticeable side effect but few of them have side effect that content 33.53%. According to evidence obtained from the informants, having this noticeable side effect local people used different mechanism to neutralize the side effect. According to discussion made from healers after treatment of the patient they flow the physical condition for any side effect, most of the side effect

observed from the patient were vomiting, fever, join paint, diarrhea, sweating, and weakness of the body. When healers have seen this they follow their own mechanism to neutralize the side effect or to minimize it as discuss above.

To neutralize the side effect on the patient showed by this study was (64.67%) of the plants have no antidote as described from key informants and only (35.33%) have antidote which prepared after physical observation of the patient either by healers or by elders having experiences. According to the key informants as a side effect was seen from any patient, healers used soup of fish or porridge that prepared from flour of maize or sorghum and give to the patient to minimize the side effect and to make patient body strong enough. As discuss above most of the side effect were vomiting, diarrhea, body weakness and sweating. So when healers observe those physical observations on the patient body, they give them the above mention for the strength of the body. Not only this majority of malaria patient has loss of appetite and then after treatment given some food to eat is recommended to the patient.

Care and restrictions in giving remedies to pregnant women

According to the respondents, the restriction on taking the remedies to treat malaria in pregnant women was dependent on the type of plant and the month of the pregnancy. As stated by the respondents, from 1 to 4 months was the series month, which is not recommended to give any remedies to the women because if they were given some remedies, there would be a chance of abortion for the pregnant women. According to the informants, restrictions on pregnancy showed that 52.10% have no restrictions on the pregnancy and 47.90% have restrictions.

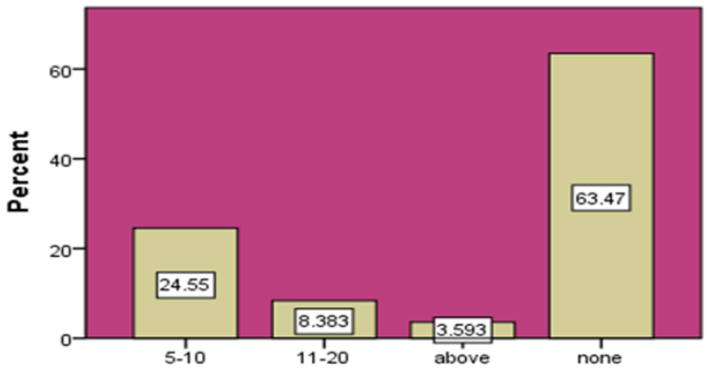

Figure 4 *Years of service as traditional healers*

The study also identified that most of the healers have good experience with how to prepare the remedy and the amount given to pregnant women. In addition to that, the elder's women themselves have the training to advise young ladies about the use of traditional medicinal plants during pregnancy and the consequences when the pregnant ladies take the remedies for one to four months (Figure 4).

Major threats and conservation of medicinal plants in Jor district

The survey investigated found that most of the medicinal plants used to prevent and treat malaria were not marketable in the locality (91.02%), and only 8.98% were marketable because some of these medicinal plants were used for human consumption at the community level. Even though some traditional medicinal plants were used to prevent and treat malaria in the locality, conservation methods remained a major threat in the district. On the other hand, there were other threats that needed to be avoided in the district, such as shifting cultivation, overgrazing, overharvesting of medicinal plants, and fire. The result of this study also evidenced that there was a need to change the traditional medicinal plants that were used to prevent and treat malaria in the modern health system and legalise traditional healers in order to get market access.

Traditional knowledge transfers and the issue of secrecy in the study area

The result of this study identified that most of the traditional medicinal plant knowledge was transferred by showing the species of the plants to the close family of the healers (46.72%), followed by, in words, 36.53%, and showing the habitat (16.77%) where the plants usually grow. This study also identified the main threats that were causing the loss of traditional knowledge on traditional plants used for malaria treatment. So the major loss of traditional knowledge was due to the unwillingness of the young generation because the way of transferring knowledge needed to move from place to place in order to look for plant species and habitat, as indicated above.

Discussion

The present study has documented 22 plant species traditionally used for the prevention and treatment of malaria in Jor District. This survey investigated that most results in the study area were recorded by female respondents (89,55.09%), followed by male respondents (78,44.9%), which showed that females in the study locality played a great role in the identification and practices of medicinal plants used for the prevention and treatment of malaria. Not only that, since females always used to collect firewood, they have good experience in harvesting the remedies and modes of administration, and they were found to have the most success in traditional medicinal plant practices to prevent and treat malaria. The result of the survey also showed that females are well trained to motivate patients to take the remedies without any fear and follow up with them because some patients fear the bitterness of plants and their odor. This study was similar to other studies that were conducted in some parts of the country (Assefa et al., 2021).

The most plant species used for malaria prevention and treatment in the study area were trees at 40%, followed by shrubs at 31.2%, herbs, runners, and runners at 4.5%, as well as climbers and bulbs that have their own value in the treatment of malaria at 4.5%, respectively. The high number of trees and shrubs used for medicinal purposes has also been reported previously by Kebebew and Mohamed (2017). According to the traditional healers, there were many medicinal plants that

were used for different types of diseases, which differed from those used for the prevention and treatment of malaria. This showed that traditional healers were knowledgeable about medicinal plants used for various diseases in addition to malaria. This study also identified that even though there were many plants used to treat diseases in the localities, the plant species that were used for the prevention and treatment of malaria were separate from each other.

Traditional healers reported that most of the medicinal plants used for the prevention and treatment of malaria were collected in wild form, while others were in a home garden or on farmland, and all these plant species have their own way of preparation and method of application. For instance, some plants were boiled and then cooled by the patient, while others were cleaned and bathed with cool water and then drank, and some plants were eaten directly. There were also some plant species that were prepared in the form of smoking as a prevention method to avoid mosquitoes landing on the wall of the house and on the human body as well. Other medicinal plants used for prevention were rubbing on the body that repels mosquitoes from landing on it. For instance, Tamurindus indica L. caesal (piniaceae) leaves boil and are then cooled by the local people, who rub on their bodies at night. They stay outside of their house without being bitten by mosquitoes. On the other hand, they rub on their bodies and go fishing in the river or lakes at night using these plants as mosquitoes' lotions.

The survey also documented that most of the traditional healers and knowledgeable elders were using different mechanisms to give the remedies to their patients. First of all, they observe the physical condition of the patient, which means the weakness and strength of the body. Not only that, they also look at the age and pregnancy of the women, which must be considered because there are some plant species that are restricted, especially for pregnant ladies and children as well. With this in mind, the healers or elders administer the estimated amount to the patient using traditional measurements or equipment, such as an athodhi in Anywaa, a cup of tea, and so forth. This study was similar to one conducted in some parts of the country, which said that lack of precision in doses among informants on certain remedies was frequently noted, which is also a frequent phenomenon in other parts of Ethiopia (Giday et al., 2009; Kebebew and Mohamed, 2017).

From the discussion made with the respondents, most of the plants used for the prevention and treatment of malaria in the study area were leaves, followed by roots and other parts like bark, stems, and bulbs. This study identified that leaves were the most widely harvested plant parts to treat malaria problems in the locality, and it is similar to findings conducted in other parts of the country (Giday *et al*., 2009; Tadese et al., 2018). Traditional healers in the local area used physical observation and asked the patients about the condition before and after treatment. Not only this, they also used to count the days after they treated someone, then ask the patient about the change in his or her body after taking the treatment. As mentioned above, the technique was one of the best ways that traditional healers and elders practiced how they assured the

treatment that they gave to the patient, whether cured or not. After treatment, healers follow the patient to see if he or she returns to their normal routine activities to check the effectiveness of the remedies.

From discussions made with local people, the traditional knowledge of using medicinal plants and its transfer to the next generation depended on close relationships with healers and family because of the secrecy. Respondent's consensus is that knowledge transfer starts with close family members, especially the elder son, who has the first chance to give next to the daughter and then the grandson and granddaughter. Similar results were observed in other studies in Ethiopia (Giday et al., 2009; Yirga, 2010; Suleman et al., 2018).

The major threats that were found in the study district were a lack of awareness about the value of medicinal plants that were used for the prevention and treatment of malaria. Even though people in the localities used these plants, there was a gap of knowledge and support from the local administration in order to promote the practices. On the other hand, the plant species used to prevent and treat malaria in the study area were not supported by research as well as technology. The study also found that agricultural expansion and shifting cultivation, wildfires, and construction were the biggest threats against medicinal plant conservation in the district. This finding agrees with previous reports (Yirga, 2010; Suleman et al., 2018) that indicate agricultural expansion was the most common threatening factor.

CONCLUSIONS

Jor District has great potential for traditional medicinal plants and practices used for the prevention and treatment of malaria. The study recorded 22 plant species used as traditional medicinal plants to prevent and treat malaria and that were used as repellents of mosquitoes not to land on humans for biting as well as walls of houses. Most of these plant remedies were used to treat human malaria in the study area. The majority of plants were prepared with single plants, followed by a mixture of two plants to treat the patient. The study found that most of the plant remedies were found in wild form, followed by home gardens.

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DECLARATION

There is no conflict of interest in this work.

DATA AVAILABILITY STATEMENT

All data were included in the article.

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